Increasing Physical Activity and Reducing Sedentary Behaviour in Mental Health Professionals

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Abstract

Clinicians with a high level of physical activity (PA) are more likely to recommend PA to their clients, compared with those with a low level of PA. Interventions to increase PA and reduce sedentary behaviour (SB) among mental health professionals may, therefore, indirectly benefit their clients with mental disorders. However, there is limited evidence on the effectiveness of interventions aimed at increasing PA and reducing SB among mental health professionals in changing their attitudes towards and practices in recommending more PA and less SB to their clients. Therefore, four studies were conducted as a part of this PhD thesis, to address this overarching research question.

A critical evaluation of interventions for increasing PA (Chapter 4) and systematic reviews and meta-analyses of interventions for reducing SB (Studies 1 and 2) provided information about the effectiveness of various PA and SB interventions among adults. The literature identified that for PA promotion, there is evidence on the short-term effectiveness of interventions based on counseling/support, and health promotion messages/information, but evidence on the long-term effectiveness of these interventions is limited. The systematic reviews also found that the use of sit-stand desks at work, restricting the use of TV devices in leisure time, and educational interventions outside workplace were effective strategies in reducing SB in the short term, however evidence on the effectiveness of these interventions in the long term is limited. Digital interventions, such as a prompts on the computer screen, and the use of wearable devices were found to be increasingly popular interventions for increasing PA and reducing SB. Evidence on the effectiveness of PA and SB interventions specifically among mental health professionals is scarce, but it can be assumed that most of the interventions that are effective in the general population of adults will also be effective among mental health professionals.

Study 3 explored attitudes and practices of mental health professionals in recommending more PA and less SB to their clients. Data were collected using a modified Exercise in Mental Illness Questionnaire in a sample of 17 Australian mental health professionals. Additionally, in focus group discussions, 10 mental health professionals provided in-depth information about their practices, facilitators, and perceived barriers in recommending more PA and less SB. It was found that PA and SB counselling in the mental health setting could be improved by: including training on PA and SB counselling in formal education and continued professional training for mental health professionals; implementing interventions to increase PA and reduce SB among mental health professionals themselves; and ensuring support from an exercise or PA promotion specialist as a part of a multi-disciplinary approach to mental health care.

Study 4 investigated the effects of an intervention designed to increase PA and reduce SB among mental health professionals on their attitudes towards and practices in recommending more PA and less SB to their clients. The intervention was informed by the findings of the Chapter 4, Study 1 and Study 2, and it consisted of a single group-based behaviour change session, which included a presentation of various strategies to increase PA and reduce SB and goal setting according to the SMART goals approach. An information booklet containing 24 strategies to increase PA and reduce SB was also provided to the participants. They also received reminder texts/calls during the following three weeks of the intervention. There was no significant overall change in PA and SB among mental health professionals, but the intervention had a positive effect on their attitudes towards recommending more PA and less SB to their clients. The mental health professionals who increased their own PA during the intervention (compared to those who did not) significantly increased the frequency of recommending more PA (p=0.009) and less SB (p=0.005) to their clients. Two post-intervention focus group discussions with the participants suggested that the intervention positively influenced their confidence in recommending more PA and less SB to their clients and provided them with pragmatic strategies to include in their practice.

The findings of the studies included in this thesis suggest that a relatively simple intervention has the potential to improve mental health professionals’ attitudes towards and practices in recommending more PA and less SB to their clients. The intervention could be scaled up to promote more PA and less SB within mental health settings, with potential benefits for mental health professionals and their clients.

Declaration

"I, Nipun Shrestha, declare that the PhD thesis by Publication entitled "Increasing Physical Activity and Reducing Sedentary Behaviour in Mental Health Professionals" is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work".

Signature:
[redacted]

Date in full:
13^{th} of August, 2020

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PART A:

DETAILS OF INCLUDED PAPERS: THESIS BY PUBLICATION

Please list details of each Paper included in the thesis submission. Copies of published Papers and submitted and/or final draft Paper manuscripts should also be included in the thesis submission

Item/ Chapter No.	Paper Title	Publication Status (e.g. published, accepted for publication, to be revised and resubmitted, currently under review, unsubmitted but proposed to be submitted)	Publication Title and Details (e.g. date published, impact factor etc.)
5	Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and menta-analysis	Published	**British Journal of Sports Medicine** **Date published January 13, 2018** **Impact factor 12.022**
6	Workplace interventions for reducing sitting at work	Published	**Cochrane Database of Systematic Reviews** **Date published December 17, 2018** **Impact factor 7.89**
7	Physical activity and sedentary behaviour counselling: attitudes and practices of mental health professionals	Currently	**Psychiatry Research** **Impact factor 2.11**
8	Improving attitudes and practices of mental health professionals in recommending more physical activity and less sedentary behaviour to their clients: findings from a mixed-methods	Currently under review	BMC Medical Education Impact factor 2.03

Declaration by [candidate name]: Nipun Shrestha

Signature: [redacted]

Date: 14 August 2020

Table of Contents

List of Figures

List of Tables

Supplementary tables and figures

Chapter 1: General introduction

This thesis primarily deals with designing a PA and SB intervention for mental health professionals and evaluating its impact on their attitudes towards and practices in recommending more physical activity (PA) and less sedentary behaviour (SB) to their clients. This chapter presents background, aims and summary overview of this PhD research project.

1.1 Background

More than half of all deaths worldwide can be attributed to non-communicable diseases (NCDs) (To et al., 2013). Among various causes of NCD mortality, a staggering proportion of deaths─nearly one-tenth─can be attributed to physical inactivity (Lee et al., 2012). Recently, some studies have indicated that SB might be a risk factor for various NCDs (Patel et al., 2010, de Rezende et al., 2014, Biddle et al., 2016, Biswas et al., 2015, Wilmot et al., 2012). The burden of physical inactivity and SB is increasing around the world with approximately 30% people still not meeting the PA levels recommended in public health guidelines (Guthold et al., 2018, Hallal et al., 2012). Similarly, data from the Eurobarometer surveys shows that nearly one fifth of adult population in 28 European Union countries engage in high levels of SB (>7.5 hours/day) (Loyen et al., 2016). Thus, the potential to avert a large number of deaths by implementing interventions to increase PA and reduce SB is immense.

Poor mental health affects a significant portion of the global population and is a leading contributor to global disease burden (Rehm and Shield, 2019). A recent systematic review with studies from 64 countries found that one in five people (20%) reported experiencing a mental illness within the last 12 months and 29.2% reported they had experienced some form of mental disorder in their life

(Steel et al., 2014). People with mental illness have poor physical health conditions, reduced social engagement and poor quality of life (Firth et al., 2019). They have been found to visit emergency departments and seek hospital admissions for physical conditions that could have been managed appropriately in primary care clinics (Kisely et al., 2015). Moreover, these people are not only at increased risk of NCDs but also are at increased risk of premature mortality compared to those without a mental illness (Ribe et al., 2014, Gardner-Sood et al., 2015, Vancampfort et al., 2015).

People with mental illness, for example those with a diagnosis of depression, are 1.42 times less likely to meet PA guidelines (Stubbs et al., 2016) and 1.94 times more likely to engage in SB of duration 8 hour or more per day compared to those without depression (Stubbs et al., 2018). The role of PA in promotion of mental wellbeing and management of mental illness has been well documented (Teychenne et al., 2020). Interventions for increasing PA might not only improve physical health, enhance social engagement and reduce the general risk of developing NCDs but also improve the treatment and management of severe mental illnesses (Bailey et al., 2018, Firth et al., 2019). Although mental health professionals are aware of this the benefits of PA (Happell et al., 2013), they do not routinely recommend PA to their clients for a range of reasons. These include concerns that recommending PA is not part of their role, perceived disruption to the therapeutic relationship, a lack of time, the belief that clients prefer traditional psychological treatments, and the belief that PA is insufficient for those with complex clinical presentations and needs (Hebert et al., 2012, Glowacki et al., 2019). Furthermore, clinicians with a higher level of PA seem to be more likely to recommend PA to their clients compared to those with a low level of PA (Hebert et al., 2012), suggesting that a mental health professional's own engagement in PA may moderate the delivery of PA interventions within routine health care. A study among health care professionals showed that those health workers who participated in sports recommend PA more frequently to their clients than those who did not (Patra et al., 2015). Interventions to increase PA and reduce SB among mental health professionals might, therefore, indirectly benefit their clients. There is good evidence of the effectiveness of PA interventions in general populations of adults (Conn et al., 2011), which may be generalizable to mental health professionals. However, such evidence is equivocal and limited in SB interventions.

Recent studies have recognised the importance of acknowledging the constrained nature of the 24-hour day in PA and SB research (Pedišić et al., 2017, Pedišić, 2014, Dumuid et al., 2019). The amounts of time spent in SB, sleep, and PA always constitute the full 24 hour day, which makes them perfectly collinear, that is, a change in the amount of time spent in one of these behaviours will necessarily result in a proportional, opposite change in one or both of the remaining behaviours (Pedišić et al., 2017). Interventions for improving one of these behaviours, therefore, need to take into consideration all the three behaviours, because, from the health perspective, it is important to know from which behaviour(s) the time is reallocated. For example, in an intervention aimed at increasing PA by 30 minutes a day, one may reallocate these 30 minutes from SB, which would likely be a 'healthy' trade-off, or from sleep, which may or may not be as healthy. The Framework for Viable Integrative Research in Time-Use Epidemiology (VIRTUE) recommends using one of the two approaches applicable to PA and/or SB interventions: 1) re-allocating time between two movement/non-movement time-use components while keeping the remaining component constant; or 2) intervening on all the movement/non-movement time-use components simultaneously to achieve an optimal time-use balance (Pedišić et al., 2017). Our intervention among mental health professionals will, therefore, aim to increase the amount of time they spend in PA and reduce the amount of time they spend in SB, and analyse the intervention effects by taking into account the amount of time spent in sleep.

To support the promotion of active lifestyles among mental health professionals and increase the likelihood of PA interventions delivered in routine mental health care, this PhD thesis, therefore, aimed to address the following research questions:

a. How effective are interventions for reducing non-occupational SB in mental health professionals by systematically reviewing studies in the general adult population?
b. How effective are interventions for reducing occupational SB in mental health professionals by systematically reviewing studies in the general adult population?
c. What are the attitudes and practices of mental health professionals in recommending more PA and less SB to their clients?
d. What are the effects of engaging mental health professionals in an intervention to increase PA and reduce SB on their attitudes towards and practices in recommending more PA and less SB to their clients?

1. 2 Aims of the thesis

The aim of this thesis is to provide evidence needed for effective promotion of balanced time use by increasing PA and reducing SB in "mental health settings". The specific objectives of this research are:

a. To investigate the evidence on the effectiveness of interventions for reducing non-occupational SB in mental health professionals by systematically reviewing studies in the general adult population;

b. To investigate the evidence on the effectiveness of workplace interventions to reduce occupational SB in mental health professionals by systematically reviewing studies in the general adult population;
c. To investigate the attitudes and practices of mental health professionals in recommending more PA and less SB to their clients;
d. To investigate the effects of engaging mental health professionals in an intervention to increase PA and reduce SB on their attitudes towards and practices in recommending more PA and less SB to their clients.

1.3 Structure of the PhD research project: A summary overview

Table 1 includes an overview of: [i] the types of evidence needed for the development and implementation of PA and SB intervention among mental health professionals aimed at improving their attitudes towards and practices in recommending more PA and less SB to their clients; [ii] current availability of such evidence; [iii] the relevance of such evidence for the realisation of this PhD research project and for future applications; and [iv] overall structure of this PhD research project.

Table 1: Structure of the PhD research project: A summary overview

Type of evidence	**Availability**	**Relevance to the current project and future applications**	**Part of the PhD research project addressing it**
Evidence on the effectiveness of different types of interventions to increase PA	Strong evidence summarised in multiple systematic reviews (Conn et al., 2011, Murray et al., 2017, Orrow et al., 2012)	Informing the development of the PA component of the intervention in Study 4	The general literature reviews (Chapters 4 and 7)
Evidence on the effectiveness of different types of interventions to reduce SB	Likely outdated evidence from multiple systematic reviews on workplace interventions (Shrestha et al., 2016, Chu et al., 2016, Prince et al., 2014) Equivocal evidence from individual studies on non-occupational interventions (Lakerveld et al., 2013, Laska et al., 2016, Otten et al., 2009)	Informing the development of the SB component of the intervention in Study 4	(Chapters 5, 6 and 7)
Evidence on attitude and practices of mental health professionals in recommending more PA and less SB to their clients	No available evidence	Informs the necessity of PA and SB intervention among mental health professionals	Chapter 9
Evidence on the effects of PA and SB intervention among mental health professionals on their attitudes towards and practices in recommending more PA and less SB to their clients	No available evidence	Providing grounds for a wider implementation of similar interventions among mental health professionals	Chapter 10

Legend: Physical activity – PA; Sedentary behaviour – SB

References

BAILEY, A. P., HETRICK, S. E., ROSENBAUM, S., PURCELL, R. & PARKER, A. G. 2018. Treating depression with physical activity in adolescents and young adults: A systematic review and meta-analysis of randomised controlled trials. *Psychol Med,* 48**,** 1068-83.

BIDDLE, S. J., BENNIE, J. A., BAUMAN, A. E., CHAU, J. Y., DUNSTAN, D., OWEN, N., STAMATAKIS, E. & VAN UFFELEN, J. G. 2016. Too much sitting and all-cause mortality: is there a causal link? *BMC Public Health,* 16**,** 635.

BISWAS, A., OH, P. I., FAULKNER, G. E., BAJAJ, R. R., SILVER, M. A., MITCHELL, M. S. & ALTER, D. A. 2015. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med,* 162**,** 123-32.

CHU, A. H. Y., NG, S. H. X., TAN, C. S., WIN, A. M., KOH, D. & MÜLLER-RIEMENSCHNEIDER, F. 2016. A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obesity Reviews,* 17**,** 467-481.

CONN, V. S., HAFDAHL, A. R. & MEHR, D. R. 2011. Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. *Am J Public Health,* 101**,** 751-8.

DE REZENDE, L. F., RODRIGUES LOPES, M., REY-LOPEZ, J. P., MATSUDO, V. K. & LUIZ ODO, C. 2014. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One,* 9**,** e105620.

DUMUID, D., PEDISIC, Z., STANFORD, T. E., MARTIN-FERNANDEZ, J. A., HRON, K., MAHER, C. A., LEWIS, L. K. & OLDS, T. 2019. The compositional isotemporal substitution model: A method for estimating changes in a health outcome for reallocation of time between sleep, physical activity and sedentary behaviour. *Stat Methods Med Res,* 28**,** 846-857.

FIRTH, J., SIDDIQI, N., KOYANAGI, A., SISKIND, D., ROSENBAUM, S., GALLETLY, C., ALLAN, S., CANEO, C., CARNEY, R., CARVALHO, A. F., CHATTERTON, M. L., CORRELL, C. U., CURTIS, J., GAUGHRAN, F., HEALD, A., HOARE, E., JACKSON, S. E., KISELY, S., LOVELL, K., MAJ, M., MCGORRY, P. D., MIHALOPOULOS, C., MYLES, H., O'DONOGHUE, B., PILLINGER, T., SARRIS, J., SCHUCH, F. B., SHIERS, D., SMITH, L., SOLMI, M., SUETANI, S., TAYLOR, J., TEASDALE, S. B., THORNICROFT, G., TOROUS, J., USHERWOOD, T., VANCAMPFORT, D., VERONESE, N., WARD, P. B., YUNG, A. R., KILLACKEY, E. & STUBBS, B. 2019. The Lancet Psychiatry Commission: a blueprint for protecting physical health in people with mental illness. *The Lancet Psychiatry,* 6**,** 675-712.

GARDNER-SOOD, P., LALLY, J., SMITH, S., ATAKAN, Z., ISMAIL, K., GREENWOOD, K. E., KEEN, A., O'BRIEN, C., ONAGBESAN, O., FUNG, C., PAPANASTASIOU, E., EBERHARD, J., PATEL, A., OHLSEN, R., STAHL, D., DAVID, A., HOPKINS, D., MURRAY, R. M., GAUGHRAN, F. & TEAM, I. M. 2015. Cardiovascular risk factors and metabolic syndrome in people with established psychotic illnesses: baseline data from the IMPaCT randomized controlled trial. *Psychol Med,* 45**,** 2619-29.

GLOWACKI, K., WEATHERSON, K. & FAULKNER, G. 2019. Barriers and facilitators to health care providers' promotion of physical activity for individuals with mental illness: A scoping review. *Ment Health Phys Act,* 16**,** 152-168.

GUTHOLD, R., STEVENS, G. A., RILEY, L. M. & BULL, F. C. 2018. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Glob Health,* 6**,** e1077-86.

HALLAL, P. C., ANDERSEN, L. B., BULL, F. C., GUTHOLD, R., HASKELL, W., EKELUND, U. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet,* 380**,** 247-57.

HAPPELL, B., PLATANIA-PHUNG, C. & SCOTT, D. 2013. Survey of Australian mental health nurses on physical activity promotion. *Int J Ment Health Promot,* 15**,** 148-161.

HEBERT, E. T., CAUGHY, M. O. & SHUVAL, K. 2012. Primary care providers' perceptions of physical activity counselling in a clinical setting: a systematic review. *Br J Sports Med,* 46**,** 625-31.

KISELY, S., EHRLICH, C., KENDALL, E. & LAWRENCE, D. 2015. Using Avoidable Admissions to Measure Quality of Care for Cardiometabolic and Other Physical Comorbidities of Psychiatric Disorders: A Population-Based, Record-Linkage Analysis. *Can J Psychiatry,* 60**,** 497-506.

LAKERVELD, J., BOT, S. D., VAN DER PLOEG, H. P. & NIJPELS, G. 2013. The effects of a lifestyle intervention on leisure-time sedentary behaviors in adults at risk: the Hoorn Prevention Study, a randomized controlled trial. *Prev Med,* 57**,** 351-6.

LASKA, M. N., LYTLE, L. A., NANNEY, M. S., MOE, S. G., LINDE, J. A. & HANNAN, P. J. 2016. Results of a 2-year randomized, controlled obesity prevention trial: Effects on diet, activity and sleep behaviors in an at-risk young adult population. *Prev Med,* 89**,** 230-6.

LEE, I. M., SHIROMA, E. J., LOBELO, F., PUSKA, P., BLAIR, S. N., KATZMARZYK, P. T. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet,* 380**,** 219-29.

LOYEN, A., VAN DER PLOEG, H. P., BAUMAN, A., BRUG, J. & LAKERVELD, J. 2016. European Sitting Championship: Prevalence and Correlates of Self-Reported Sitting Time in the 28 European Union Member States. *PLoS One,* 11**,** e0149320.

MURRAY, J. M., BRENNAN, S. F., FRENCH, D. P., PATTERSON, C. C., KEE, F. & HUNTER, R. F. 2017. Effectiveness of physical activity interventions in achieving behaviour change maintenance in young and middle aged adults: A systematic review and meta-analysis. *Soc Sci Med,* 192**,** 125-133.

ORROW, G., KINMONTH, A. L., SANDERSON, S. & SUTTON, S. 2012. Effectiveness of physical activity promotion based in primary care: systematic review and meta-analysis of randomised controlled trials. *BMJ,* 344**,** e1389.

OTTEN, J. J., JONES, K. E., LITTENBERG, B. & HARVEY-BERINO, J. 2009. Effects of television viewing reduction on energy intake and expenditure in overweight and obese adults: a randomized controlled trial. *Arch Intern Med,* 169**,** 2109-15.

PATEL, A. V., BERNSTEIN, L., DEKA, A., FEIGELSON, H. S., CAMPBELL, P. T., GAPSTUR, S. M., COLDITZ, G. A. & THUN, M. J. 2010. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *Am J Epidemiol,* 172**,** 419-29.

PATRA, L., MINI, G. K., MATHEWS, E. & THANKAPPAN, K. R. 2015. Doctors' self-reported physical activity, their counselling practices and their correlates in urban Trivandrum, South India: should a full-service doctor be a physically active doctor? *Br J Sports Med,* 49**,** 413-6.

PEDIŠIĆ, Ž. 2014. Measurement issues and por adjustments for physical activity and sleep undermine sedentary behaviour research —The focus should shift to the balance between sleep, sedentary behaviour, standing and activity. *Kinesiology,* 1**,** 135-46.

PEDIŠIĆ, Ž., DUMUID, D. & OLDS, T. 2017. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology,* 49**,** 252-69.

PRINCE, S. A., SAUNDERS, T. J., GRESTY, K. & REID, R. D. 2014. A comparison of the effectiveness of physical activity and sedentary behaviour interventions in reducing sedentary time in adults: a systematic review and meta-analysis of controlled trials. *Obes Rev,* 15**,** 905-19.

REHM, J. & SHIELD, K. D. 2019. Global Burden of Disease and the Impact of Mental and Addictive Disorders. *Curr Psychiatry Rep,* 21**,** 10.

RIBE, A. R., LAURSEN, T. M., SANDBAEK, A., CHARLES, M., NORDENTOFT, M. & VESTERGAARD, M. 2014. Long-term mortality of persons with severe mental illness and diabetes: a population-based cohort study in Denmark. *Psychol Med,* 44**,** 3097-107.

SHRESTHA, N., KUKKONEN-HARJULA, K. T., VERBEEK, J. H., IJAZ, S., HERMANS, V. & BHAUMIK, S. 2016. Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev,* 3**,** CD010912.

STEEL, Z., MARNANE, C., IRANPOUR, C., CHEY, T., JACKSON, J. W., PATEL, V. & SILOVE, D. 2014. The global prevalence of common mental disorders: a systematic review and meta-analysis 1980-2013. *Int J Epidemiol,* 43**,** 476-93.

STUBBS, B., KOYANAGI, A., SCHUCH, F. B., FIRTH, J., ROSENBAUM, S., VERONESE, N., SOLMI, M., MUGISHA, J. & VANCAMPFORT, D. 2016. Physical activity and depression: a large cross-sectional, population-based study across 36 low- and middle-income countries. *Acta Psychiatr Scand,* 134**,** 546-556.

STUBBS, B., VANCAMPFORT, D., FIRTH, J., SCHUCH, F. B., HALLGREN, M., SMITH, L., GARDNER, B., KAHL, K. G., VERONESE, N., SOLMI, M., CARVALHO, A. F. & KOYANAGI, A. 2018. Relationship between sedentary behavior and depression: A mediation analysis of influential factors across the lifespan among 42,469 people in low- and middle-income countries. *J Affect Disord,* 229**,** 231-238.

TEYCHENNE, M., WHITE, R. L., RICHARDS, J., SCHUCH, F. B., ROSENBAUM, S. & BENNIE, J. A. 2020. Do we need physical activity guidelines for mental health: What does the evidence tell us? *Mental Health and Physical Activity,* 18**,** 100315.

TO, Q. G., CHEN, T. T., MAGNUSSEN, C. G. & TO, K. G. 2013. Workplace physical activity interventions: a systematic review. *Am J Health Promot,* 27**,** e113-23.

VANCAMPFORT, D., STUBBS, B., MITCHELL, A. J., DE HERT, M., WAMPERS, M., WARD, P. B., ROSENBAUM, S. & CORRELL, C. U. 2015. Risk of metabolic syndrome and its components in people with schizophrenia and related psychotic disorders, bipolar disorder and major depressive disorder: a systematic review and meta-analysis. *World Psychiatry,* 14**,** 339-47.

WILMOT, E. G., EDWARDSON, C. L., ACHANA, F. A., DAVIES, M. J., GORELY, T., GRAY, L. J., KHUNTI, K., YATES, T. & BIDDLE, S. J. 2012. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetol,* 55**,** 2895-905.

Chapter 2: Literature review

Chapter outline

The specific aim of this chapter is to summarise and critically appraise the literature related to:

a. the association between PA and mental health;

b. the effectiveness of PA interventions at the workplace and in the community setting;

c. the effectiveness of PA interventions in the mental health setting; and

d. the effectiveness of SB interventions at work and outside work in adults, including, among others, mental health professionals.

2.1 Physical activity and sedentary behaviour

PA is defined as "any bodily movement produced by skeletal muscles that result in energy expenditure" (Caspersen et al., 1985). The Australian physical activity and sedentary behaviour guidelines recommend that adults should engage in at least 150 minutes/week of moderate-intensity PA or 75 minutes/week of vigorous-intensity PA, or a combination of both. It also recommends engaging in muscle-strengthening activities on at least two days a week (Australian Government Department of Health, 2019). A recent study with pooled data from 358 surveys across 168 countries reported 27.5% (95% CI: 25-32.2) of adults were insufficiently active in 2016 (men: 23.4% and women: 31.7%) (Guthold et al., 2018a). Similarly, in the year 2014-15, nearly half of the Australian adults did not engage in sufficient PA in the last week (Australian Bureau of Statistics, 2015). This high prevalence of insufficient PA has been established as a causal factor for many chronic conditions such as cardiovascular disease, diabetes, and cancer (Lee et al., 2012).

The unprecedented advancement in technology in the last few decades has seen opportunities for PA curtailed and favoured sedentariness in every domain at work, at home, in leisure, and in transport. Thus, recently there has been a tremendous growth of research interest in SB. It has been estimated that for every hour spent in SB, there is a 2% increase in mortality risk, which increases to 8% per hour for people spending more than 8 hours in SB in a day (Chau et al., 2013). SB has been conceptualized lately as a major risk factor for mortality(Rezende et al., 2016), independent of PA (Patel et al., 2010). However, the evidence for such an association independent of PA is still limited. In an individual patient data meta-analysis of 16 prospective studies, including 1,005791 participants with follow-up ranging from 2 to 18.1 years, a strong association between sitting and mortality was observed at lower PA levels. The association, however, seems to weaken with increasing levels of PA, and disappear at levels equivalent to more than 60 to 75 min of moderate-intensity PA a day (Ekelund et al., 2016). Similar observations were seen in a recent prospective study that included 149,077 participants with median follow-up of 8.9 year. An association was observed for sitting with all-cause and CVD mortality risk among adults with low PA and attenuated for those who met the current PA recommendations (Stamatakis et al., 2019). Recent studies have argued that not only reducing total sitting time but also breaking up time between individual sits in one stretch have beneficial effects on plasma glucose levels, serum cholesterol and triglyceride levels (Buckley et al., 2015, Healy et al., 2015).

SB can accumulate in a variety of settings such as household, leisure, transport, and work (Owen et al., 2011). However, SB in all contexts cannot be deemed harmful. Some forms of SB primarily that accumulated during TV viewing (Ekelund et al., 2016, Ford and Caspersen, 2012) and commuting by car (Sugiyama et al., 2016) are consistently associated with poor health outcomes. On the other hand, other forms of SB, such as reading, have been found less harmful and might even be beneficial (Bavishi et al., 2016, Carson et al., 2016). Likewise, replacing SB with purposeful activities during leisure time, for example exercising for improving fitness, might have greater health benefits due to a range factors such as a sense of achievement and enjoyment (Firth et al., 2019).

According to the Australian Bureau of Statistics, Australian adults spend ~ 9 h/day in SBs which included 22 hours per week sitting at work and commuting by car and four hours per day of leisure SB (Australian Bureau of Statistics, 2013, Tanamas et al., 2013). Additionally, the time spent on TV viewing has increased significantly (~5h/day) in the last two decades among Australian adults (Australian Bureau of Statistics, 2013). Based on the emerging evidence on SB, Australia has already incorporated recommendations to reduce the time spent sitting as part of their PA guidelines (Australian Government Department of Health, 2019).

2.2 Physical activity, sedentary behaviour, and mental health

Mental health is defined "as a state of well-being in which a person recognises his or her own abilities, can endure the general stresses of life, is able to work productively and can contribute to their community" (WHO, 2018a). Therefore, a person with positive mental health is someone not just free of any mental illness but should be able to enjoy life and can endure stressful life events (Galderisi et al., 2015). To maintain positive mental health, people often use PA as a coping strategy against stressful life events and to enhance mood as well as gain immediate psychological benefits (Stults-Kolehmainen and Sinha, 2014). The positive association of PA with mental health and quality of life has been firmly established in the literature (Eddolls et al., 2018, Harris, 2018, Tamminen et al., 2020). In a large cohort study involving 33,908 adults, engaging in regular PA was effective in preventing depression in later life (Harvey et al., 2018). A cross-sectional study among American adults found a negative association between regular PA and various mental disorders, such as anxiety, depressive disorders, and a number of specific phobias (Goodwin, 2003). Similarly, there was a 22% decrease in the risk of depression and 27% decrease in risk of anxiety among participants meeting the recommended levels of PA based on the meta-analysis of cohort studies (Schuch et al., 2019, Felipe B. Schuch et al., 2018). The emerging evidence suggests that SB is also associated with poor mental health particularly anxiety (Teychenne et al., 2015) and depression (Teychenne et al., 2010). A longitudinal study that followed 271 healthy adults over 12 months reported a reduction in sedentary time in participants had a positive impact on their mental wellbeing (Ellingson et al., 2018). Therefore, everybody, including health professionals, should engage in sufficient levels of PA and less SB to maintain positive mental health. However, as seen by the global high rates of insufficient PA, engaging in sufficient PA is challenging for the general population. It may be even more of a challenge for people with physical or mental illnesses, for example, people with mental illness experience significant psychological barriers such as perceived stress, low mood and lack of support (Firth et al., 2016). The professional support in the form of PA counselling might be therefore essential to overcoming such barriers and motivate people with mental health problems to engage in regular PA (Firth et al., 2019).

According to the Global Burden of Disease 2016, mental illness contributes to 13% of disability-adjusted life-years which is equivalent to the estimated burden for cardiovascular and circulatory diseases (Vigo et al., 2016). In the year 2011, the Australia Burden of Disease Survey estimated that around 12% of the total burden of disease could be attributed to mental and substance use disorders (AIHW, 2016). It was also found that almost half of Australian adults are likely to experience from some form of mental disorder in their life (Australian Government Department of Health, 2009). The life span of people with severe mental illness is shortened compared to those without a serious mental illness, largely due to the increased risk of chronic diseases such as cardiometabolic disease and diabetes, and adverse effects of medications used to treat their mental illness (DE Hert et al., 2011, Tiihonen et al., 2009, Holt and Peveler, 2010). In a recent study conducted among Australian adults, people with depression and/or anxiety were more likely to suffer from chronic conditions such as elevated blood pressure, chronic musculoskeletal pain, asthma, heart disease, stroke, and cancer, compared to those without depression and/or anxiety (Stanton et al., 2019). Similarly, in another study from Australia, the likelihood of reporting physical health comorbidities increased between 1.5 to 3.2 times in people with mental illnesses compared to those without mental illnesses (Scott et al., 2012). In an analysis of the clinical records of 1.7 million people from England and Wales it was found that the likelihood of experiencing life-threatening cardiometabolic events, such as stroke and ischemic heart disease, is double and 1.6 times, respectively, in individuals with schizophrenia and bipolar disorder (Hippisley-Cox and Pringle, 2005).

Moreover, people with mental illnesses are less likely to meet the PA guidelines compared to the general population (Stanton et al., 2019) and tend to engage in high levels of SB (12.6 hours/day for people with schizophrenia and 9.9 hours/day for people with major depressive disorders) (Stubbs et al., 2016a, Stubbs et al., 2016b, Vancampfort et al., 2017). People who were experiencing a mental illness for a longer duration and who were prescribed antipsychotic medications were more likely to engage in insufficient PA (Vancampfort et al., 2017). In most instances, the focus for seeking treatment for people with severe mental illnesses is for their mental condition, and their physical health remains largely ignored by themselves and by mental health clinicians (Blanner Kristiansen et al., 2015, Ewart et al., 2016). In addition, mental health care providers tend to focus on treating the symptoms of mental disorders and do not consider the patient's physical health as their primary responsibility (Celik Ince et al., 2018, Gray and Brown, 2017), whereas other health care professionals often tend to consider the physical symptoms in people with mental illness as a reflection of their of mental health concerns (Happell et al., 2016). As a consequence of this, the physical health of people with mental health illness often remains unattended by both mental health clinicians and general practitioners. Hence, the need to address the physical health of people with a mental illness has been acknowledged recently by the Australian Government's Fifth National Mental Health Plan (Commonwealth of Australia, 2017).

A Dutch study found a significantly lower prevalence of anxiety, any mood disorder, and substance use disorder in individuals who exercised at least an hour/week (Ten Have et al., 2011). The same study also reported that engagement in regular PA was associated with recovery from mental illness at a three-year follow-up (Ten Have et al., 2011). People with major depressive disorder (Schuch et al., 2016) and anxiety disorders (Aylett et al., 2018) were found to benefit from exercise recommendation in a meta-analyses of randomised control trials (RCT) comparing exercise versus control comparison groups. A study conducted with adults diagnosed with obsessive compulsive disorder indicated that participating in a 12-week moderate intensity aerobic PA program resulted in decrease in anxiety, better mood and reduced compulsions (Abrantes et al., 2019). Similarly a meta-analysis of 17 trials assessing effectiveness of PA interventions for adults with schizophrenia reported reduction in psychiatric symptoms from engaging in aerobic activity for an average of 90 minutes/week (SMD -0.72, 95% CI: -1.14 to -0.29) (Firth et al., 2015). Further combining PA recommendation with cognitive behaviour therapy or antidepressant treatment was found to be more effective in reducing depressive symptoms than cognitive behaviour therapy or antidepressant treatment alone (Kvam et al., 2016). Therefore, interventions for increasing PA might not only reduce the general risk of developing cardio-metabolic diseases but also improve the treatment and management of severe mental illnesses (Bailey et al., 2018).

2.3 Effectiveness of physical activity interventions in adults, including, among others, mental health professionals

Around 56% of the WHO's member countries have formulated policies to address a high prevalence of insufficient PA, and they set a target to reduce it by 10% (relative reduction) by 2025 (WHO, 2018b). However, it is highly unlikely that this target will be met by 2025 (Guthold et al., 2018b). It has been estimated that 31% of the world population does not meet the recommended levels of PA (Kohl et al., 2012). The growing epidemic of physical inactivity is evident in low-, middle, and high-income countries, especially in the last decade (Ng and Popkin, 2012, Guthold et al., 2018b). In 2016, the Global Burden of Disease study found that 9.0%, 2.8% and 4.9% of ischaemic heart disease, diabetes and cancer related disability-adjusted life years is attributable to insufficient PA (IHME, 2016). Similarly, it has been estimated that for every 10% increase in population level PA, half a million global deaths each year from NCDs will be prevented (Love et al., 2018). In addition, some studies have reported the mental health benefits of meeting PA guidelines in adults (Sloan et al., 2013, Vankim and Nelson, 2013, Bernard et al., 2018, Chekroud et al., 2018). Thus, promoting PA seems to be "the best buy" in public health interventions for addressing the growing burden of NCDs worldwide.

Mental health professionals are members of the general adult population. It might, therefore, be assumed that the available evidence for effective interventions for increasing PA and reducing SB in the general population of adults may also work for mental health professionals. The current evidence-based strategies and approaches for increasing PA were reviewed according to their settings, including workplace and community wide interventions. Initially the evidence available from reviews was assessed but the evidence available for workplace settings was inconsistent across the reviews. Hence, the evidence from primary studies was summarized to enable drawing sound conclusions on the effectiveness of PA intervention in the workplace setting (Chapter 4: Review of physical activity interventions).

2.4 Effectiveness of physical activity interventions in the mental health setting

2.4.1 For clients

Lifestyle counselling by a clinician is regarded as a cornerstone in the prevention and management of NCDs, including mental disorders. Several clinical trials have assessed the effectiveness of lifestyle counselling by health care workers on their clients' PA levels. A cluster randomised control trial, the Green Prescription Program study (Elley et al., 2003), reported that PA counselling by providers to their inactive clients during regular visits was effective in increasing leisure PA by 9.7% among clients in the intervention group compared to control group over 12 months follow-up. Similarly, a systematic review (Orrow et al., 2012) found that PA or fitness in sedentary adults were improved by counselling intervention delivered in person or by phone (or both) on multiple occasions by primary care clinicians at 12 months follow-up (Standardised mean difference (SMD) 0.25, 0.11 to 0.38, 13 studies). A pre-post study with 19 weeks follow-up evaluated a behaviour change intervention in private psychiatric hospital outpatients (Fraser et al., 2018). The intervention comprised of registered nurse-led behaviour change intervention and supportive feedback to encourage behaviour change provided by a medical practitioner. The study did not report a significant change in PA in the participants but found a low attrition rate and high satisfaction among the participants. Hence, while there is some evidence that behaviour change PA interventions are feasible and acceptable for people with mental illness, more studies with rigorous study design and larger sample sizes are warranted.

With regards to the effectiveness of PA interventions in the management of mental illness, a systematic review (Cooney et al., 2013) conducted a pooled analysis of 35 trials and found a moderate reduction in depressive symptoms for PA intervention compared to no intervention or control condition (SMD: 0.62; 95% CI: -0.81 to -0.42). Similarly, it also found PA intervention to be more effective compared to medications (SMD -0.11, 95% CI -0.34 to 0.12) and psychotherapies (SMD -0.03, 95% CI -0.32 to 0.26) (Cooney et al., 2013). The included studies in this review, however, had methodological limitations such as inadequate allocation concealment and failure to blind outcome assessor. Thus, the quality of evidence was considered to be moderate. In a sensitivity analysis, that included studies judged to have a low risk of bias (6 studies), the pooled effect size was not significant for PA intervention compared to no intervention or control condition (SMD -0.3, 95% CI -0.6 to 0.00) (Cooney et al., 2013). However, Ekkekakis et al. (2015) argued that the effectiveness of PA interventions for depression was underestimated. This study re-analysed the Cooney et al. (2013) meta-analysis by modifying the study selection criteria such as defining PA in a border sense (including yoga as well as unstructured exercise) and included postnatal depression and excluded studies with no/active control groups. These changes increased the effect size for the pooled estimate (SMD 0.9, 95% CI: 1.1 to 0.7), making PA intervention highly effective for depressive symptoms (Ekkekakis, 2015). Similar results for the effectiveness of PA intervention in depression was found in a recent meta-analysis of 25 RCTs

(SMD 1.1; 95% CI: 0.8 to 1.4) (Schuch et al., 2016). Hence, the recommendation of PA by mental health professionals seems to be beneficial in treatment of some forms of mental disorders.

2.4.2 For mental health professionals

Health care professionals can influence healthy lifestyle choices among populations across the lifespan. However, their knowledge about healthy lifestyle behaviours does not necessarily translate into their own choices of healthier lifestyle behaviours (Mo et al., 2011, Jinks et al., 2003, Saridi et al., 2019). Moreover their choices of lifestyle and behaviour might impact their productivity (Letvak et al., 2011), quality of care (Letvak et al., 2011, Sarafis et al., 2016) and their counselling practices (Hebert et al., 2012). Therefore, interventions intended to improve lifestyle behaviours among health care professionals might also indirectly improve health outcome in their clients.

PA has been recognized for its potential in the treatment and management of mental disorders (Bailey et al., 2018). The integration of PA as an essential component of mental health services depends on mental health professionals' attitudes towards PA and culture within mental health treatment facilities (Rosenbaum et al., 2016). Helping mental health professionals to increase their own PA levels and develop the ability to formulate their own PA plans might change their attitude towards recommending PA to their clients (Howard and Gamble, 2011, Terry and Cutter, 2013). Moreover, some studies have reported insufficient levels of PA in health care professionals (Owoeye et al., 2016, Rye et al., 2012, Malik et al., 2011). Owoeye et al.(2016) measured mean daily step count in 180 health care professionals over seven days and reported that only 20% of them achieved the 10,000-daily steps target. Engaging in 10,000 daily steps has been found to be equivalent to amount of PA recommended in WHO guidelines (Le Masurier et al., 2003, Pate et al., 1995). Similarly, another study among registered nurses in UK found that almost 50'% registered nurses in the sample did not engage in sufficient level of PA (Malik et al., 2011). The increasing prevalence of mental disorders, especially depression, coupled with declining levels of PA, underscores the need for promotion of PA in mental health care settings.

In a study conducted among health professionals in non-mental health care settings, it was reported that worksite PA intervention was effective in changing the activity behaviour along with improvement in anthropometric measurements at six months follow-up (Tucker et al., 2016). A pre-post study among 79 health care workers found that a multicomponent lifestyle intervention of 12 months duration comprising of access to gym, professional psychological advice, nutritional counselling and dental consultation was effective in increasing physical activity and fitness (Terebessy et al., 2016). Similarly, in a RCT among 42 health care workers from Brazil, those participants that received coaching session, motivational messages and information on PA improved their PA levels compared to control group (Gomes et al., 2019). Fibbins et al. (2018) conducted a systematic review and found five studies that assessed the effectiveness of PA interventions among mental health professionals. The intervention strategies that were assessed included i) education sessions on various topics like smoking cessation, stress management, nutrition, physical fitness/PA, and ii) exercise sessions like sporting events, nature walking and team games, yoga sessions, and walking clubs. These studies provided evidence for the feasibility and acceptability of exercise interventions aimed at mental health professionals but were not enough to draw any conclusions on the effectiveness of such interventions. Similarly, a recent study conducted among mental health staff (both clinical and non-clinical) in Australia found that providing a lifestyle intervention that included PA and nutritional counselling, improved physical fitness, increased PA and reduced time spent in SB in the participants at 16-week follow-up

(Fibbins et al., 2020). This study did not have a control group and recruited both clinical and non-clinical staff (e.g., administrative and research staff) which limits the applicability of its findings in mental health professionals across Australia. The available evidence therefore highlights the potential feasibility of PA and/or SB intervention in increasing PA and physical fitness among mental health professionals.

2.5 Effectiveness of sedentary behaviour interventions in adults, including, among others, mental health professionals

Recently SB has drawn a huge interest amongst researchers in PA epidemiology with global estimates suggesting that SB is responsible for 3.8% of deaths worldwide (Rezende et al., 2016). The increasing trend in time spent in SB in adults underscores the need to consider SB as a significant public health problem. SB refers to any activity in a sitting, reclining, or lying position with low energy expenditure. SBs are investigated from two perspectives in the literature: first, as an independent risk factor for various NCDs (de Rezende et al., 2014); and second, as a component of time use, where it affects health in an interplay with PA and sleep (Pedišić et al., 2017). The promising SB interventions for the general population might as well work for mental health professionals; however, such evidence is equivocal and limited for SB interventions. Adults primarily accumulate SB at their workplaces, during leisure, and while commuting (Owen et al., 2011). There are plenty of opportunities to reduce SB in each domain. Therefore, we conducted two systematic reviews─one for SB interventions at work and one for SB interventions outside the work domain─exploring the effectiveness of SB interventions in adults, including, among others, mental health professionals (Chapter 5 and 6).

References

ABRANTES, A. M., FARRIS, S. G., BROWN, R. A., GREENBERG, B. D., STRONG, D. R., MCLAUGHLIN, N. C. & RIEBE, D. 2019. Acute effects of aerobic exercise on negative affect and obsessions and compulsions in individuals with obsessive-compulsive disorder. *J Affect Disord,* 245**,** 991-997.

AIHW 2016. Australian Institute of Health and Welfare and causes of illness and death in Australia 2011. Australian Burden of Disease Study series no. 3. BOD 4. Canberra.

AUSTRALIAN BUREAU OF STATISTICS 2013. Australian Health Survey: physical activity 2011-12.

AUSTRALIAN BUREAU OF STATISTICS 2015. National Health Survey: First Results, 2014-15 - 4364.0.55.001.

AUSTRALIAN GOVERNMENT DEPARTMENT OF HEALTH 2009. Prevalence of mental disorders in the Australian population. *(accessed 28 September 2019). Available online: https://www1.health.gov.au/internet/publications/publishing.nsf/Content/mental-pubs-m-mhaust2-toc~mental-pubs-m-mhaust2-hig~mental-pubs-m-mhaust2-hig-pre*.

AUSTRALIAN GOVERNMENT DEPARTMENT OF HEALTH 2019. Australia's physical activity & sedentary behaviour guidelines for adults (18-64 years). *(accessed July 2020). Available online: https://www1.health.gov.au/internet/main/publishing.nsf/Content/health-pubhlth-strateg-phys-act-guidelines#npa1864*.

AYLETT, E., SMALL, N. & BOWER, P. 2018. Exercise in the treatment of clinical anxiety in general practice – a systematic review and meta-analysis. *BMC Health Serv Res,* 18**,** 559.

BAILEY, A. P., HETRICK, S. E., ROSENBAUM, S., PURCELL, R. & PARKER, A. G. 2018. Treating depression with physical activity in adolescents and young adults: A systematic review and meta-analysis of randomised controlled trials. *Psychol Med,* 48**,** 1068-83.

BAVISHI, A., SLADE, M. D. & LEVY, B. R. 2016. A chapter a day: Association of book reading with longevity. *Soc Sci Med,* 164**,** 44-48.

BERNARD, P., DORE, I., ROMAIN, A. J., HAINS-MONFETTE, G., KINGSBURY, C. & SABISTON, C. 2018. Dose response association of objective physical activity with mental health in a representative national sample of adults: A cross-sectional study. *PLoS One,* 13**,** e0204682.

BLANNER KRISTIANSEN, C., JUEL, A., VINTHER HANSEN, M., HANSEN, A. M., KILIAN, R. & HJORTH, P. 2015. Promoting physical health in severe mental illness: patient and staff perspective. *Acta Psychiatr Scand,* 132**,** 470-8.

BUCKLEY, J. P., HEDGE, A., YATES, T., COPELAND, R. J., LOOSEMORE, M., HAMER, M., BRADLEY, G. & DUNSTAN, D. W. 2015. The sedentary office: an expert statement on the growing case for change towards better health and productivity. *Br J Sports Med,* 49**,** 1357-62.

CARSON, V., HUNTER, S., KUZIK, N., GRAY, C. E., POITRAS, V. J., CHAPUT, J. P., SAUNDERS, T. J., KATZMARZYK, P. T., OKELY, A. D., CONNOR GORBER, S., KHO, M. E., SAMPSON, M., LEE, H. & TREMBLAY, M. S. 2016. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab,* 41**,** S240-65.

CASPERSEN, C. J., POWELL, K. E. & CHRISTENSON, G. M. 1985. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep,* 100**,** 126-31.
CELIK INCE, S., PARTLAK GUNUSEN, N. & SERCE, O. 2018. The opinions of Turkish mental health nurses on physical health care for individuals with mental illness: A qualitative study. *J Psychiatr Ment Health Nurs,* 25**,** 245-257.
CHAU, J. Y., GRUNSEIT, A. C., CHEY, T., STAMATAKIS, E., BROWN, W. J., MATTHEWS, C. E., BAUMAN, A. E. & VAN DER PLOEG, H. P. 2013. Daily sitting time and all-cause mortality: a meta-analysis. *PLoS One,* 8**,** e80000.
CHEKROUD, S. R., GUEORGUIEVA, R., ZHEUTLIN, A. B., PAULUS, M., KRUMHOLZ, H. M., KRYSTAL, J. H. & CHEKROUD, A. M. 2018. Association between physical exercise and mental health in 1·2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *Lancet Psychiatry,* 5**,** 739-746.
COMMONWEALTH OF AUSTRALIA 2017. The fifth national mental health and suicide prevention plan. Canberra, Australia: Australian Government.
COONEY, G. M., DWAN, K., GREIG, C. A., LAWLOR, D. A., RIMER, J., WAUGH, F. R., MCMURDO, M. & MEAD, G. E. 2013. Exercise for depression. *Cochrane Database Syst Rev***,** CD004366.
DE HERT, M., CORRELL, C. U., BOBES, J., CETKOVICH-BAKMAS, M., COHEN, D., ASAI, I., DETRAUX, J., GAUTAM, S., MOLLER, H. J., NDETEI, D. M., NEWCOMER, J. W., UWAKWE, R. & LEUCHT, S. 2011. Physical illness in patients with severe mental disorders. I. Prevalence, impact of medications and disparities in health care. *World Psychiatry,* 10**,** 52-77.
DE REZENDE, L. F., RODRIGUES LOPES, M., REY-LOPEZ, J. P., MATSUDO, V. K. & LUIZ ODO, C. 2014. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One,* 9**,** e105620.
EDDOLLS, W. T. B., MCNARRY, M. A., LESTER, L., WINN, C. O. N., STRATTON, G. & MACKINTOSH, K. A. 2018. The association between physical activity, fitness and body mass index on mental well-being and quality of life in adolescents. *Qual Life Res,* 27**,** 2313-2320.
EKELUND, U., STEENE-JOHANNESSEN, J., BROWN, W. J., FAGERLAND, M. W., OWEN, N., POWELL, K. E., BAUMAN, A., LEE, I. M., LANCET PHYSICAL ACTIVITY SERIES 2 EXECUTIVE, C. & LANCET SEDENTARY BEHAVIOUR WORKING, G. 2016. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet,* 388**,** 1302-10.
EKKEKAKIS, P. 2015. Honey, I shrunk the pooled SMD! Guide to critical appraisal of systematic reviews and meta-analyses using the Cochrane review on exercise for depression as example. *Ment Health Phys Act,* 8**,** 21-36.
ELLEY, C. R., KERSE, N., ARROLL, B. & ROBINSON, E. 2003. Effectiveness of counselling patients on physical activity in general practice: cluster randomised controlled trial. *BMJ,* 326**,** 793.
ELLINGSON, L. D., MEYER, J. D., SHOOK, R. P., DIXON, P. M., HAND, G. A., WIRTH, M. D., PALUCH, A. E., BURGESS, S., HEBERT, J. R. & BLAIR, S. N. 2018. Changes in sedentary time are associated with changes in mental wellbeing over 1year in young adults. *Prev Med Rep,* 11**,** 274-281.

EWART, S. B., BOCKING, J., HAPPELL, B., PLATANIA-PHUNG, C. & STANTON, R. 2016. Mental health consumer experiences and strategies when seeking physical health care: A focus group study. *Glob Qual Nurs Res,* 3**,** 2333393616631679.

FELIPE B. SCHUCH, PH.D. „ DAVY VANCAMPFORT, PH.D. „ JOSEPH FIRTH, PH.D. „ SIMON ROSENBAUM, PH.D. „ PHILIP B. WARD, PH.D. „ EDSON S. SILVA, B.SC. „ MATS HALLGREN, PH.D. „ ANTONIO PONCE DE LEON, PH.D. „ ANDREA L. DUNN, PH.D. „ ANDREA C. DESLANDES, PH.D. „ MARCELO P. FLECK, PH.D. „ ANDRE F. CARVALHO, PH.D. , & BRENDON STUBBS, PH.D. 2018. Physical activity and incident depression: A meta-analysis of prospective cohort studies. *Am J Psychiatry,* 175**,** 631-648.

FIBBINS, H., WARD, P. B., CURTIS, J., WATKINS, A., LEDERMAN, O., MORELL, R. & ROSENBAUM, S. 2020. Effectiveness of a brief lifestyle intervention targeting mental health staff: analysis of physical fitness and activity in the Keeping Our Staff in Mind study. *BMJ Open Sport Exerc Med,* 6**,** e000761.

FIBBINS, H., WARD, P. B., WATKINS, A., CURTIS, J. & ROSENBAUM, S. 2018. Improving the health of mental health staff through exercise interventions: a systematic review. *J Ment Health,* 27**,** 184-191.

FIRTH, J., COTTER, J., ELLIOTT, R., FRENCH, P. & YUNG, A. R. 2015. A systematic review and meta-analysis of exercise interventions in schizophrenia patients. *Psychol Med,* 45**,** 1343-61.

FIRTH, J., ROSENBAUM, S., STUBBS, B., GORCZYNSKI, P., YUNG, A. R. & VANCAMPFORT, D. 2016. Motivating factors and barriers towards exercise in severe mental illness: a systematic review and meta-analysis. *Psychol Med,* 46**,** 2869-2881.

FIRTH, J., SIDDIQI, N., KOYANAGI, A., SISKIND, D., ROSENBAUM, S., GALLETLY, C., ALLAN, S., CANEO, C., CARNEY, R., CARVALHO, A. F., CHATTERTON, M. L., CORRELL, C. U., CURTIS, J., GAUGHRAN, F., HEALD, A., HOARE, E., JACKSON, S. E., KISELY, S., LOVELL, K., MAJ, M., MCGORRY, P. D., MIHALOPOULOS, C., MYLES, H., O'DONOGHUE, B., PILLINGER, T., SARRIS, J., SCHUCH, F. B., SHIERS, D., SMITH, L., SOLMI, M., SUETANI, S., TAYLOR, J., TEASDALE, S. B., THORNICROFT, G., TOROUS, J., USHERWOOD, T., VANCAMPFORT, D., VERONESE, N., WARD, P. B., YUNG, A. R., KILLACKEY, E. & STUBBS, B. 2019. The Lancet Psychiatry Commission: a blueprint for protecting physical health in people with mental illness. *The Lancet Psychiatry,* 6**,** 675-712.

FORD, E. S. & CASPERSEN, C. J. 2012. Sedentary behaviour and cardiovascular disease: a review of prospective studies. *Int J Epidemiol,* 41**,** 1338-53.

FRASER, S. J., BROWN, W. J., WHITEFORD, H. A. & BURTON, N. W. 2018. Impact of nurse-led behavioural counselling to improve metabolic health and physical activity among adults with mental illness. *Int J Ment Health Nurs,* 27**,** 619-630.

GALDERISI, S., HEINZ, A., KASTRUP, M., BEEZHOLD, J. & SARTORIUS, N. 2015. Toward a new definition of mental health. *World Psychiatry,* 14**,** 231-3.

GOMES, G., BISETTO, L., PAIXAO, A., COELHO, M., CATARINO, C., FORMENTON, N., GRAMANI-SAY, K. & MININEL, V. 2019. Effects of a coaching intervention about physical activity among health professional in primary care settings: a randomized controlled trial. *J Sci Med Sport,* 22**,** S84.

GOODWIN, R. D. 2003. Association between physical activity and mental disorders among adults in the United States. *Prev Med,* 36**,** 698-703.

GRAY, R. & BROWN, E. 2017. What does mental health nursing contribute to improving the physical health of service users with severe mental illness? A thematic analysis. *Int J Ment Health Nurs,* 26**,** 32-40.

GUTHOLD, R., STEVENS, G. A., RILEY, L. M. & BULL, F. C. 2018a. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Glob Health,* 6**,** e1077-86.

GUTHOLD, R., STEVENS, G. A., RILEY, L. M. & BULL, F. C. 2018b. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health,* 6**,** e1077-e1086.

HAPPELL, B., EWART, S. B., BOCKING, J., PLATANIA-PHUNG, C. & STANTON, R. 2016. 'That red flag on your file': misinterpreting physical symptoms as mental illness. *J Clin Nurs,* 25**,** 2933-42.

HARRIS, M. A. 2018. The relationship between physical inactivity and mental wellbeing: Findings from a gamification-based community-wide physical activity intervention. *Health Psychol Open,* 5**,** 2055102917753853.

HARVEY, S. B., OVERLAND, S., HATCH, S. L., WESSELY, S., MYKLETUN, A. & HOTOPF, M. 2018. Exercise and the prevention of depression: Results of the HUNT cohort study. *Am J Psychiatry,* 175**,** 28-36.

HEALY, G. N., WINKLER, E. A., OWEN, N., ANURADHA, S. & DUNSTAN, D. W. 2015. Replacing sitting time with standing or stepping: associations with cardio-metabolic risk biomarkers. *Eur Heart J,* 36**,** 2643-9.

HEBERT, E. T., CAUGHY, M. O. & SHUVAL, K. 2012. Primary care providers' perceptions of physical activity counselling in a clinical setting: a systematic review. *Br J Sports Med,* 46**,** 625-31.

HIPPISLEY-COX, J. & PRINGLE, M. 2005. Health inequalities experienced by people with schizophrenia and manic depression: Analysis of general practice data in England and Wales. DRC, London.

HOLT, R. & PEVELER, R. 2010. Diabetes and cardiovascular risk in severe mental illness: a missed opportunity and challenge for the future. *Practical Diabetes International,* 27**,** 79-84ii.

HOWARD, L. & GAMBLE, C. 2011. Supporting mental health nurses to address the physical health needs of people with serious mental illness in acute inpatient care settings. *J Psychiatr Ment Health Nurs,* 18**,** 105-12.

IHME 2016 Institute for Health Metrics and Evaluation. Global Burden of Disease United States: University of Washington. *(accessed 26 July 2020); Available online:* https://vizhub.healthdata.org/gbd-compare/. .

JINKS, A. M., LAWSON, V. & DANIELS, R. 2003. A survey of the health needs of hospital staff: implications for health care managers. *J Nurs Manag,* 11**,** 343-50.

KOHL, H. W., 3RD, CRAIG, C. L., LAMBERT, E. V., INOUE, S., ALKANDARI, J. R., LEETONGIN, G., KAHLMEIER, S. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. The pandemic of physical inactivity: global action for public health. *Lancet,* 380**,** 294-305.

KVAM, S., KLEPPE, C. L., NORDHUS, I. H. & HOVLAND, A. 2016. Exercise as a treatment for depression: A meta-analysis. *J Affect Disord,* 202**,** 67-86.

LE MASURIER, G. C., SIDMAN, C. L. & CORBIN, C. B. 2003. Accumulating 10,000 steps: does this meet current physical activity guidelines? *Res Q Exerc Sport,* 74**,** 389-94.

LEE, I. M., SHIROMA, E. J., LOBELO, F., PUSKA, P., BLAIR, S. N., KATZMARZYK, P. T. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet,* 380**,** 219-29.

LETVAK, S., RUHM, C. & LANE, S. 2011. The impact of nurses' health on productivity and quality of care. *JONA: The J Nurs Admin,* 41.

LOVE, R., ADAMS, J., VAN SLUIJS, E. M. F., FOSTER, C. & HUMPHREYS, D. 2018. A cumulative meta-analysis of the effects of individual physical activity interventions targeting healthy adults. *Obes Rev,* 19**,** 1164-1172.

MALIK, S., BLAKE, H. & BATT, M. 2011. How healthy are our nurses? New and registered nurses compared. *Br J Nurs,* 20**,** 489-96.

MO, P. K., BLAKE, H. & BATT, M. E. 2011. Getting healthcare staff more active: the mediating role of self-efficacy. *Br J Health Psychol,* 16**,** 690-706.

NG, S. W. & POPKIN, B. M. 2012. Time use and physical activity: a shift away from movement across the globe. *Obes Rev,* 13**,** 659-80.

ORROW, G., KINMONTH, A. L., SANDERSON, S. & SUTTON, S. 2012. Effectiveness of physical activity promotion based in primary care: systematic review and meta-analysis of randomised controlled trials. *BMJ,* 344**,** e1389.

OWEN, N., SUGIYAMA, T., EAKIN, E. E., GARDINER, P. A., TREMBLAY, M. S. & SALLIS, J. F. 2011. Adults' sedentary behavior determinants and interventions. *Am J Prev Med,* 41**,** 189-96.

OWOEYE, O., TOMORI, A. & AKINBO, S. 2016. Pedometer-determined physical activity profile of healthcare professionals in a Nigerian tertiary hospital. *Niger Med J,* 57**,** 99-103.

PATE, R. R., PRATT, M., BLAIR, S. N., HASKELL, W. L., MACERA, C. A., BOUCHARD, C., BUCHNER, D., ETTINGER, W., HEATH, G. W., KING, A. C. & ET AL. 1995. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA,* 273**,** 402-7.

PATEL, A. V., BERNSTEIN, L., DEKA, A., FEIGELSON, H. S., CAMPBELL, P. T., GAPSTUR, S. M., COLDITZ, G. A. & THUN, M. J. 2010. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. *Am J Epidemiol,* 172**,** 419-29.

PEDIŠIĆ, Ž., DUMUID, D. & OLDS, T. 2017. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology,* 49**,** 252-69.

REZENDE, L. F., SA, T. H., MIELKE, G. I., VISCONDI, J. Y., REY-LOPEZ, J. P. & GARCIA, L. M. 2016. All-Cause Mortality Attributable to Sitting Time: Analysis of 54 Countries Worldwide. *Am J Prev Med,* 51**,** 253-63.

ROSENBAUM, S., WATKINS, A., WARD, P. B., PEARCE, D., FITZPATRICK, K., CURTIS, J. & KEEPING THE BODY IN MIND TEAM, S. 2016. Psychiatry HeAL thyself! *Aust N Z J Psychiatry,* 50**,** 600.

RYE, P. L., REESON, M. E., PEKRUL, C. M., ASFOUR, N. A., KUNDAPUR, R., WILSON, M. P., PAUSJENSSEN, A. M. & WILSON, T. W. 2012. Comparing health behaviours of internal medicine residents and medical students: an observational study. *Clin Invest Med,* 35**,** E40-4.

SARAFIS, P., ROUSAKI, E., TSOUNIS, A., MALLIAROU, M., LAHANA, L., BAMIDIS, P., NIAKAS, D. & PAPASTAVROU, E. 2016. The impact of occupational stress on nurses' caring behaviors and their health related quality of life. *BMC Nurs,* 15**,** 56.

SARIDI, M., FILIPPOPOULOU, T., TZITZIKOS, G., SARAFIS, P., SOULIOTIS, K. & KARAKATSANI, D. 2019. Correlating physical activity and quality of life of healthcare workers. *BMC Res Notes,* 12**,** 208.

SCHUCH, F. B., STUBBS, B., MEYER, J., HEISSEL, A., ZECH, P., VANCAMPFORT, D., ROSENBAUM, S., DEENIK, J., FIRTH, J., WARD, P. B., CARVALHO, A. F. & HILES, S. A. 2019. Physical activity protects from incident anxiety: A meta-analysis of prospective cohort studies. *Depression and Anxiety,* 36**,** 846-858.

SCHUCH, F. B., VANCAMPFORT, D., RICHARDS, J., ROSENBAUM, S., WARD, P. B. & STUBBS, B. 2016. Exercise as a treatment for depression: A meta-analysis adjusting for publication bias. *J Psychiatr Res,* 77**,** 42-51.

SCOTT, D., BURKE, K., WILLIAMS, S., HAPPELL, B., CANOY, D. & RONAN, K. 2012. Increased prevalence of chronic physical health disorders in Australians with diagnosed mental illness. *Aust N Z J Public Health,* 36**,** 483-6.

SLOAN, R. A., SAWADA, S. S., GIRDANO, D., LIU, Y. T., BIDDLE, S. J. & BLAIR, S. N. 2013. Associations of sedentary behavior and physical activity with psychological distress: a cross-sectional study from Singapore. *BMC Public Health,* 13**,** 885.

STAMATAKIS, E., GALE, J., BAUMAN, A., EKELUND, U., HAMER, M. & DING, D. 2019. Sitting time, physical activity, and risk of mortality in adults. *J Am Coll Cardiol,* 73**,** 2062-2072.

STANTON, R., ROSENBAUM, S., REBAR, A. & HAPPELL, B. 2019. Prevalence of chronic health conditions in Australian adults with depression and/or anxiety. *Issues Ment Health Nurs***,** 1-6.

STUBBS, B., FIRTH, J., BERRY, A., SCHUCH, F. B., ROSENBAUM, S., GAUGHRAN, F., VERONESSE, N., WILLIAMS, J., CRAIG, T., YUNG, A. R. & VANCAMPFORT, D. 2016a. How much physical activity do people with schizophrenia engage in? A systematic review, comparative meta-analysis and meta-regression. *Schizophr Res,* 176**,** 431-440.

STUBBS, B., WILLIAMS, J., GAUGHRAN, F. & CRAIG, T. 2016b. How sedentary are people with psychosis? A systematic review and meta-analysis. *Schizophr Res,* 171**,** 103-9.

STULTS-KOLEHMAINEN, M. A. & SINHA, R. 2014. The effects of stress on physical activity and exercise. *Sports Med,* 44**,** 81-121.

SUGIYAMA, T., WIJNDAELE, K., KOOHSARI, M. J., TANAMAS, S. K., DUNSTAN, D. W. & OWEN, N. 2016. Adverse associations of car time with markers of cardio-metabolic risk. *Prev Med,* 83**,** 26-30.

TAMMINEN, N., REINIKAINEN, J., APPELQVIST-SCHMIDLECHNER, K., BORODULIN, K., MÄKI-OPAS, T. & SOLIN, P. 2020. Associations of physical activity with positive mental health: A population-based study. *Ment Health Phys Act,* 18**,** 100319.

TANAMAS, S. K., MAGLIANO, D. J., LYNCH, B., SETHI, P., WILLENBERG, L., POLKINGHORNE, K. R., CHADBAN, S., DUNSTAN, D. & J.E., S. 2013. AusDiab 2012. The Australian diabetes, obesity and lifestyle study. Baker IDI Heart and Diabetes Institute, Melbourne. *(accessed 20 July 2020). Available online:* https://www.baker.edu.au/research/laboratories/clinical-diabetes/project-ausdiab.

TEN HAVE, M., DE GRAAF, R. & MONSHOUWER, K. 2011. Physical exercise in adults and mental health status findings from the Netherlands mental health survey and incidence study (NEMESIS). *J Psychosom Res,* 71**,** 342-8.
TEREBESSY, A., MATYASOVSZKY, M., HORVATH, F., HOROSZ, A., JUHASZ, I. & GYORFFY, Z. 2016. The role of physical activity in health promotion of healthcare workers. *Orv Hetil,* 157**,** 1563-1570.
TERRY, J. & CUTTER, J. 2013. Does education improve mental health practitioners' confidence in meeting the physical health needs of mental health service users? A mixed methods pilot study. *Issues Ment Health Nurs,* 34**,** 249-55.
TEYCHENNE, M., BALL, K. & SALMON, J. 2010. Sedentary behavior and depression among adults: a review. *Int J Behav Med,* 17**,** 246-54.
TEYCHENNE, M., COSTIGAN, S. A. & PARKER, K. 2015. The association between sedentary behaviour and risk of anxiety: a systematic review. *BMC Public Health,* 15**,** 513.
TIIHONEN, J., LONNQVIST, J., WAHLBECK, K., KLAUKKA, T., NISKANEN, L., TANSKANEN, A. & HAUKKA, J. 2009. 11-year follow-up of mortality in patients with schizophrenia: a population-based cohort study (FIN11 study). *Lancet,* 374**,** 620-7.
TUCKER, S., FARRINGTON, M., LANNINGHAM-FOSTER, L. M., CLARK, M. K., DAWSON, C., QUINN, G. J., LAFFOON, T. & PERKHOUNKOVA, Y. 2016. Worksite physical activity intervention for ambulatory clinic nursing staff. *Workplace Health Saf,* 64**,** 313-25.
VANCAMPFORT, D., FIRTH, J., SCHUCH, F. B., ROSENBAUM, S., MUGISHA, J., HALLGREN, M., PROBST, M., WARD, P. B., GAUGHRAN, F., DE HERT, M., CARVALHO, A. F. & STUBBS, B. 2017. Sedentary behavior and physical activity levels in people with schizophrenia, bipolar disorder and major depressive disorder: a global systematic review and meta-analysis. *World Psychiatry,* 16**,** 308-315.
VANKIM, N. A. & NELSON, T. F. 2013. Vigorous physical activity, mental health, perceived stress, and socializing among college students. *Am J Health Promot,* 28**,** 7-15.
VIGO, D., THORNICROFT, G. & ATUN, R. 2016. Estimating the true global burden of mental illness. *The Lancet Psychiatry,* 3**,** 171-178.
WHO 2018a. World Health Organization. Mental health: strengthening our response. . *(accessed 26 July 2020). Available online: https://www.who.int/news-room/fact-sheets/detail/mental-health-strengthening-our-response*.
WHO 2018b. World Health Organization. Physical activity key facts. *(accessed 20 September 2019). Available online: https://www.who.int/news-room/fact-sheets/detail/physical-activity*.

Chapter 3: Methodology and Conceptual Framework

Chapter outline: This chapter discusses the frameworks that are used in this PhD thesis: the ecological framework (Sallis et al., 2006, Stokols, 1992), the theory of planned behaviour (TPB) (Ajzen, 1991), and the VIRTUE framework (Pedišić et al., 2017).

3.1 Ecological framework

Recognising the impact of environmental settings on health outcomes, Stokols et al. (1992) proposed the ecological concept of health promotion. It emphasises the multiple level factors that shapes individual's behaviour that should be addressed for health promotion (Stokols, 1992). Thus, the ecological model focuses on the interplay between individual's characteristics (e.g. sex, beliefs, and attitudes), social environmental (friends, family, colleagues) and physical environmental (e.g. availability of equipment and facilities) (Stokols, 1992).

Before the 1990s, PA research was limited to leisure-time or recreational PA. However, interest from other disciplines such as planners and designers from transportation and urban planning industries soon led the public health researchers to acknowledge the significance of other domains of PA (Sallis et al., 2006). The frameworks that were used in PA research only targeted individuals or small groups. Hence, the gap in transdisciplinary approaches targeting individuals, environments, social support, and policies necessitated the introduction of ecological framework in PA research (Sallis et al., 2006). According to ecological models, the successful strategies for increasing PA and reducing SB include:

a) Creating infrastructure that promotes PA and discourages SB (e.g., urban design with easy access to parks and high safety for pedestrians and cyclists;

b) Increasing awareness and understanding of the need to increase PA and reduce SB;

c) Using social networks and organisational support to inform changes in policies and norms related to PA and SB (Sallis et al., 2006).

The ecological framework considers PA behaviour of a person is shaped by multiple factors that interact directly and indirectly spanning from the individual to environment and social policy. It is inappropriate to assume a person would modify his/her activity behaviour without considering the impacts of social support and built environment (Rhodes et al., 2018).

Based on this, for the purpose of Studies 1 and 2 (Chapter 5 and 6), we categorised different interventions that might be effective (in isolation or conjunction with each other) in reducing SB into three broad strategies (Figure 1).

a. Environmental changes
    - At the workplace: Provision of sit-stand desks, placing printers away from the desk;
    - Outside of work: removing chairs/sofas from the TV area; placing the computer screen at standing height; using TV control devices to restrict TV viewing time.
b. Policy changes

- At the workplace: formation of walking or exercise groups at the workplace; or organising walking/standing meetings;
- Outside of work: devising active-commuting options better accessible, safe, and more attractive.

c. Provision of information and counselling
    - At the workplace: using signs or prompts at the workplace (e.g., posters) or at the workstation (e.g., on a work computer); implementing e-health interventions; providing counselling (e.g., face-to-face or telephone)
    - Outside of work: using signs or prompts on personal computers and TVs; implementing e-health interventions; providing counselling.

3.2 Theory of planned behaviour

The complex nature of human behaviour is difficult to explain. In an attempt to explain human behaviour, Icek Ajzen proposed the theory of planned behaviour in 1985 in his article "From intentions to actions: A theory of planned behaviour" (Ajzen, 1991). This theory of planned behaviour was built on his earlier work, the theory of reasoned action (Hill et al., 1977). According to this theory, if people judge behaviour as positive (attitude), and if they consider their significant others want them to act in a certain way (subjective norm), it motivates them to perform the behaviour. It also suggests that if people are confident enough to perform a behaviour, then they will have a higher intention to execute that behaviour (perceived behavioural control) (Ajzen, 1991).

In this perspective, an individual's intention to spend time in PA is the proximal determinant of PA. The proximal determinants of intention are attitudes, subjective norms, and perceived behavioural control. Attitude represents what an individual thinks of benefits or harms of being physically active or sedentary; subjective norms reflect what an individual perceives regarding other's views on PA and SB and whether they wish to comply or agree with such views, and their perception on degree of control over the time they spend being physically active (or sedentary) which determine perceived behavioural control.

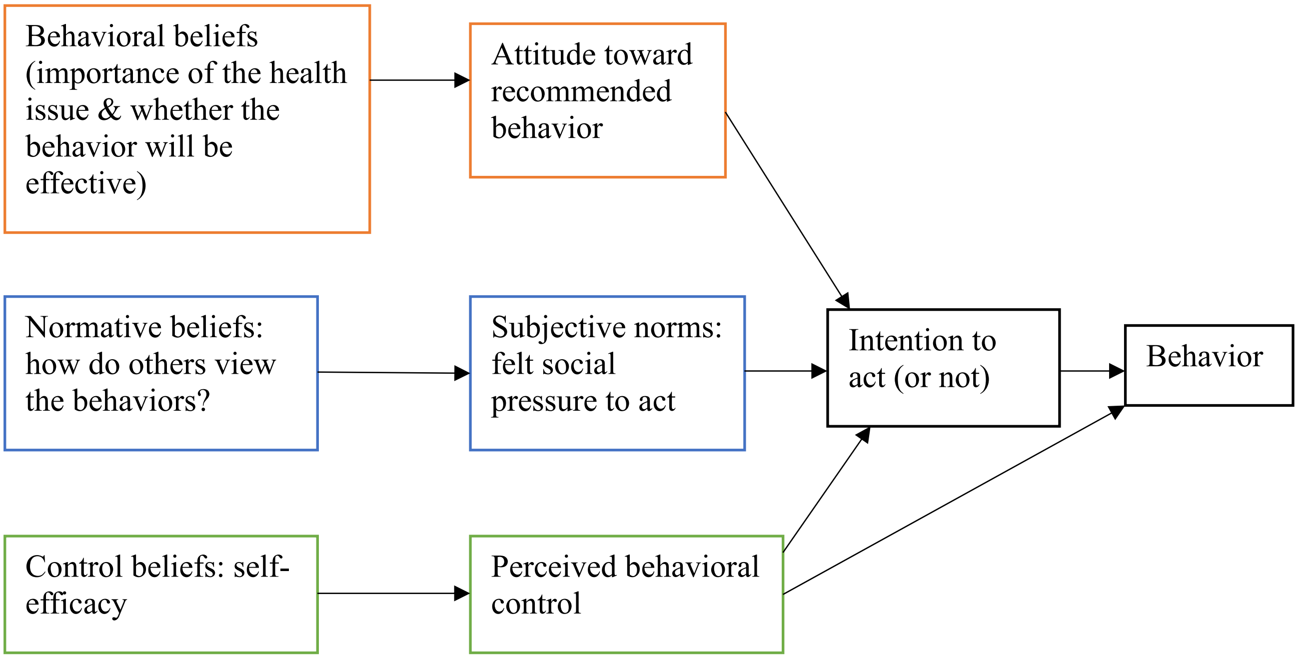

Figure 1: The framework for the Theory of planned behavior (Ajzen, 1991)

The TPB draws on persuasive techniques to modify individuals' beliefs and attitudes in line with the target behaviour. It has been applied in a variety of settings in PA research such as clinical settings (Latimer et al., 2006), schools (Chatzisarantis and Hagger, 2005), and the workplace (Bardus, 2014, Shafieinia et al., 2016). The application of theory to PA intervention enables one to systematically evaluate the factors that lead to or mediate changes in behaviour, and thus helps to identify the components of interventions that were effective in changing the behaviour (Michie and Abraham, 2004). Downs and Hausenblas (2005) reviewed exercise intervention studies based on the TPB and found exercise behaviour to be significantly related to all the TPB constructs, except for subjective norm. Steinmetz et al. (2016) reviewed 82 articles that assessed 123 TPB-based behaviour change interventions for seven different behaviour domains and found that PA interventions had the strongest and the most consistent effect on all TPB variables. Although very popular in health promotion, TPB is not universally accepted and critics have questioned its validity and utility (Sniehotta et al., 2014). It has been argued that TPB has failed to explain the change in each and every behaviour, for example for some behaviours, attitudes and perceived behavioural control have a stronger influence on intentions and for others, subjective norms are a stronger influence (Ajzen, 2015). Despite these limitations, the theory has still demonstrated efficiency in explaining a wide spectrum of behaviours (McEachan et al., 2011).

The intervention developed and evaluated in Study 4 (Chapter 10) is grounded in the theory of planned behaviour. It addresses proximal determinants of PA and SB. The intervention aims to make a positive change in attitudes towards PA and SB through group counselling. To affect participants' subjective norms, group discussion was encouraged to facilitate the exchange of participants' thoughts on PA and SB, in addition to receiving positive feedback from the researchers. To influence their perceived behavioural control, participants set their goals at the beginning of the intervention and received reminder texts/calls during the intervention.

Even though people are aware of the adverse effects of physical inactivity and/or SB, yet they do not engage in sufficient PA and instead spend a lot of time in SBs. It is thus clear that for modifying habitual behaviour like physical inactivity, knowledge alone is insufficient and requires additional strategies to reinforce and sustain the behavioural change. Provision of information on PA and/or SB is useful in initiating change in behaviour, however, additional strategies like individually tailored goal setting and action planning are required to sustain change in established behaviours.

Table 2: Determinants, theoretical methods and strategies for increasing physical activity and reducing sedentary behaviour

Determinants of SB and PA	**Method according to the TPB framework**	**Intervention strategies**
Attitude	Self-regulation	Group counseling
Subjective norms	Mobilizing social support	Group counseling and facilitation for group email conversation on the benefits of PA Positive feedback and weekly reminders from researchers
Perceived behavioural control	Goal setting/ reinforcement	Counseling session: worksheets to help extract planning goals (when, where, with whom) Reminder calls/text

TPB = Theory of planned behaviour, PA = PA

3.3 Time-use epidemiology and VIRTUE framework

The various components of time use across 24-hour day, i.e., SB, sleep, and PA has been demonstrated to be associated with health. The unhealthy lifestyle behaviours such as low levels of PA, excessive time spent in SB, and inappropriate sleep duration are associated with cardiometabolic disease, all-cause mortality, and site-specific cancer (Cappuccio et al., 2011, Cappuccio et al., 2010b, Cappuccio et al., 2010a, de Rezende et al., 2014, Blake et al., 2012). These lifestyle behaviours were thought to be independent health risk factors and were previously investigated in isolation, failing to take into account co-dependency with the remaining movement-related behaviours.

In 2007, Tremblay and colleagues started a new discourse in PA research when they suggested public health guidelines should recommend a balanced distribution of time between sleep, physical inactivity, and PA for a healthy life (Tremblay et al., 2007). Later Mekary et al. (2009) proposed an isotemporal substitution model to investigate how the reallocation of time between PA and SB is associated with weight change. This model was extensively used to study the association of time re-allocations between sleep, SB, and PA with various health outcomes (Boyle et al., 2017, Buman et al., 2014, Huang et al., 2016, Stamatakis et al., 2015, Vallance et al., 2017, Grgic et al., 2018). However, this isotemporal substitution model did not address the true compositional nature of time-use data. The time spent in SB, PA and sleeping should be interpreted as proportions of a 24-hour day or any other unit of time. The proportions of time spent in these behaviours vary between people but always sum up to 1, i.e., 100% for each person (Pedišić et al., 2017). The amounts of time spent in sleeping, in SB, and in PA are mutually exclusive and exhaustive components of the 24-hour day. None of the above-mentioned behaviours can be changed independently, without changing one or more of the remaining behaviours (Pedišić et al., 2017). The failure of previous models to acknowledge the compositional nature of time use led Pedišić et al. (2017) to propose the VIRTUE framework (Figure 3). This framework recognises the finite 24 hours in a day, and that the distribution of time spent in SB, sleep, and PA is associated with several health outcomes, such as cardiometabolic disease, site-specific cancer, and all-cause mortality (Chastin et al., 2015, Carson et al., 2016, Dumuid et al., 2017, Fairclough et al., 2017). Moreover, overweight and obese adults were found to have a combination of unhealthy lifestyle behaviours including physical inactivity, excessive TV viewing, and poor sleep duration (Cassidy et al., 2017). The VIRTUE framework states that we should aim for attaining a sustainable optimal balance in all these time-use components, and that focusing on a single component of a time-use composition without taking into account its co-dependency with the remaining components may lead to erroneous results. It defines five research areas: 1) methods in time-use epidemiology; 2) outcomes of health-related components of time use; 3) prevalence of the optimal time-use balance; 4) determinants of health-related components of time use and; 5) time-use interventions.

There is a lack of intervention trials that aimed to increase PA or reduce SB among the participants, while taking into account to which movement or non-movement behaviour was the time reallocated. This may have significant methodological and interpretational implications. Study 4 assessed the effects of an intervention on SB and PA, while acknowledging these behaviours are co-dependent parts of a 24-hour movement-related time-use composition. Study 4, therefore, fits within the fifth area of the VIRTUE framework (Pedišić et al., 2017).

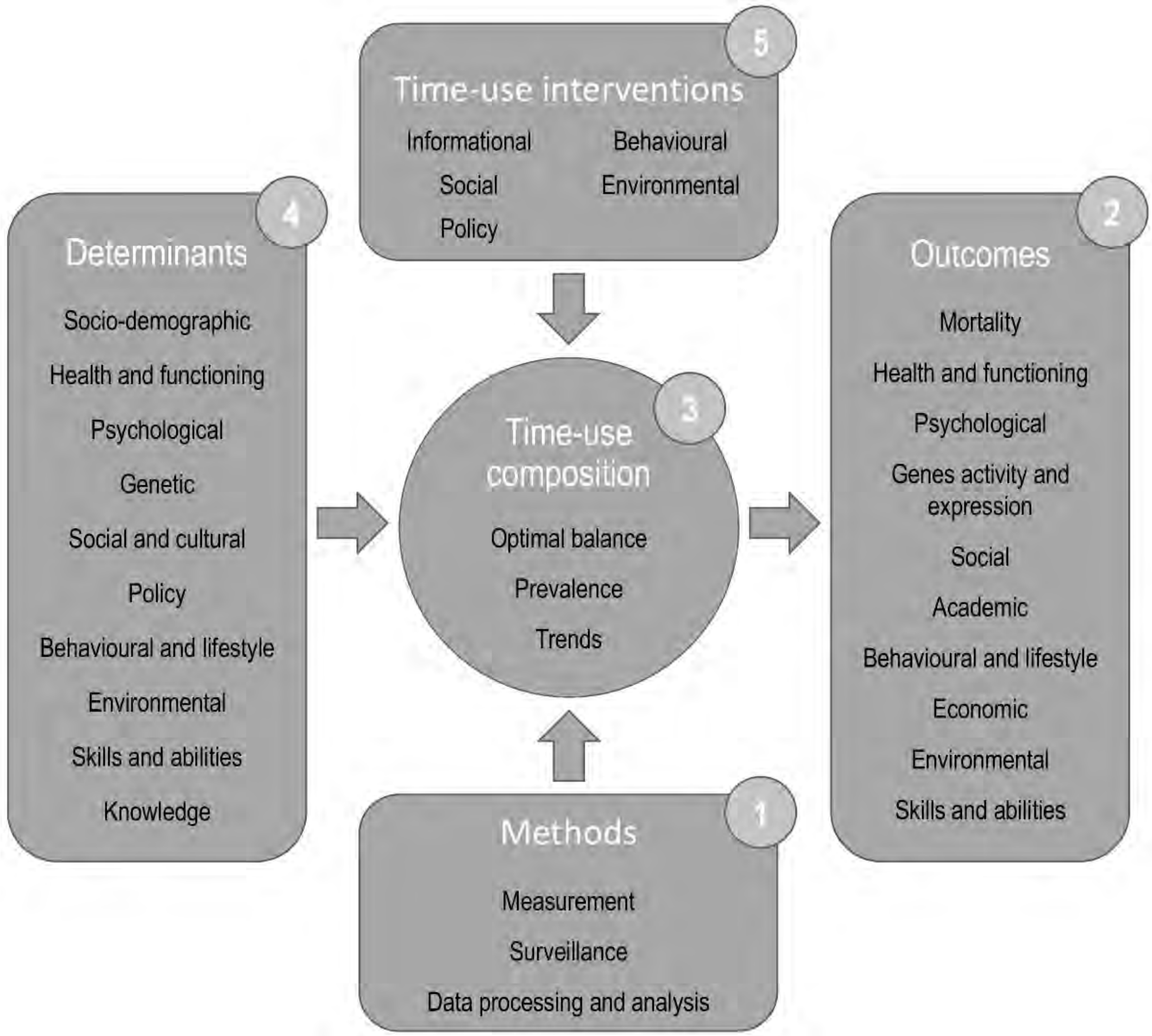

Figure 2: The framework for Viable Integrative Research in Time-Use-Epidemiology (VIRTUE framework)

(Taken with permission from Pedišić et al. (2017))

References

AJZEN, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50**,** 179-211.

AJZEN, I. 2015. The theory of planned behaviour is alive and well, and not ready to retire: a commentary on Sniehotta, Presseau, and Araújo-Soares. *Health Psychol Rev,* 9**,** 131-137.

BARDUS, M. 2014. Reasons for participating and not participating in a e-health workplace physical activity intervention. *Int J Workplace Health Manag,* 7**,** 229-246.

BLAKE, H., MO, P. K., LEE, S. & BATT, M. E. 2012. Health in the NHS: lifestyle behaviours of hospital employees. *Perspect Public Health,* 132**,** 213-5.

BOYLE, T., VALLANCE, J. K., BUMAN, M. P. & LYNCH, B. M. 2017. Reallocating time to sleep, sedentary time, or physical activity: Associations with waist circumference and body mass index in breast cancer survivors. *Cancer Epidemiol Biomarkers Prev,* 26**,** 254-260.

BUMAN, M. P., WINKLER, E. A., KURKA, J. M., HEKLER, E. B., BALDWIN, C. M., OWEN, N., AINSWORTH, B. E., HEALY, G. N. & GARDINER, P. A. 2014. Reallocating time to sleep, sedentary behaviors, or active behaviors: associations with cardiovascular disease risk biomarkers, NHANES 2005-2006. *Am J Epidemiol,* 179**,** 323-34.

CAPPUCCIO, F. P., COOPER, D., D'ELIA, L., STRAZZULLO, P. & MILLER, M. A. 2011. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. *Eur Heart J,* 32**,** 1484-92.

CAPPUCCIO, F. P., D'ELIA, L., STRAZZULLO, P. & MILLER, M. A. 2010a. Quantity and quality of sleep and incidence of type 2 diabetes: a systematic review and meta-analysis. *Diab Care,* 33**,** 414-20.

CAPPUCCIO, F. P., D'ELIA, L., STRAZZULLO, P. & MILLER, M. A. 2010b. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep,* 33**,** 585-92.

CARSON, V., TREMBLAY, M. S., CHAPUT, J. P. & CHASTIN, S. F. 2016. Associations between sleep duration, sedentary time, physical activity, and health indicators among Canadian children and youth using compositional analyses. *Appl Physiol Nutr Metab,* 41**,** S294-302.

CASSIDY, S., CHAU, J. Y., CATT, M., BAUMAN, A. & TRENELL, M. I. 2017. Low physical activity, high television viewing and poor sleep duration cluster in overweight and obese adults; a cross-sectional study of 398,984 participants from the UK Biobank. *Int J Behav Nutr Phys Act,* 14**,** 57.

CHASTIN, S. F., PALAREA-ALBALADEJO, J., DONTJE, M. L. & SKELTON, D. A. 2015. Combined effects of time spent in physical activity, sedentary behaviors and sleep on obesity and cardio-metabolic health markers: A novel compositional data analysis approach. *PLoS One,* 10**,** e0139984.

CHATZISARANTIS, N. L. D. & HAGGER, M. S. 2005. Effects of a brief intervention based on the theory of planned behavior on leisure-time physical activity participation. *J Sport Exerc Psychol,* 27**,** 470.

DE REZENDE, L. F., RODRIGUES LOPES, M., REY-LOPEZ, J. P., MATSUDO, V. K. & LUIZ ODO, C. 2014. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One,* 9**,** e105620.

DOWNS, D. S. & HAUSENBLAS, H. A. 2005. Elicitation studies and the theory of planned behavior: a systematic review of exercise beliefs. *Psychol Sport Exerc,* 6**,** 1-31.

DUMUID, D., STANFORD, T. E., MARTIN-FERNANDEZ, J. A., PEDISIC, Z., MAHER, C. A., LEWIS, L. K., HRON, K., KATZMARZYK, P. T., CHAPUT, J. P., FOGELHOLM, M., HU, G., LAMBERT, E. V., MAIA, J., SARMIENTO, O. L., STANDAGE, M., BARREIRA, T. V., BROYLES, S. T., TUDOR-LOCKE, C., TREMBLAY, M. S. & OLDS, T. 2017. Compositional data analysis for physical activity, sedentary time and sleep research. *Stat Methods Med Res*, 962280217710835.

FAIRCLOUGH, S. J., DUMUID, D., TAYLOR, S., CURRY, W., MCGRANE, B., STRATTON, G., MAHER, C. & OLDS, T. 2017. Fitness, fatness and the reallocation of time between children's daily movement behaviours: an analysis of compositional data. *Int J Behav Nutr Phys Act,* 14, 64.

GRGIC, J., DUMUID, D., BENGOECHEA, E. G., SHRESTHA, N., BAUMAN, A., OLDS, T. & PEDISIC, Z. 2018. Health outcomes associated with reallocations of time between sleep, sedentary behaviour, and physical activity: a systematic scoping review of isotemporal substitution studies. *Int J Behav Nutr Phys Act,* 15, 69.

HILL, R. J., FISHBEIN, M. & AJZEN, I. 1977. Belief, attitude, intention and behavior: An introduction to theory and research. *Contemp Sociol,* 6, 244.

HUANG, W. Y., WONG, S. H., HE, G. & SALMON, J. O. 2016. Isotemporal Substitution Analysis for Sedentary Behavior and Body Mass Index. *Med Sci Sports Exerc,* 48, 2135-2141.

LATIMER, A. E., GINIS, K. A. M. & ARBOUR, K. P. 2006. The efficacy of an implementation intention intervention for promoting physical activity among individuals with spinal cord injury: A randomized controlled trial. *Rehab Psychol,* 51, 273-280.

MCEACHAN, R. R. C., CONNER, M., TAYLOR, N. J. & LAWTON, R. J. 2011. Prospective prediction of health-related behaviours with the Theory of Planned Behaviour: a meta-analysis. *Health Psychol Rev,* 5, 97-144.

MEKARY, R. A., WILLETT, W. C., HU, F. B. & DING, E. L. 2009. Isotemporal substitution paradigm for physical activity epidemiology and weight change. *Am J Epidemiol,* 170, 519-27.

MICHIE, S. & ABRAHAM, C. 2004. Interventions to change health behaviours: evidence-based or evidence-inspired? *Psychol Health,* 19, 29-49.

PEDIŠIĆ, Ž., DUMUID, D. & OLDS, T. 2017. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology,* 49, 252-69.

RHODES, R. E., SAELENS, B. E. & SAUVAGE-MAR, C. 2018. Understanding physical activity through interactions between the built environment and social cognition: A systematic review. *Sports Med,* 48, 1893-1912.

SALLIS, J. F., CERVERO, R. B., ASCHER, W., HENDERSON, K. A., KRAFT, M. K. & KERR, J. 2006. An ecological approach to creating active living communities. *Annu Rev Public Health,* 27, 297-322.

SHAFIEINIA, M., HIDARNIA, A., KAZEMNEJAD, A. & RAJABI, R. 2016. Effects of a theory based intervention on physical activity among female employees: A quasi-experimental study. *Asian J Sports Med,* 7, e31534.

SNIEHOTTA, F. F., PRESSEAU, J. & ARAUJO-SOARES, V. 2014. Time to retire the theory of planned behaviour. *Health Psychol Rev,* 8, 1-7.

STAMATAKIS, E., ROGERS, K., DING, D., BERRIGAN, D., CHAU, J., HAMER, M. & BAUMAN, A. 2015. All-cause mortality effects of replacing sedentary time with physical activity and sleeping using an isotemporal substitution model: a prospective study of 201,129 mid-aged and older adults. *Int J Behav Nutr Phys Act,* 12**,** 121.

STEINMETZ, H., KNAPPSTEIN, M., AJZEN, I., SCHMIDT, P. & KABST, R. 2016. How effective are behavior change interventions based on the theory of planned behavior? *Zeitschrift für Psychologie,* 224**,** 216-233.

STOKOLS, D. 1992. Establishing and maintaining healthy environments. Toward a social ecology of health promotion. *Am Psychol,* 47**,** 6-22.

TREMBLAY, M. S., ESLIGER, D. W., TREMBLAY, A. & COLLEY, R. 2007. Incidental movement, lifestyle-embedded activity and sleep: new frontiers in physical activity assessmentThis article is part of a supplement entitled Advancing physical activity measurement and guidelines in Canada: a scientific review and evidence-based foundation for the future of Canadian physical activity guidelines co-published by Applied Physiology, Nutrition, and Metabolism and the Canadian Journal of Public Health. It may be cited as Appl. Physiol. Nutr. Metab. 32(Suppl. 2E) or as Can. J. Public Health 98(Suppl. 2). *Appl Physiol Nutr Metab,* 32**,** S208-S217.

VALLANCE, J. K., BUMAN, M. P., LYNCH, B. M. & BOYLE, T. 2017. Reallocating time to sleep, sedentary, and active behaviours in non-Hodgkin lymphoma survivors: associations with patient-reported outcomes. *Ann Hematol,* 96**,** 749-755.

Chapter 4: Review of physical activity interventions

Chapter outline: Although the benefits of PA are well established, studies consistently report prevalence of high levels of physical inactivity all over the world (Lee et al., 2012). Physical inactivity has been regarded as the 4th leading risk factor for global mortality due to the increased risk of developing non-communicable diseases (WHO, 2020). In 2015, physical inactivity was estimated to contribute to 2.5% of disease burden which included 19% type 2 diabetes burden and 12% coronary heart disease burden in Australian adults (AIHW, 2015). Thus, PA promotion might help in reducing the disease burden as well as global mortality due to non-communicable diseases. This chapter investigates the effectiveness of interventions aimed at increasing PA in general populations of adults implemented i) in workplace and ii) in community settings., including, among others, mental health professionals.

4.1 Effectiveness of workplace physical activity interventions

4.1.1 Background

People spend an average of more than half of their waking hours at work (WHO/WEF, 2008, Munir et al., 2018, Thorp et al., 2012). Therefore, the workplace is an important setting for promotion of PA. Moreover, PA interventions implemented at worksites can benefit from social (availability of significant others i.e. friends and colleagues) as well as organisational support in getting employees moving. There is good evidence that an organisation can reap benefits in terms of improved productivity and reduced health care costs by supporting employees in maintaining healthy behaviors (Shrestha et al., 2016).

4.1.2 Methods

A comprehensive literature search was conducted in Pubmed/Medline and 17 reviews were identified that assessed effectiveness of PA interventions in the workplace (Anderson et al., 2009, Conn et al., 2009, Heath et al., 2012, Hutchinson and Wilson, 2012, Kwak et al., 2014, Mozaffarian et al., 2012, Schroer et al., 2014, Matson-Koffman et al., 2005, Barr-Anderson et al., 2011, Jirathananuwat and Pongpirul, 2017, To et al., 2013, Vuillemin et al., 2011, Wong et al., 2012, Abraham and Graham-Rowe, 2009, Dugdill et al., 2008, Freak-Poli et al., 2013, Malik et al., 2014). The physical activities strategies that were assessed in the studies comprised of one or more of following components: exercise, education, counseling and/or environmental restructuring. The effectiveness of group counseling was not consistent across the reviews with one review reporting inconclusive evidence (Vuillemin et al., 2011) and another reporting a strong evidence (Dugdill et al., 2008) in increasing PA among employees. Out of five reviews (Barr-Anderson et al., 2011, Hutchinson and Wilson, 2012, Vuillemin et al., 2011, Malik et al., 2014, Matson-Koffman et al., 2005) that evaluated exercise interventions, two reviews (Vuillemin et al., 2011, Hutchinson and Wilson, 2012) did not find an evidence of their effectiveness in increasing PA. Education/health promotion messages were found to be effective in one review (Malik et al., 2014) while inconclusive in another (Dugdill et al., 2008). An overview of reviews (Schroer et al., 2014) of workplace health interventions for promoting healthy lifestyles suggested that multicomponent interventions comprising of exercise, education, counseling and/or environmental restructuring might be an effective strategy in increasing PA at workplace. The results from the identified reviews on effectiveness of PA interventions are not consistent. Moreover, most reviews did not pool the estimates from the included studies due to heterogeneity in intervention and outcome measures. Since the evidence available for effectiveness of PA interventions in workplace settings was inconsistent across the reviews, the evidence from primary studies was summarized to enable conclusions on the effectiveness of PA interventions in the workplace setting to be drawn. The eligibility of studies that were included in previous systematic reviews were assessed. In addition, snowballing using forward citation tracking and checking the reference list of the identified systematic reviews were performed to locate additional studies.

Studies were included in the review if they met the following inclusion criteria:

1. Randomized controlled trial (RCT) aimed at increasing PA level

2. Conducted in a workplace setting;

3. Included level of PA or energy expenditure as an outcome measure,

Studies that were limited to employees with some chronic conditions (e.g., cardiovascular disease, musculoskeletal pain) were excluded. Intervention studies that primarily aimed to reduce SB were also excluded. The follow-up duration of up to 6 months was considered short term, more than 6 months and up to 1-year medium term and more than 1-year long term.

The studies were classified into four broad intervention groups a) PA/exercise interventions, b) counseling/support intervention, c) health promotion messages/information interventions, and d) environmental restructuring. The results of the included studies were assessed based on the resemblance of population, intervention components, outcome, and follow-up. The studies were only pooled when more than one study provided usable data in any single comparison. For clustered randomized trials that reported usable data for meta-analysis, an intra-cluster correlation of 0.10 was used for the calculation of the design effect (Campbell et al., 2001). The pooled effect size in the meta-analyses was reported as SMD due to following reasons: a) data for the same outcome were reported in different forms such as same data reported as dichotomous in one study and continuous in another study (Section 9.4.6 Cochrane Handbook for Systematic Reviews of Interventions) (Higgins and Green, 2011), and b) studies measured the same outcome in different scales. The studies were considered to be heterogeneous (in terms of intervention components and outcomes measurement), and therefore random-effects model was used to calculate pooled effect sizes. The observed value of I^2: 0%–40% was considered likely not important; 30%–60% moderate heterogeneity; 50%–90% substantial heterogeneity; and 75%–100% as considerable heterogeneity (Higgins and Green, 2011). Cochrane risk of bias tool was used to assess the risk of bias in the included studies (Higgins and Green, 2011). The 'risk of bias was assessed in the following domains: random sequence generation; allocation concealment; blinding of outcome assessment; incomplete outcome data and baseline comparability/imbalance. A judgement of ‘low risk’, ‘high risk’ or ‘unclear risk’ was assigned was assigned to each domain. Blinding of participants and personnel and selection reporting bias were not assessed due to the self-evident nature of PA interventions and the unavailability of protocol for most of the studies. Studies were judged to be at low risk of overall bias when the study described random sequence generation, allocation concealment, blinding of outcome assessment, complete outcome data, and baseline comparability in sufficient detail.

In addition, behaviour change techniques (BCTs) used in the intervention in the included studies were also coded based on 93 discrete BCTs described by Michie et al. (2013) for lifestyle intervention (e.g., setting goals, reminders for self-monitoring of behaviour, and information on consequences of behaviour in general). Coding and comparing BCTs in intervention description across studies that reported positive and negative findings might help in discovering the effective element of interventions and may help in guiding the design of future interventions.

4.1.3 Results

4.1.3.1 Included studies

In total, 40 studies met the inclusion criteria. Studies included workers from both the public and private sectors; six studies included employees in government offices, 21 included employees in private companies, six included health workers, and seven included researchers and other academic staff. The studies were conducted in Australia (n=2), the USA (n=18), Canada (n=2), UK (n=5), Asia (n=1) and other countries in Europe (n=12) (Supplementary table 1). The studies were grouped under the following four headings:

<u>Exercise interventions</u>

Four studies evaluated the effectiveness of exercise interventions. The type of exercise intervention included walking (Coleman et al., 1999, Gilson et al., 2009), an option to choose medium-to-high intensity exercises (von Thiele Schwarz et al., 2008), and resistance training (Pedersen et al., 2009).

<u>Counselling/support intervention</u>

Eleven studies evaluated the effectiveness of counseling/support intervention. The interventions included tailored face-to-face counseling (Aittasalo et al., 2004, Nisbeth et al., 2000, Purath et al., 2004, Opdenacker and Boen, 2008, Proper et al., 2003), tailored health messages and social support (Campbell et al., 2002), motivational interviewing/counseling (MacKinnon et al., 2010), peer support programme (Nichols et al., 2000, Rowland et al., 2018), telephone counseling (Opdenacker and Boen, 2008, van Wier et al., 2009, Purath et al., 2004, Reijonsaari et al., 2012), counseling through email (van Wier et al., 2009), and group counseling (Rowland et al., 2018).

<u>Health promotion messages/information intervention</u>

Eighteen studies evaluated the effectiveness of health promotion messages/information intervention. The mode of PA intervention included web-based health promotion messages (Cook et al., 2007, Marshall et al., 2003, Napolitano et al., 2003, Spittaels et al., 2007, Slootmaker et al., 2009, Blake et al., 2017, Hager et al., 2002), written health promotion materials (Cook et al., 2007, Blissmer and McAuley, 2002, Marshall et al., 2003, Peterson and Aldana, 1999, Plotnikoff et al., 2007, Mutrie et al., 2002), health promotion workshops/classes (Loughlan and Mutrie, 1997, Morgan et al., 2011), tailored health promotion messages delivered by email (Sternfeld et al., 2009, Hager et al., 2002), PA tracking followed by health promotion activities (Dadaczynski et al., 2017), and multicomponent interventions (e.g., a combination of written health promotion materials/workshops/classes, posters, and flyers) (McEachan et al., 2011, Siegel et al., 2010, Prestwich et al., 2012).

Environmental restructuring

Seven studies evaluated the effectiveness of environmental restructuring intervention. The mode of PA intervention included changes in desk (installation of elliptical desk/stationary high desk) (Carr et al., 2016, Miyachi et al., 2015), access to the fitness center (Gazmararian et al., 2013, Thorndike et al., 2014), installation of fitness equipment in the workplace (French et al., 2010), adopting policies for encouraging activity at work (Dishman et al., 2009, Sorensen et al., 2005).

The longest follow-up was 6 months or less in 22 studies (Blake et al., 2017, Blissmer and McAuley, 2002, Carr et al., 2016, Coleman et al., 1999, Cook et al., 2007, Dadaczynski et al., 2017, Dishman et al., 2009, Gilson et al., 2009, Marshall et al., 2003, Miyachi et al., 2015, Morgan et al., 2011, Napolitano et al., 2003, Opdenacker and Boen, 2008, Peterson and Aldana, 1999, Prestwich et al., 2012, Purath et al., 2004, Rowland et al., 2018, Spittaels et al., 2007, Thorndike et al., 2014, van Wier et al., 2009, Hager et al., 2002, Loughlan and Mutrie, 1997) , between 6 months and 12 months in 13 studies (Aittasalo et al., 2004, Gazmararian et al., 2013, McEachan et al., 2011, Mutrie et al., 2002, Nichols et al., 2000, Nisbeth et al., 2000, Pedersen et al., 2009, Plotnikoff et al., 2007, Proper et al., 2003, Reijonsaari et al., 2012, Slootmaker et al., 2009, Sternfeld et al., 2009, von Thiele Schwarz et al., 2008), and more than 12 months in five studies (Campbell et al., 2002, French et al., 2010, MacKinnon et al., 2010, Siegel et al., 2010, Sorensen et al., 2005). PA was measured using activity monitors in four studies, both self-reports and activity monitor in one study, and the remaining studies used self-reports.

4.1.3.2 Risk of bias in included studies

Apart from three studies (Gilson et al., 2009, Nichols et al., 2000, Proper et al., 2003), all the studies were judged at low risk of bias for random sequence generation, whereas, only five studies were judged at low risk of bias for allocation concealment (Carr et al., 2016, Prestwich et al., 2012, Reijonsaari et al., 2012, Slootmaker et al., 2009, van Wier et al., 2009), and seven studies (Blake et al., 2012, Carr et al., 2016, Marshall et al., 2003, Morgan et al., 2011, Mutrie et al., 2002, Pedersen et al., 2014, Prestwich et al., 2012) had a low risk of bias for blinding of outcome assessment. Similarly, 16 studies (Aittasalo et al., 2004, Carr et al., 2016, Cook et al., 2007, Gazmararian et al., 2013, Gilson et al., 2009, French et al., 2010, MacKinnon et al., 2010, Marshall et al., 2003, Miyachi et al., 2015, Morgan et al., 2011, Mutrie et al., 2002, Nichols et al., 2000, Nisbeth et al., 2000, Opdenacker and Boen, 2008, Prestwich et al., 2012, Reijonsaari et al., 2012, Slootmaker et al., 2009, Spittaels et al., 2007, von Thiele Schwarz et al., 2008, Sorensen et al., 2005, Sternfeld et al., 2009, van Wier et al., 2009) and 25 studies (Aittasalo et al., 2004, Carr et al., 2016, Cook et al., 2007, Gazmararian et al., 2013, Gilson et al., 2009, MacKinnon et al., 2010, Marshall et al., 2003, Miyachi et al., 2015, Morgan et al., 2011, Nisbeth et al., 2000, Reijonsaari et al., 2012, Slootmaker et al., 2009, Spittaels et al., 2007, von Thiele Schwarz et al., 2008, Blake et al., 2017, Blissmer and McAuley, 2002, Coleman et al., 1999, Dadaczynski et al., 2017, McEachan et al., 2011, Napolitano et al., 2003, Pedersen et al., 2014, Plotnikoff et al., 2007, Rowland et al., 2018, Thorndike et al., 2014, van Wier et al., 2009) were judged at low risk of bias for attrition bias and baseline comparability respectively. Overall, only four studies (Carr et al., 2016, Reijonsaari et al., 2012, Slootmaker et al., 2009, van Wier et al., 2009) were judged to have a low risk of bias.

Study ID	Random sequence generation	Allocation concealment	Blinding of outcome assessor	Attrition bias	Baseline comparability
Aittasalo et al.	+	?	-	+	+
Blake et al.	+	?	+	-	+
Blismmer et al.	+	?	-	-	+
Campebell et al.	+	-	-	-	-
Carr et al.	+	+	+	+	+
Coleman et al.	+	-	-	?	+
Cook et al.	+	?	-	+	+
Dadaczynski et al.	+	?	-	-	+
Dishman et al.	+	-	-	-	-
French et al.	+	-	-	+	-
Gazmararian et al.	+	?	-	+	+
Gilson et al.	-	-	-	+	+
Hager et al.	+	-	-	-	-
Loughlan et al.	+	-	-	?	-
Mackinnon et al.	+	-	-	+	+
Marshall et al.	+	-	+	+	+
McEachan et al.	+	-	-	?	+
Miyachi et al.	+	?	-	+	+
Morgan et al.	+	-	+	+	+
Mutrie et al.	+	-	+	+	-
Napolitano et al.	+	?	-	-	+
Nicholos et al.	-	-	-	+	-
Nisbeth et al.	+	?	-	+	+
Opendacker et al.	+	-	-	+	-
Pedersen et al.	+	-	+	?	-
Peterson et al.	+	?	-	-	+
Plontikoff et al.	+	?	-	-	+
Prestwich et al.	+	+	+	+	-
Proper et al.	-	-	-	-	-
Purath et al.	+	?	-	+	-
Reijonsaari et al.	+	+	-	+	+
Rowland et al.	+	?	-	-	+
Siegel et al.	+	-	-	?	-
Slootmaker et al.	+	+	-	+	+
Sorenson et al.	+	-	-	+	-
Spittaels et al.	+	-	-	+	+
Sternfeld et al.	+	-	-	+	-
Thorndike et al.	+	?	-	-	+
van Wier et al.	+	+	-	+	+
Schwarz et al.	+	?	-	+	+

?	Unclear risk
+	Low risk
-	High risk

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item in included studies

Several BCTs were used in the included studies. Among the BCTs identified in the intervention, the most used ones were: goal setting (20 studies) (Aittasalo et al., 2004, Coleman et al., 1999, MacKinnon et al., 2010, Nisbeth et al., 2000, Opdenacker and Boen, 2008, Purath et al., 2004, Reijonsaari et al., 2012, van Wier et al., 2009, Blissmer and McAuley, 2002, Marshall et al., 2003, McEachan et al., 2011, Morgan et al., 2011, Napolitano et al., 2003, Peterson and Aldana, 1999, Slootmaker et al., 2009, Sternfeld et al., 2009, Dadaczynski et al., 2017, Dishman et al., 2009, Loughlan and Mutrie, 1997, Hager et al., 2002), prompt for self-monitoring of behaviours (14 studies) (Aittasalo et al., 2004, Coleman et al., 1999, Opdenacker and Boen, 2008, Reijonsaari et al., 2012, Marshall et al., 2003, McEachan et al., 2011, Morgan et al., 2011, Mutrie et al., 2002, Napolitano et al., 2003, Slootmaker et al., 2009, Sternfeld et al., 2009, Dadaczynski et al., 2017, Gazmararian et al., 2013, Thorndike et al., 2014), and social change/social support (12 studies) (MacKinnon et al., 2010, Blissmer and McAuley, 2002, Marshall et al., 2003, McEachan et al., 2011, Morgan et al., 2011, Napolitano et al., 2003, Prestwich et al., 2012, Dadaczynski et al., 2017, Carr et al., 2016, Gazmararian et al., 2013, Loughlan and Mutrie, 1997). Most of the studies that used these techniques reported significant increase in PA, however some studies did not report a significant increase in PA: goal setting (Aittasalo et al., 2004, Reijonsaari et al., 2012, Slootmaker et al., 2009, Nisbeth et al., 2000, McEachan et al., 2011) prompt for self-monitoring of behaviour (Aittasalo et al., 2004, Reijonsaari et al., 2012, Slootmaker et al., 2009, Thorndike et al., 2014), and social change/social support (McEachan et al., 2011, Prestwich et al., 2012, French et al., 2010).

4.1.3.3 Effects of interventions

<u>Exercise interventions</u>

Five studies reported an increase in PA levels following the intervention (Coleman et al., 1999, Gilson et al., 2009, von Thiele Schwarz et al., 2008, Gazmararian et al., 2013, Pedersen et al., 2009), but the findings from one study did not reach statistical significance (Pedersen et al., 2009). Coleman et al. (1999) found that participants assigned to three groups of 30 minutes of brisk walking each with different bouts significantly increased their PA at short-term follow-up. Similarly, Gilson et al. (2009) found that the step counts were significantly increased in participants assigned to route based walking and incidental walking groups compared to a control group at short-term follow-up. von Thiele Schwarz et al. (2008) found a weekly increase in PA by 2–4 hour in participants who were offered a compulsory workplace PA compared to the control group at medium-term follow-up.

<u>Counselling/support intervention</u>

Out of 11 studies categorised as counseling intervention, only five studies reported data that could be pooled in a meta-analysis for short-term follow-up. Five studies (Aittasalo et al., 2004, Nichols et al., 2000, Purath et al., 2004, Rowland et al., 2018, van Wier et al., 2009) including 1312 participants (intervention group = 795) revealed a small effect on PA levels following intervention at short-term follow-up: SMD 0.257, 95% CI 0.126 to 0.387, I2 = 18%, with heterogeneity likely not important. Of the remaining six studies, only three (Campbell et al., 2002, MacKinnon et al., 2010, Proper et al., 2003) reported a statistically significant increase in PA levels compared to the control group. Campbell et al. (2002) reported that women provided with a tailored online intervention and peer support reported a significant increase in their average frequency of flexibility and resistance exercise compared to the control group at long-term follow-up. Similarly, Proper et al. (2003) reported participants receiving tailored counselling intervention increased total energy expenditure compared to the control group at mid-term follow-up. However, MacKinnon et al. (2010) reported that a group counselling with peer support was more effective in improving PA compared to tailored counselling at long-term follow-up.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Aittasalo 2004	0.090	0.170	0.029	-0.243	0.424	0.529	0.597
Nicholos 2000	0.531	0.265	0.070	0.012	1.050	2.004	0.045
Purath 2004	0.446	0.124	0.015	0.204	0.689	3.604	0.000
Rowland 2018	0.055	0.320	0.102	-0.572	0.682	0.171	0.864
van weir 2009a	0.275	0.108	0.012	0.064	0.486	2.555	0.011
van Weir 2009b	0.136	0.107	0.011	-0.073	0.346	1.275	0.202
	0.257	0.067	0.004	0.126	0.387	3.857	0.000

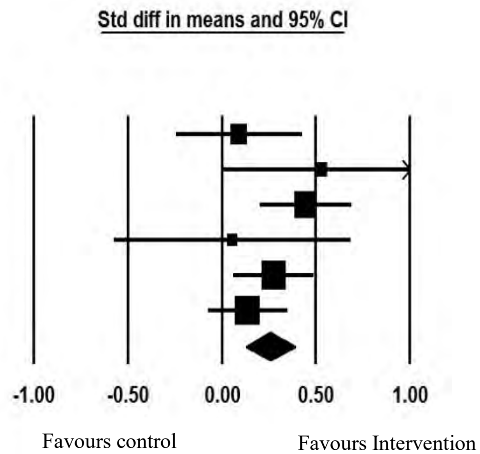

Figure 4: Meta-analysis: Counseling/support interventions at short term (0 to 6 months)

Health promotion messages/information interventions

Of the 18 studies categorised as health promotion messages/information interventions, only ten reported data that could be pooled in a meta-analysis for short-term follow-up. Ten studies (Blissmer and McAuley, 2002, McEachan et al., 2011, Morgan et al., 2011, Napolitano et al., 2003, Slootmaker et al., 2009, Sternfeld et al., 2009, Dadaczynski et al., 2017, Peterson and Aldana, 1999, Mutrie et al., 2002, Hager et al., 2002), including 3654 participants (intervention group = 1980), showed a small effect of health promotion interventions on PA levels at short-term follow-up (SMD 0.122, 95% CI 0.005 to 0.239, I^2 = 56%) with moderate heterogeneity. Of the remaining nine studies, only three studies (Blake et al., 2017, Prestwich et al., 2012, Spittaels et al., 2007) reported a statistically significant increase in PA levels compared to a control group. Spittaels et al. (2007) found that reminder emails with and without stage-of-change matched, and a standard PA advice control were equally effective in significantly increasing PA levels at short-term follow-up. “Stages of change” in the transtheoretical model are stages people go through when making (or not making) changes to their behavior. These include precontemplation, contemplation, preparation/determination, action, maintenance and relapse or termination (Prochaska and DiClemente, 1983). Blake et al. (2017) found that both SMS and email delivered PA promotion intervention was effective in increasing PA levels at short-term follow-up. Similarly, Prestwich et al. (2012) found that planning PA strategies together with a partner was effective in increasing PA in the intervention group compared to the control group at short-term follow-up.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Blissmer 2002	0.406	0.223	0.050	-0.032	0.844	1.816	0.069
McEachan 2011	0.031	0.056	0.003	-0.079	0.142	0.557	0.578
Morgan 2011	0.384	0.196	0.038	0.001	0.768	1.965	0.049
Napolitano 2003	0.543	0.288	0.083	-0.021	1.106	1.887	0.059
Sternfeld 2009	0.146	0.072	0.005	0.005	0.287	2.036	0.042
Slootmaker 2009	-0.115	0.205	0.042	-0.518	0.287	-0.561	0.575
Dadaczynski 2017	-0.179	0.168	0.028	-0.508	0.151	-1.064	0.287
Hager 2002a	-0.039	0.150	0.022	-0.332	0.255	-0.259	0.795
Hager 2002b	0.093	0.149	0.022	-0.199	0.385	0.624	0.533
Peterson 1999a	0.405	0.130	0.017	0.150	0.660	3.116	0.002
Peterson 1999b	-0.169	0.129	0.017	-0.423	0.084	-1.308	0.191
Mutrie 2002	0.363	0.169	0.029	0.032	0.694	2.148	0.032
	0.122	0.060	0.004	0.005	0.239	2.038	0.042

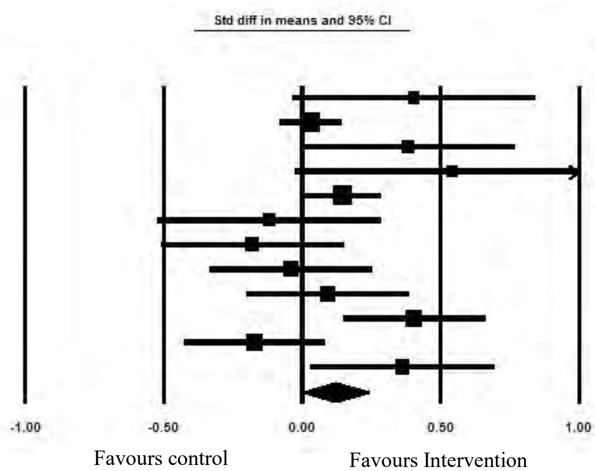

Figure 5: Meta-analysis: Health promotion messages/information intervention at short-term (0-6 months)

Environmental restructuring

The pooled analysis of two studies (Carr et al., 2016, Miyachi et al., 2015) comparing changes in desk versus control including 86 participants (intervention group 43 participants) showed a small but non-significant effect on PA levels following intervention at short-term follow-up: SMD 0.328, 95% CI -0.086 to 0.741, $I^2 = 0\%$; with heterogeneity likely not important. Of the remaining five studies, only three reported a statistically significant increase in PA levels compared to a control group. Dishman et al. (2009) found a significant increase in PA compared to the control group following environmental restructuring and goal setting at short-term follow-up. Gazmararian et al. (2013) found gym membership and education were effective in increasing PA in employees compared to the control group at medium-term follow-up. Similarly, Sorensen et al. (2005) found a significant increase in PA compared to the control group with participatory strategies and environmental restructuring at long-term follow-up.

Study name	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Miyachi 2015	0.210	0.340	0.116	-0.457	0.877	0.617	0.537
Carr 2015	0.401	0.269	0.072	-0.126	0.927	1.492	0.136
	0.328	0.211	0.044	-0.086	0.741	1.553	0.120

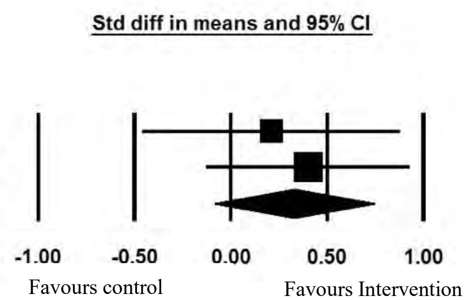

Figure 6: Meta-analysis: Environmental restructuring at short-term (0-6 months)

4.2 Effectiveness of community-wide physical activity interventions

Multiple factors shape an individual's PA behavior which interact at individual, environmental, societal and policy level (Bauman et al., 2012). Thus, changing large section of population health behavior needs approaches operating at multi-level which can be achieved with community-wide interventions (Bauman et al., 2012, Heath et al., 2012). Community-wide interventions usually involve environmental restructuring and planning initiatives that would benefit the population for the long term. A review by Baker et al. (2015) found inconsistent evidence of the effectiveness of community-wide PA interventions across 33 included studies. In addition, these included studies had methodological limitations. The intervention strategies included collaboration with governmental or non-governmental entities, tailored counseling by health professionals, mass media campaigns, or other communication strategies and environmental restructuring. A study from Hangzhou city in China (Jiang et al., 2008), evaluated an intervention comprising door-to-door distribution of instructions and information and counselling strategies by health practitioners. It reported a significant increase in PA at post intervention follow-up. Similarly, a recent community-wide intervention with five years follow-up found a higher proportion of Japanese adults in communities receiving the intervention engaged in the recommended levels of regular PA compared to control communities (Kamada et al., 2018). The intervention consisted of information delivery through various media channels, different types of social support, and targeted educational outreach. This review only included those studies which had a minimum of six months follow-up as it considered six months as the minimum period required to maintain a newly acquired behaviour. Another review by Boch et al. (2014) found 55 studies on community-wide PA intervention strategies, namely exercise/walking sessions, print or digital interventions, public campaigns, and face-to-face counselling. However, it found that only face to face counseling and mail mediated (print) interventions were effective. This review included studies with follow-up less than six months as well and included only ten studies with follow-up duration of 6 months or more (Bock et al., 2014). The pooled effect size for the studies with follow-up duration of 6 months or more was insignificant, which is consistent with findings from Baker et al. (2015) review.

4.3 Summary of findings

4.3.1 Workplace settings

The findings from this review suggest that counseling/support interventions and health promotion messages/information interventions were associated with a modest increase in PA in the short-term. However, the evidence for their effectiveness at medium and long term is limited. Similarly, there is limited evidence for the effectiveness of exercise interventions and environment restructuring. Though heterogeneity in the pooled analysis was not substantial, findings need to be interpreted with caution as several studies could not be pooled in the analyses.

The mean effect size for change in PA reported by Conn et al. (2009) (0.21, 95% CI 0.11 to 0.31) and Abraham and Graham-Rowe (2009) (0.2, 95% CI 0.14 to 0.27) lies between our two estimates for counseling intervention (0.257, 95% CI 0.126 to 0.387) and health promotion messages/information interventions (0.122, 95% CI 0.005 to 0.239). However, the effect sizes reported by these previous reviews must be interpreted with caution as these reviews pooled heterogeneous interventions and different follow-up duration into a single meta-analysis. It is still not clear that the amount of increase in PA level that we found in our pooled analyses would be enough to attain the PA recommendations. Our findings are consistent with the magnitude of effect sizes for interventions for other public health conditions, highlighting the difficulties in modifying health behaviours (Stice et al., 2006). Stair use might also be an effective strategy to increase habitual PA at the worksite, but we did not find any randomized study assessing it. Previous reviews suggested stair use is minimally effective (Dugdill et al., 2008) or inconclusive (Vuillemin et al., 2011) based on non-randomized studies. Most used and efficacious BCTs in PA interventions were goal setting, prompt for self-monitoring of behaviours and planning social change/social change. The finding of this review corroborate with a systematic review that assessed BCTs used in interventions promoting diet and physical activity (Greaves et al., 2011).

Most of the included studies in this review had follow-up periods of 6 months or less duration. Therefore, future research should investigate the long-term effectiveness of interventions beyond six months. Most of the studies included in this review were conducted in high-income countries. Therefore, it is not clear if the findings of this review are applicable beyond the setting in which the studies were conducted. Future studies should also address the issues pertaining to cultural contexts and diversity in workplace settings.

4.3.2 Community-wide interventions

Though several strategies seem promising in increasing PA in the community in the short-term, the evidence of effectiveness in the long-term is lacking. There is some evidence of effectiveness for targeted PA interventions in the long-term. The key challenge in the PA promotion in the communities is to identify the approaches that suit the cultural context of the particular community and resources at their disposal. The success of community-based interventions depends on inter-sectoral collaboration between various stakeholders; for example, to promote cycling, collaboration is needed between urban planning and transport sectors.

4.4. Intervention strategies that might be effective in both settings

Although there is limited evidence, walking interventions appear to be a promising strategy to get people moving (Coleman et al., 1999, Gilson et al., 2009, Dugdill et al., 2008). It is reasonable to assume that participation in sport, gym-based exercise and running might be more effective measures to increase PA, but walking is a low cost, widely accepted alternative with low risk of injury (Hootman et al., 2001) that can be easily incorporated into daily life. It is even suitable for people who cannot undertake strenuous activities like gym-based exercise, sports or running.

Environmental restructuring interventions that target built-in features of workplace or community or organizational policies and practices favorable for PA can have an impact on a larger segment of employees/population. On one hand, these interventions are expensive, and on the other hand, they are difficult to evaluate and implement due to their complex nature. Active commuting increases adherence to activity recommendations (Berrigan et al., 2006). However, a study (Mutrie et al., 2002) found that interventions for active commuting might not be effective until and unless the environment for active commuting is improved, such as separate cycling lanes and cycling trails. Altogether, a combination of interventions would seem like a promising approach.

The most used strategies in the studies included were goal setting and self-monitoring. Both these strategies provide motivation for people to engage in activities to achieve what they desired. Additionally, effectiveness of goal can be increased by enabling the individual to monitor and receive feedback on their progress en route to their goal (Locke and Latham, 2002). In a meta-analysis by Abraham and Graham-Rowe (2009), interventions with self-monitoring components resulted in average effect size almost twice as large as those for interventions without self-monitoring while there was no difference in average effect sizes for intervention with goal setting compared to intervention without goal setting. Both these strategies are potentially effective BCTs and hence should be incorporated while designing a PA intervention (Dugdill et al., 2008, Jirathananuwat and Pongpirul, 2017).

Most of the PA intervention studies conducted thus far have been with only highly interested participants, without any serious health conditions under ideal circumstances. However, the real-world setting is different from the settings of these studies, therefore, the effectiveness of PA interventions assessed in these studies will be less meaningful if it cannot be delivered in a real-world setting. Thus, translational research that fills the gap between controlled settings and real-world settings is critical for implementation of the interventions at the population level that have been shown to be effective in controlled settings.

References

ABRAHAM, C. & GRAHAM-ROWE, E. 2009. Are worksite interventions effective in increasing physical activity? A systematic review and meta-analysis. *Health Psychol Rev,* 3**,** 108-144.

AIHW 2015. Australian Institute of Health and Welfare. Australian Burden of Disease Study 2015: Interactive data on risk factor burden. *(accessed 28 September 2019). Available online: https://www.aihw.gov.au/reports/burden-of-disease/interactive-data-risk-factor-burden/contents/physical-inactivity*.

AITTASALO, M., MIILUNPALO, S. & SUNI, J. 2004. The effectiveness of physical activity counseling in a work-site setting. A randomized, controlled trial. *Patient Educ Couns,* 55**,** 193-202.

ANDERSON, L. M., QUINN, T. A., GLANZ, K., RAMIREZ, G., KAHWATI, L. C., JOHNSON, D. B., BUCHANAN, L. R., ARCHER, W. R., CHATTOPADHYAY, S., KALRA, G. P., KATZ, D. L. & TASK FORCE ON COMMUNITY PREVENTIVE, S. 2009. The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: a systematic review. *Am J Prev Med,* 37**,** 340-57.

BAKER, P. R., FRANCIS, D. P., SOARES, J., WEIGHTMAN, A. L. & FOSTER, C. 2015. Community wide interventions for increasing physical activity. *Cochrane Database Syst Rev,* 1**,** CD008366.

BARR-ANDERSON, D. J., AUYOUNG, M., WHITT-GLOVER, M. C., GLENN, B. A. & YANCEY, A. K. 2011. Integration of short bouts of physical activity into organizational routine a systematic review of the literature. *Am J Prev Med,* 40**,** 76-93.

BAUMAN, A. E., REIS, R. S., SALLIS, J. F., WELLS, J. C., LOOS, R. J., MARTIN, B. W. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Correlates of physical activity: why are some people physically active and others not? *Lancet,* 380**,** 258-71.

BERRIGAN, D., TROIANO, R. P., MCNEEL, T., DISOGRA, C. & BALLARD-BARBASH, R. 2006. Active transportation increases adherence to activity recommendations. *Am J Prev Med,* 31**,** 210-6.

BLAKE, H., MO, P. K., LEE, S. & BATT, M. E. 2012. Health in the NHS: lifestyle behaviours of hospital employees. *Perspect Public Health,* 132**,** 213-5.

BLAKE, H., SUGGS, L. S., COMAN, E., AGUIRRE, L. & BATT, M. E. 2017. Active8! Technology-Based Intervention to Promote Physical Activity in Hospital Employees. *Am J Health Promot,* 31**,** 109-118.

BLISSMER, B. & MCAULEY, E. 2002. Testing the requirements of stages of physical activity among adults: the comparative effectiveness of stage-matched, mismatched, standard care, and control interventions. *Ann Behav Med,* 24**,** 181-9.

BOCK, C., JARCZOK, M. N. & LITAKER, D. 2014. Community-based efforts to promote physical activity: a systematic review of interventions considering mode of delivery, study quality and population subgroups. *J Sci Med Sport,* 17**,** 276-82.

CAMPBELL, M. K., MOLLISON, J. & GRIMSHAW, J. M. 2001. Cluster trials in implementation research: estimation of intracluster correlation coefficients and sample size. *Stat Med,* 20**,** 391-9.

CAMPBELL, M. K., TESSARO, I., DEVELLIS, B., BENEDICT, S., KELSEY, K., BELTON, L. & SANHUEZA, A. 2002. Effects of a tailored health promotion program for female blue-collar workers: health works for women. *Prev Med,* 34**,** 313-23.

CARR, L. J., LEONHARD, C., TUCKER, S., FETHKE, N., BENZO, R. & GERR, F. 2016. Total Worker Health Intervention Increases Activity of Sedentary Workers. *Am J Prev Med,* 50**,** 9-17.

COLEMAN, K. J., RAYNOR, H. R., MUELLER, D. M., CERNY, F. J., DORN, J. M. & EPSTEIN, L. H. 1999. Providing sedentary adults with choices for meeting their walking goals. *Prev Med,* 28**,** 510-9.

CONN, V. S., HAFDAHL, A. R., COOPER, P. S., BROWN, L. M. & LUSK, S. L. 2009. Meta-analysis of workplace physical activity interventions. *Am J Prev Med,* 37**,** 330-9.

COOK, R. F., BILLINGS, D. W., HERSCH, R. K., BACK, A. S. & HENDRICKSON, A. 2007. A field test of a web-based workplace health promotion program to improve dietary practices, reduce stress, and increase physical activity: randomized controlled trial. *J Med Internet Res,* 9**,** e17.

DADACZYNSKI, K., SCHIEMANN, S. & BACKHAUS, O. 2017. Promoting physical activity in worksite settings: results of a German pilot study of the online intervention Healingo fit. *BMC Public Health,* 17**,** 696.

DISHMAN, R. K., DEJOY, D. M., WILSON, M. G. & VANDENBERG, R. J. 2009. Move to Improve: a randomized workplace trial to increase physical activity. *Am J Prev Med,* 36**,** 133-41.

DUGDILL, L., BRETTLE, A., HULME, C., MCCLUSKEY, S. & LONG, A. F. 2008. Workplace physical activity interventions: a systematic review. *International Journal of Workplace Health Management,* 1**,** 20-40.

FREAK-POLI, R. L., CUMPSTON, M., PEETERS, A. & CLEMES, S. A. 2013. Workplace pedometer interventions for increasing physical activity. *Cochrane Database Syst Rev***,** CD009209.

FRENCH, S. A., HARNACK, L. J., HANNAN, P. J., MITCHELL, N. R., GERLACH, A. F. & TOOMEY, T. L. 2010. Worksite environment intervention to prevent obesity among metropolitan transit workers. *Prev Med,* 50**,** 180-5.

GAZMARARIAN, J. A., ELON, L., NEWSOME, K., SCHILD, L. & JACOBSON, K. L. 2013. A randomized prospective trial of a worksite intervention program to increase physical activity. *Am J Health Promot,* 28**,** 32-40.

GILSON, N. D., PUIG-RIBERA, A., MCKENNA, J., BROWN, W. J., BURTON, N. W. & COOKE, C. B. 2009. Do walking strategies to increase physical activity reduce reported sitting in workplaces: a randomized control trial. *Int J Behav Nutr Phys Act,* 6**,** 43.

GREAVES, C. J., SHEPPARD, K. E., ABRAHAM, C., HARDEMAN, W., RODEN, M., EVANS, P. H., SCHWARZ, P. & GROUP, I. S. 2011. Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health,* 11**,** 119.

HAGER, R. L., HARDY, A., ALDANA, S. G. & GEORGE, J. D. 2002. Evaluation of an internet, stage-based physical activity intervention. *Am J Health Educ,* 33**,** 329-337.

HEATH, G. W., PARRA, D. C., SARMIENTO, O. L., ANDERSEN, L. B., OWEN, N., GOENKA, S., MONTES, F., BROWNSON, R. C. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Evidence-based intervention in physical activity: lessons from around the world. *Lancet,* 380**,** 272-81.

HIGGINS, J. P. T. & GREEN, S. 2011. Cochrane handbookfor systematic reviews of interventions version 5.1.0[updated March 2011]. *The Cochrane Collaboration. Available Online* www.cochrane-handbook.org.

HOOTMAN, J. M., MACERA, C. A., AINSWORTH, B. E., MARTIN, M., ADDY, C. L. & BLAIR, S. N. 2001. Association among physical activity level, cardiorespiratory fitness, and risk of musculoskeletal injury. *Am J Epidemiol,* 154**,** 251-8.

HUTCHINSON, A. D. & WILSON, C. 2012. Improving nutrition and physical activity in the workplace: a meta-analysis of intervention studies. *Health Promot Int,* 27**,** 238-49.

JIANG, B., WANG, W. & WU, S. 2008. The effects of community intervention measures on prevention and control of hypertension. *Chinese J Prev Cont Chronic Non-communicable Disease* 16**,** 254-7.

JIRATHANANUWAT, A. & PONGPIRUL, K. 2017. Promoting physical activity in the workplace: A systematic meta-review. *J Occup Health,* 59**,** 385-393.

KAMADA, M., KITAYUGUCHI, J., ABE, T., TAGURI, M., INOUE, S., ISHIKAWA, Y., BAUMAN, A., LEE, I. M., MIYACHI, M. & KAWACHI, I. 2018. Community-wide intervention and population-level physical activity: a 5-year cluster randomized trial. *Int J Epidemiol,* 47**,** 642-653.

KWAK, L., HAGSTROMER, M., JENSEN, I., KARLSSON, M. L., ALIPOUR, A. & ELINDER, L. S. 2014. Promoting physical activity and healthy dietary behavior: the role of the occupational health services: a scoping review. *J Occup Environ Med,* 56**,** 35-46.

LEE, I. M., SHIROMA, E. J., LOBELO, F., PUSKA, P., BLAIR, S. N., KATZMARZYK, P. T. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet,* 380**,** 219-29.

LOCKE, E. A. & LATHAM, G. P. 2002. Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *Am Psychologist,* 57**,** 705-717.

LOUGHLAN, C. & MUTRIE, N. 1997. An evaluation of the effectiveness of three interventions in promoting physical activity in a sedentary population. *Health Educ J,* 56**,** 154-165.

MACKINNON, D. P., ELLIOT, D. L., THOEMMES, F., KUEHL, K. S., MOE, E. L., GOLDBERG, L., BURRELL, G. L. & RANBY, K. W. 2010. Long-term effects of a worksite health promotion program for firefighters. *Am J Health Behav,* 34**,** 695-706.

MALIK, S. H., BLAKE, H. & SUGGS, L. S. 2014. A systematic review of workplace health promotion interventions for increasing physical activity. *Br J Health Psychol,* 19**,** 149-80.

MARSHALL, A. L., LESLIE, E. R., BAUMAN, A. E., MARCUS, B. H. & OWEN, N. 2003. Print versus website physical activity programs: a randomized trial. *Am J Prev Med,* 25**,** 88-94.

MATSON-KOFFMAN, D. M., BROWNSTEIN, J. N., NEINER, J. A. & GREANEY, M. L. 2005. A site-specific literature review of policy and environmental interventions that promote physical activity and nutrition for cardiovascular health: what works? *Am J Health Promot,* 19**,** 167-93.

MCEACHAN, R. R., LAWTON, R. J., JACKSON, C., CONNER, M., MEADS, D. M. & WEST, R. M. 2011. Testing a workplace physical activity intervention: a cluster randomized controlled trial. *Int J Behav Nutr Phys Act,* 8**,** 29.

MICHIE, S., RICHARDSON, M., JOHNSTON, M., ABRAHAM, C., FRANCIS, J., HARDEMAN, W., ECCLES, M. P., CANE, J. & WOOD, C. E. 2013. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med,* 46**,** 81-95.

MIYACHI, M., KURITA, S., TRIPETTE, J., TAKAHARA, R., YAGI, Y. & MURAKAMI, H. 2015. Installation of a stationary high desk in the workplace: effect of a 6-week intervention on physical activity. *BMC Public Health,* 15**,** 368.

MORGAN, P. J., COLLINS, C. E., PLOTNIKOFF, R. C., COOK, A. T., BERTHON, B., MITCHELL, S. & CALLISTER, R. 2011. Efficacy of a workplace-based weight loss program for overweight male shift workers: the Workplace POWER (Preventing Obesity Without Eating like a Rabbit) randomized controlled trial. *Prev Med,* 52**,** 317-25.

MOZAFFARIAN, D., AFSHIN, A., BENOWITZ, N. L., BITTNER, V., DANIELS, S. R., FRANCH, H. A., JACOBS, D. R., JR., KRAUS, W. E., KRIS-ETHERTON, P. M., KRUMMEL, D. A., POPKIN, B. M., WHITSEL, L. P., ZAKAI, N. A., AMERICAN HEART ASSOCIATION COUNCIL ON, E., PREVENTION, C. O. N. P. A. & METABOLISM, C. O. C. C. C. O. C. D. I. T. Y. C. O. T. K. I. C. 2012. Population approaches to improve diet, physical activity, and smoking habits: a scientific statement from the American Heart Association. *Circulation,* 126**,** 1514-63.

MUNIR, F., BIDDLE, S. J. H., DAVIES, M. J., DUNSTAN, D., ESLIGER, D., GRAY, L. J., JACKSON, B. R., O'CONNELL, S. E., YATES, T. & EDWARDSON, C. L. 2018. Stand More AT Work (SMArT Work): using the behaviour change wheel to develop an intervention to reduce sitting time in the workplace. *BMC Public Health,* 18**,** 319.

MUTRIE, N., CARNEY, C., BLAMEY, A., CRAWFORD, F., AITCHISON, T. & WHITELAW, A. 2002. "Walk in to Work Out": a randomised controlled trial of a self help intervention to promote active commuting. *J Epidemiol Community Health,* 56**,** 407-12.

NAPOLITANO, M. A., FOTHERINGHAM, M., TATE, D., SCIAMANNA, C., LESLIE, E., OWEN, N., BAUMAN, A. & MARCUS, B. 2003. Evaluation of an internet-based physical activity intervention: a preliminary investigation. *Ann Behav Med,* 25**,** 92-9.

NICHOLS, J. F., WELLMAN, E., CAPAROSA, S., SALLIS, J. F., CALFAS, K. J. & ROWE, R. 2000. Impact of a worksite behavioral skills intervention. *Am J Health Promot,* 14**,** 218-21, ii.

NISBETH, O., KLAUSEN, K. & ANDERSEN, L. B. 2000. Effectiveness of counselling over 1 year on changes in lifestyle and coronary heart disease risk factors. *Patient Educ Couns,* 40**,** 121-31.

OPDENACKER, J. & BOEN, F. 2008. Effectiveness of face-to-face versus telephone support in increasing physical activity and mental health among university employees. *J Phys Act Health,* 5**,** 830-43.

PEDERSEN, M. T., BLANGSTED, A. K., ANDERSEN, L. L., JORGENSEN, M. B., HANSEN, E. A. & SJOGAARD, G. 2009. The effect of worksite physical activity intervention on physical capacity, health, and productivity: a 1-year randomized controlled trial. *J Occup Environ Med,* 51**,** 759-70.

PEDERSEN, S. J., COOLEY, P. D. & MAINSBRIDGE, C. 2014. An e-health intervention designed to increase workday energy expenditure by reducing prolonged occupational sitting habits. *Work,* 49**,** 289-95.

PETERSON, T. R. & ALDANA, S. G. 1999. Improving exercise behavior: an application of the stages of change model in a worksite setting. *Am J Health Promot,* 13**,** 229-32, iii.

PLOTNIKOFF, R. C., BRUNET, S., COURNEYA, K. S., SPENCE, J. C., BIRKETT, N. J., MARCUS, B. & WHITELEY, J. 2007. The efficacy of stage-matched and standard public health materials for promoting physical activity in the workplace: the Physical Activity Workplace Study (PAWS). *Am J Health Promot,* 21**,** 501-9.

PRESTWICH, A., CONNER, M. T., LAWTON, R. J., WARD, J. K., AYRES, K. & MCEACHAN, R. R. 2012. Randomized controlled trial of collaborative implementation intentions targeting working adults' physical activity. *Health Psychol,* 31**,** 486-95.

PROCHASKA, J. O. & DICLEMENTE, C. C. 1983. Stages and processes of self-change of smoking: toward an integrative model of change. *J Consult Clin Psychol,* 51**,** 390-5.

PROPER, K. I., HILDEBRANDT, V. H., VAN DER BEEK, A. J., TWISK, J. W. & VAN MECHELEN, W. 2003. Effect of individual counseling on physical activity fitness and health: a randomized controlled trial in a workplace setting. *Am J Prev Med,* 24**,** 218-26.

PURATH, J., MILLER, A. M., MCCABE, G. & WILBUR, J. 2004. A brief intervention to increase physical activity in sedentary working women. *Can J Nurs Res,* 36**,** 76-91.

REIJONSAARI, K., VEHTARI, A., KAHILAKOSKI, O. P., VAN MECHELEN, W., ARO, T. & TAIMELA, S. 2012. The effectiveness of physical activity monitoring and distance counseling in an occupational setting - results from a randomized controlled trial (CoAct). *BMC Public Health,* 12**,** 344.

ROWLAND, S. A., BERG, K. E., KUPZYK, K. A., PULLEN, C. H., COHEN, M. Z., SCHULZ, P. S. & YATES, B. C. 2018. Feasibility and Effect of a Peer Modeling Workplace Physical Activity Intervention for Women. *Workplace Health Saf,* 66**,** 428-436.

SCHROER, S., HAUPT, J. & PIEPER, C. 2014. Evidence-based lifestyle interventions in the workplace--an overview. *Occup Med (Lond),* 64**,** 8-12.

SHRESTHA, N., PEDISIC, Z., NEIL-SZTRAMKO, S., KUKKONEN-HARJULA, K. T. & HERMANS, V. 2016. The Impact of Obesity in the Workplace: a Review of Contributing Factors, Consequences and Potential Solutions. *Curr Obes Rep,* 5**,** 344-60.

SIEGEL, J. M., PRELIP, M. L., ERAUSQUIN, J. T. & KIM, S. A. 2010. A worksite obesity intervention: results from a group-randomized trial. *Am J Public Health,* 100**,** 327-33.

SLOOTMAKER, S. M., CHINAPAW, M. J., SCHUIT, A. J., SEIDELL, J. C. & VAN MECHELEN, W. 2009. Feasibility and effectiveness of online physical activity advice based on a personal activity monitor: randomized controlled trial. *J Med Internet Res,* 11**,** e27.

SORENSEN, G., BARBEAU, E., STODDARD, A. M., HUNT, M. K., KAPHINGST, K. & WALLACE, L. 2005. Promoting behavior change among working-class, multiethnic workers: results of the healthy directions--small business study. *Am J Public Health,* 95**,** 1389-95.

SPITTAELS, H., DE BOURDEAUDHUIJ, I., BRUG, J. & VANDELANOTTE, C. 2007. Effectiveness of an online computer-tailored physical activity intervention in a real-life setting. *Health Educ Res,* 22**,** 385-96.

STERNFELD, B., BLOCK, C., QUESENBERRY, C. P., JR., BLOCK, T. J., HUSSON, G., NORRIS, J. C., NELSON, M. & BLOCK, G. 2009. Improving diet and physical activity with ALIVE: a worksite randomized trial. *Am J Prev Med,* 36**,** 475-83.

STICE, E., SHAW, H. & MARTI, C. N. 2006. A meta-analytic review of obesity prevention programs for children and adolescents: the skinny on interventions that work. *Psychol Bull,* 132**,** 667-91.

THORNDIKE, A. N., MILLS, S., SONNENBERG, L., PALAKSHAPPA, D., GAO, T., PAU, C. T. & REGAN, S. 2014. Activity monitor intervention to promote physical activity of physicians-in-training: randomized controlled trial. *PLoS One,* 9**,** e100251.

THORP, A. A., HEALY, G. N., WINKLER, E., CLARK, B. K., GARDINER, P. A., OWEN, N. & DUNSTAN, D. W. 2012. Prolonged sedentary time and physical activity in workplace

and non-work contexts: a cross-sectional study of office, customer service and call centre employees. *Int J Behav Nutr Phys Act,* 9**,** 128.
TO, Q. G., CHEN, T. T., MAGNUSSEN, C. G. & TO, K. G. 2013. Workplace physical activity interventions: a systematic review. *Am J Health Promot,* 27**,** e113-23.
VAN WIER, M. F., ARIENS, G. A., DEKKERS, J. C., HENDRIKSEN, I. J., SMID, T. & VAN MECHELEN, W. 2009. Phone and e-mail counselling are effective for weight management in an overweight working population: a randomized controlled trial. *BMC Public Health,* 9**,** 6.
VON THIELE SCHWARZ, U., LINDFORS, P. & LUNDBERG, U. 2008. Health-related effects of worksite interventions involving physical exercise and reduced workhours. *Scand J Work Environ Health,* 34**,** 179-88.
VUILLEMIN, A., ROSTAMI, C., MAES, L., VAN CAUWENBERGHE, E., VAN LENTHE, F. J., BRUG, J., DE BOURDEAUDHUIJ, I. & OPPERT, J. M. 2011. Worksite physical activity interventions and obesity: a review of European studies (the HOPE project). *Obes Facts,* 4**,** 479-88.
WHO 2020. World Health Organization. Global strategy on diet, physical activity and health. *(accessed 28 July 2020). Available online:* https://www.who.int/dietphysicalactivity/factsheet_adults/en/.
WHO/WEF 2008. World Health Organization/World Economic Forum. Preventing non communicable diseases in the workplace through diet and physical activity. *(accessed 20 September 2019). Available online:* http://www.weforum.org/pdf/Wellness/WHOWEF_report.pdf
WONG, J. Y., GILSON, N. D., VAN UFFELEN, J. G. & BROWN, W. J. 2012. The effects of workplace physical activity interventions in men: a systematic review. *Am J Mens Health,* 6**,** 303-13.

Chapter 5: Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis (Study 1)

Chapter outline: This chapter investigates the effectiveness of interventions for reducing non-occupational SB (such as leisure and transport) in mental health professionals by systematically reviewing studies in the general adult population.

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1. PUBLICATION DETAILS (to be completed by the candidate)

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

Signature	Date
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3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;

2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;

3. There are no other authors of the publication according to these criteria;

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Abstract

Background: No systematic reviews of effectiveness of interventions for reducing non-occupational SB is available. Therefore, the aim of this systematic review was to assess the effectiveness of interventions for reducing non-occupational SB in adults and older adults.

Methods: An electronic search through nine databases was performed. Randomized controlled trial (RCT) and cluster RCT among adults testing effectiveness of interventions aimed to reduce non-occupational SB were considered for inclusion. Two review authors independently screened studies for eligibility and completed data extraction and risk of bias assessment.

Results: We included 19 studies that evaluated multicomponent lifestyle intervention, counselling or education, TV control devices and workplace interventions, which included SB measures during leisure time. Evidence from the meta-analyses suggests that interventions can reduce leisure sitting time in adults in the medium-term (-29 min/day; 95% confidence interval [CI]: -55, -2.3) and TV viewing in the short (-25 min/day; 95% CI: -37, -13) and medium term (-11 min/day; 95% CI: -20, -2). No significant pooled effects were found for transport sitting time, leisure-time computer use and long-term outcomes. We found no evidence for effectiveness of interventions for reducing non-occupational sedentary time in older adults.

Conclusions: The findings of this systematic review suggest the interventions may be effective in reducing non-occupational SB in the short-to-medium term in adults. However, no significant effect was found on long-term outcomes. The quality of evidence was, however, very low to low. No evidence was available on the effectiveness of non-occupational interventions on reducing sedentary time in older adults. Further high-quality research with larger sample is warranted.

Keywords: TV viewing, leisure sitting, sitting, computer use, transport sitting

5.1. Background

Data based on self-reports from 28 European Union countries show that during a typical day, 18.5% of adults spend more than 7.5 hours sitting (Loyen et al., 2016). Moreover, time-use surveys show a significant decline in PA and increase in SB globally (Ng and Popkin, 2012). As noted in a recent systematic review, older adults are even more sedentary than adults, as on average, they spend 9.4 hours per day in SB (Harvey et al., 2015). Studies have shown that SB may be associated with increased risk of all-cause mortality, cardiovascular disease, type 2 diabetes, and site-specific cancer (Thorp et al., 2011). Furthermore, global estimates suggest that high levels of SB and insufficient PA cause 3.8% and 9% of all deaths, respectively (Rezende et al., 2016, Lee et al., 2012).

When outside of the workplace, people are exposed to many opportunities to engage in sedentary activities. The time spent in front of the computer or television screen and using devices like tablets, smartphones and gaming consoles has great potential to increase leisure-time SB (Shuval et al., 2013). The self-reported data from USA Labor (U.S. Department of Labor, 2016) shows that TV viewing was the most prevalent leisure activity (i.e., 2.8 hours per day) among US adults in 2015, accounting for more than half of all leisure-time activities (U.S. Department of Labor, 2016). Older adults also seem to spend a large proportion of their waking hours watching TV (i.e., 3.3 hours per day) (Harvey et al., 2015). Additionally, at the population level, a significant amount of time is spent sitting in transport (Sugiyama et al., 2013). In a study among desk-based employees in Australia, self-reported transport related sitting time equated to 60 minutes per day which was approximately 11% of the total daily sitting time (Bennie et al., 2015). The use of sedentary forms of commuting has largely increased due to increased car ownership over the last several decades in high-income countries (Brian and Rapino, 2011, Australian Bureau of Statistics, 2009) and recent research indicates a significant association between greater use of cars and obesity (McCormack and Virk, 2014).

Interventions for reducing non-occupational SB can be implemented at the individual, environmental, and wider community level. At the individual level, people can be made aware of the need to reduce their time spent in sedentary pursuits by: (i) counseling or interviewing (Verweij et al., 2012), (ii) self-monitoring, alongside goal setting to review their own behavior (Spring et al., 2012), and personalized feedback (De Cocker et al., 2016) and (iii) by using prompts, which remind them of the need to break prolonged sedentary periods. Interventions such as restricting access to the television by using an electronic lock-out systems (Otten et al., 2009) or, the installation of sit-stand desks (Chau et al., 2014) are employed to modify the environment of the individual, and as a result, to reduce sedentary time. At the community level, interventions can be policies for active transport or, policies for increasing the availability of open spaces in neighborhoods for recreational walking and cycling (Sallis et al., 2006).

Several systematic reviews have been published that focus on interventions for reducing sitting time at work (Shrestha et al., 2016, Chu et al., 2016). Although non-occupational sitting time comprises a large amount of total SB, somewhat surprisingly, no reviews have focused on the effects of interventions on reducing non-occupational SB. Tharen-Borowski and colleagues (Thraen-Borowski et al., 2017) recently published a systematic review of non-worksite interventions for reducing SB. However, they only reported their effects on reducing total sedentary time, not making the distinction between occupational and non-occupational domains. Therefore, the aim of this systematic review coupled with a meta-analysis was to provide an in-depth scrutiny of the current body of literature on the effects of interventions on reducing SB in leisure-time, transport and household domains in adults and older adults, herein, referred collectively as non-occupational SB.

5.2. Methods

5.2.1 Search Strategy

This review was performed adhering to the PRISMA guidelines (Moher et al., 2009). The review protocol has been registered in PROSPERO (registration id: CRD42016051059). A comprehensive search of the following databases was performed: Academic Search Premier, Nursing/Academic Edition of Health Source, MasterFILE Premier, SPORTDiscus, MEDLINE/PubMed, Scopus, PsycINFO, CINAHL and Web of Science. Full search syntaxes can be found in supplementary table 2. Secondary searches were performed by (a) scanning the reference list of each full text that was assessed and (b) performing forward citation tracking of the included studies (using Scopus, Web of Science, and Google Scholar databases). The search concluded on 19th October 2016.

5.2.2 Inclusion criteria

Studies were deemed suitable for inclusion if they met the following criteria:

(a) a randomized controlled trial (RCT), crossover RCT, or a cluster RCT conducted with participants aged 18 years or older. We planned to conduct a separate meta-analysis for studies with participants older than 60 years, as people in this age group are more likely to have comorbid conditions, and, therefore, types, context, and outcomes of the interventions in this age group might differ from those among adults of a younger age.

(b) the interventions were aimed to reduce SB and/or increase PA and reported at least one domain of non-occupational SB, such as total leisure sitting time, household sitting time, and transport sitting time, or total non-occupational SB measured by questionnaires or wearable devices (e.g., accelerometer/inclinometer).

(c) the effectiveness of the interventions was compared with either no intervention or with another intervention.

Workplace interventions can, in addition to work-related SB, also influence non-occupational behavior. Therefore, all studies implementing SB interventions at the workplace were included, if they reported effects on non-occupational SB. We included studies in which the intervention aimed at reducing non–occupational SB was provided at any frequency, and for any duration. We did not exclude full texts published in languages other than English.

To reduce selection bias, two authors (NS and HP) independently performed the search process. Studies were excluded based on the title, abstract or full text. Disagreements were resolved by discussion and consensus with a third author (ZP).

5.2.3 Data extraction

Studies were individually coded by two of the authors (NS and GW) for the following variables:

(a) study design;

(b) participant characteristics (including the number of participants randomized into groups and the mean age or age range)

(c) study location;

(d) description of intervention and follow-up length;

(e) description of the control group

(f) methods for the assessment of outcomes;

(g) description of outcomes.

Study authors were contacted to obtain missing information and verification of key study characteristics.

5.2.4 Appraisal of study quality

Two authors (NS and JG) independently assessed the risk of bias for each of the included studies using the Cochrane risk of bias tool (Supplementary figure 1) (Higgins and Green, 2011). We assigned a judgement of "low risk", "high risk" or "unclear risk" of bias relating to the following domains: random sequence generation; allocation concealment; blinding of participants and personnel; blinding of outcome assessment; incomplete outcome data; selective outcome reporting; validity of outcome measure; and baseline comparability/imbalance for age and gender (Shrestha et al., 2016). The studies were judged as having a low risk of bias overall if they had a low risk of bias for random allocation, allocation concealment, blinding of outcome assessment, incomplete outcome data and valid outcome measure. It is difficult to blind participants, personnel in the studies trying to modify activity behavior, so we did not consider this domain in classifying trials into high versus low risk of bias in overall judgement.

5.2.5 Statistical analysis

A meta-analysis was performed to calculate pooled effect sizes for different domains/types of non-occupational SB: total leisure-time SB; total transport sitting time; TV viewing time; and leisure computer use. The meta-analysis was performed using the Comprehensive Meta-Analysis software (Biostat Inc., Englewood, NJ, USA). The difference between the intervention group and the control group in the mean change from pre- to post-intervention was used as a measure of effect size.

Three out of the four included cluster RCTs (Pesola, 2016, French et al., 2011, Sternfeld et al., 2009) accounted for the clustering. For these three studies we, therefore, did not need to adjust for the design effect. For the remaining study (De Cocker et al., 2016), the design effect was calculated based on a relatively large assumed intra-cluster correlation coefficient of 0.10. This assumption was based on a realistic estimate by analogy from implementation research studies (Campbell et al., 2001). Where study authors reported multiple trial arms in a single trial, only the relevant arms were included. In studies where two comparisons needed to be combined in the same meta-analysis, to avoid double-counting, we reduced the number of participants in the control group by half. Verweij *et al*,(2012) and Chau *et al*,(2014) reported weekday and weekend leisure-time SB separately. Since none of the included studies reported the correlation between weekday and weekend sitting time; we assumed the correlation of 0.44 previously reported by Drenowatz *et al*,(2016). We then calculated combined effect size estimates for weekday and weekend SB and their variances as recommended by Fu and colleagues (Fu et al., 2013). Follow-up times of four months or less were deemed as short-term, four months to one year as medium-term, and more than one year as long-term. The I^2 statistic was used to assess heterogeneity among the trials in each analysis. We considered the observed value of I^2: 0% to 40% as likely not important; 30% to

60% as moderate heterogeneity; 50% to 90% as substantial heterogeneity; and 75% to 100% as considerable heterogeneity, as recommended by Higgins and Green (2011). The random effects model was used in all analyses. We performed a subgroup analysis according to different types of interventions to investigate heterogeneity among the trials. The sensitivity analysis was also carried out by excluding interventions that markedly increased the overall heterogeneity and by modifying the cut-offs for categorising the follow-up duration (Supplementary figure 2). In the latter sensitivity analysis, three months or less were considered a short-term, three to six months a medium-term, and more than six months a long-term follow-up. The only cross-over study (Chau et al., 2014), included in the analyses was reported as a step-wedged cluster RCT and had no distinct first and second period. In the main analysis, we therefore included the original effect estimate reported in the study, and also performed a sensitivity analysis excluding this study. Relatively low number of included studies prevented us to assess the robustness of findings by excluding studies with high risk of bias from the meta-analyses. We could not assess for publication bias as none of the meta-analyses we conducted had 10 or more trials (Higgins and Green, 2011). The statistical significance threshold was set a priori at $p < 0.05$. The quality of evidence was assessed independently by two authors following the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria (Supplementary table 4) (Guyatt et al., 2011a, Guyatt et al., 2011b).

5.3. Results

5.3.1 Search results

Out of the 7518 documents identified in the initial search, 89 full-text studies were deemed as potentially relevant and were scrutinized in detail. As shown in Figure 7, 70 studies were excluded based on the following reasons: studies did not report leisure sitting time (*n* = 47), they were not conducted among adults (*n* = 16), the interventions were not targeted to adults, that is, they were conducted in children but measured parents' SB (*n* = 2) or were not RCTs (*n* = 5). Twenty papers from nineteen studies(Chau et al., 2014, De Cocker et al., 2016, Dutta et al., 2014, French et al., 2011, Gomersall et al., 2015a, Hu et al., 2012, Lakerveld et al., 2013, Laska et al., 2016, Otten et al., 2009, Pesola, 2016, Petersen et al., 2012, Raynor et al., 2013, Rockette-Wagner et al., 2015, Spring et al., 2012, Steeves et al., 2012, Sternfeld et al., 2009, Tomayko et al., 2017, Verweij et al., 2012, Aadahl et al., 2014, Gomersall et al., 2015b) are included in this review.

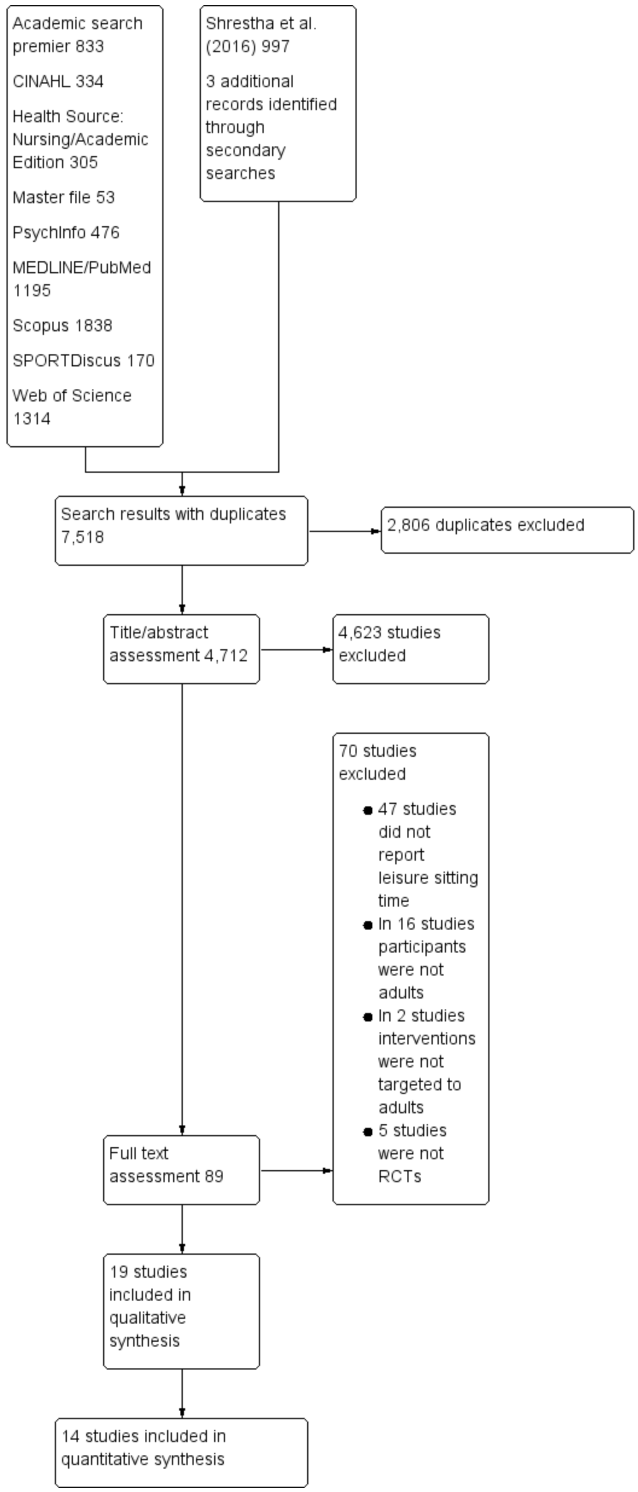

Figure 7: PRISMA flow diagram, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomised control trial

5.3.2 Included studies

Twelve of the 19 included studies were RCTs (Hu et al., 2012, Aadahl et al., 2014, Gomersall et al., 2015a, Laska et al., 2016, Petersen et al., 2012, Otten et al., 2009, Raynor et al., 2013, Rockette-Wagner et al., 2015, Spring et al., 2012, Steeves et al., 2012, Tomayko et al., 2017, Lakerveld et al., 2013), two were cross-over RCTs (Dutta et al., 2014, Chau et al., 2014) and five were cluster RCTs (French et al., 2011, Pesola, 2016, Sternfeld et al., 2009, De Cocker et al., 2016, Verweij et al., 2012). The included studies assessed the effectiveness of: [i] multi-component lifestyle interventions that included a SB and/or PA element (Hu et al., 2012, French et al., 2011, Gomersall et al., 2015a, Laska et al., 2016, Petersen et al., 2012, Steeves et al., 2012, Tomayko et al., 2017, Lakerveld et al., 2013, Rockette-Wagner et al., 2015, Spring et al., 2012); [ii] counselling or education to reduce and self-monitor leisure time SB (Aadahl et al., 2014, De Cocker et al., 2016, Pesola, 2016); [iii] television control devices to restrict access to TV (Raynor et al., 2013, Otten et al., 2009); and [iv] interventions implemented at the workplace which included SB measures during leisure time (Verweij et al., 2012, Chau et al., 2014, Dutta et al., 2014, Sternfeld et al., 2009).

Various domains of leisure-time SB were reported in these studies. TV viewing was reported in 10 studies (French et al., 2011, De Cocker et al., 2016, Gomersall et al., 2015a, Laska et al., 2016, Otten et al., 2009, Raynor et al., 2013, Rockette-Wagner et al., 2015, Steeves et al., 2012, Tomayko et al., 2017, Lakerveld et al., 2013), total leisure sitting time in 9 studies (Hu et al., 2012, Sternfeld et al., 2009, Pesola, 2016, Verweij et al., 2012, Chau et al., 2014, Aadahl et al., 2014, Petersen et al., 2012, Lakerveld et al., 2013, Dutta et al., 2014, Spring et al., 2012), leisure computer use in 4 studies (Laska et al., 2016, Lakerveld et al., 2013, Chau et al., 2014, De Cocker et al., 2016), and transport sitting time in 3 studies (De Cocker et al., 2016, Chau et al., 2014, Gomersall et al., 2015a). In five studies the follow-up was four months or less (De Cocker et al., 2016, Chau et al., 2014, Otten et al., 2009, Petersen et al., 2012, Dutta et al., 2014), while in nine studies it was 12 months or less (Pesola, 2016, Sternfeld et al., 2009, Verweij et al., 2012, Aadahl et al., 2014, Gomersall et al., 2015a, Raynor et al., 2013, Spring et al., 2012, Steeves et al., 2012, French et al., 2011). The remaining five studies followed participants for more than 12 months (Hu et al., 2012, Laska et al., 2016, Rockette-Wagner et al., 2015, Tomayko et al., 2017, Lakerveld et al., 2013).

In 11 studies the control group participants were instructed to maintain their usual lifestyle or received usual care (French et al., 2011, Sternfeld et al., 2009, Pesola, 2016, De Cocker et al., 2016, Chau et al., 2014, Verweij et al., 2012, Aadahl et al., 2014, Gomersall et al., 2015a, Otten et al., 2009, Rockette-Wagner et al., 2015, Dutta et al., 2014), whereas, in four studies, control group participants received general information on healthy lifestyles (Hu et al., 2012, Petersen et al., 2012, Laska et al., 2016, Lakerveld et al., 2013). Spring *et al* (2012), conducted a four-arm trial where the effectiveness of a different combination of advice to change one dietary behavior and one activity behavior (high sedentary leisure time or low PA) were assessed. In the Tomyako *et al* (2017), the delivery format of a curriculum for obesity prevention among families with young children (the 'Healthy lifestyle toolkit') compared in-home mentoring to delivery by mail (Tomayko et al., 2017). Raynor *et al*,(2013) conducted two pilot studies where SB intervention (counseling and restricting access to television) was compared with PA counseling intervention. In the study by Steeves *et al* (2012), participants who were instructed to 'briskly step or walk for the duration of each commercial break on TV' were compared to participants who were 'walking briskly for at least 30 minutes'. The included studies were conducted in Australia, USA, China and high-income nations in Europe, namely Denmark, Belgium, Finland and Netherlands. A description of characteristics of each included study is presented in Supplementary table 3.

5.3.3 Risk of bias in included studies

Nine studies did not report how the random sequence was generated and were thus judged to be at unclear risk for the selection bias domain (Hu et al., 2012, French et al., 2011, Sternfeld et al., 2009, Pesola, 2016, De Cocker et al., 2016, Otten et al., 2009, Petersen et al., 2012, Rockette-Wagner et al., 2015, Tomayko et al., 2017). Only three studies reported allocation concealment (Otten et al., 2009, Petersen et al., 2012, Lakerveld et al., 2013). Except for three studies (Aadahl et al., 2014, Verweij et al., 2012, Lakerveld et al., 2013), blinding of participants and personnel was not possible, and thus the studies were judged as either high risk or unclear risk for the performance bias domain. Leisure SB was assessed with self-administered questionnaires in 13 studies (Hu et al., 2012, French et al., 2011, Sternfeld et al., 2009, De Cocker et al., 2016, Verweij et al., 2012, Aadahl et al., 2014, Gomersall et al., 2015a, Laska et al., 2016, Petersen et al., 2012, Rockette-Wagner et al., 2015, Spring et al., 2012, Tomayko et al., 2017, Lakerveld et al., 2013, Steeves et al., 2012). In these studies, participants receiving the intervention would have been aware of the set goals and the purpose of the intervention and may have misreported sedentary time. This was, therefore, judged as a high risk for detection bias. SB was assessed using television control devices in two studies (Otten et al., 2009, Raynor et al., 2013) and with both self-reports and accelerometers in three studies (Pesola, 2016, Chau et al., 2014, Dutta et al., 2014). These studies did not report the blinding of outcome assessor and were thus, judged unclear risk for detection bias. We judged the studies with the attrition rate of less than 10% and studies that performed intention to treat analysis as “low risk” for the domain of attrition bias. Six studies (Aadahl et al., 2014, De Cocker et al., 2016, Gomersall et al., 2015a, Petersen et al., 2012, Sternfeld et al., 2009, Verweij et al., 2012) were judged as high risk for attrition bias. Five papers did not present results for all the outcomes mentioned in their study protocols. It might be that the missing results will be presented in future papers from the same study. Such studies were, therefore, judged unclear risk for selective reporting (Aadahl et al., 2014, De Cocker et al., 2016, Lakerveld et al., 2013, Rockette-Wagner et al., 2015, Sternfeld et al., 2009). Remaining studies reported results for all outcomes mentioned in the protocol or in the methods section and were thus judges at low risk for selective reporting (Chau et al., 2014, French et al., 2011, Gomersall et al., 2015a, Hu et al., 2012, Laska et al., 2016, Otten et al., 2009, Pesola, 2016, Petersen et al., 2012, Raynor et al., 2013, Spring et al., 2012, Steeves et al., 2012, Tomayko et al., 2017, Verweij et al., 2012). Overall, we judged all 19 studies to be at a high risk of bias. A summary of the judgments about each risk of bias item for each of the included studies is presented in Figure 8.

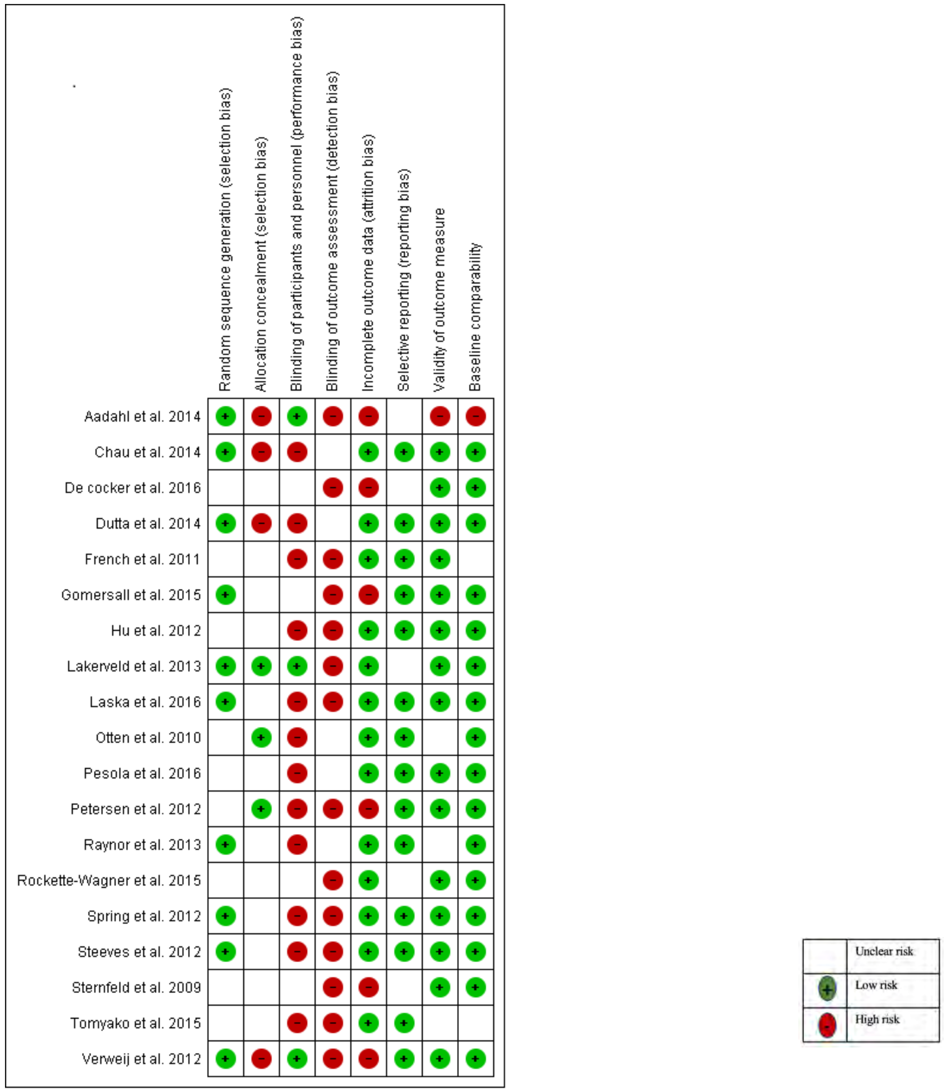

Figure 8: Risk of bias summary: review authors' judgements about each risk of bias item for each included study

5.3.4 Effects of interventions

Studies were pooled according to outcome measure (see Figure 3). We could not pool studies according to the type of intervention as interventions were heterogeneous and there were only a few studies for each intervention. However, a subgroup analysis was performed according to type of intervention to investigate heterogeneity.

5.3.4.1 Outcome: Total leisure sitting time

We pooled six studies reporting total leisure sitting time at medium-term follow-up (Hu et al., 2012, Sternfeld et al., 2009, Pesola, 2016, Verweij et al., 2012, Aadahl et al., 2014, Lakerveld et al., 2013). The pooled analysis showed that the interventions reduced sitting time on average by 30 minutes per day (95% confidence interval [CI] -58 to -2 min/day, figure 9). However, there was substantial heterogeneity between pooled studies (I^2 = 91%). When the sensitivity analysis was performed by excluding the studies conducted in the workplace setting (Sternfeld et al., 2009, Verweij et al., 2012), the pooled effect showed a similar reduction in sitting time of 30 minutes per day (95% CI: -62, -2 min/day; I^2 = 94%), again with considerable heterogeneity. In the subgroup analysis, none of the interventions showed a significant reduction in total leisure sitting time at medium-term follow up.

Three studies could not be included in the meta-analysis (Spring et al., 2012, Dutta et al., 2014, Petersen et al., 2012). Spring et al. (2012), only reported a reduction in total leisure sitting time by on average 90 minutes per day at 20 weeks follow-up. Dutta et al. (2014), reported no difference in total leisure sitting time between intervention and control periods. Data presented by Petersen et al. (2012), did not allow for calculation of time spent in SB, and the study was, therefore, not included in the meta-analysis.

None of the included studies reported total leisure sitting time at short and long-term follow up.

Group by Intervention type	Study name	Difference in means	Lower limit	Upper limit	p-Value	Sample size: Intervention	Sample size: Control
Leisure sitting medium-term follow-up							
	Aadahl et al. 2014	-48.60	-81.02	-16.18	0.003	76	65
	Pesola et al. 2016	-2.63	-7.95	2.69	0.333	56	52
Educational		-22.72	-67.41	21.97	0.319		
	Lakerveld et al. 2014	-14.20	-32.80	4.40	0.135	253	249
	Hu et al. 2012	-60.00	-75.50	-44.50	0.000	586	594
Multicomponent		-37.40	-82.28	7.48	0.102		
	Sternfeld et al. 2009	-75.20	-153.40	3.00	0.059	195	436
	Verweij et al. 2014	-7.50	-32.17	17.17	0.551	274	249
Workplace		-30.76	-93.78	32.25	0.339		
Overall		-30.18	-58.47	-1.88	0.037		

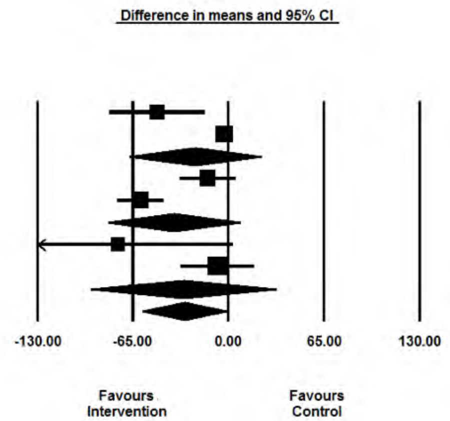

Figure 9: Forrest plot showing effects of interventions on total leisure sitting time

5.3.4.2 Outcome: TV viewing

We pooled six studies reporting TV viewing at short-term follow-up (De Cocker et al., 2016, Chau et al., 2014, Gomersall et al., 2015a, Laska et al., 2016, Otten et al., 2009, Raynor et al., 2013). The pooled analysis showed that the interventions reduced TV viewing by on average 56 minutes per day (95% CI: -73, -38; I^2 = 79%, figure 10), with considerable heterogeneity. The sensitivity analysis performed by excluding the studies that assessed restricting access to the TV using television control devices (Raynor et al., 2013, Otten et al., 2009) resulted in an average reduction of 34 minutes per day (95% CI: -60, -8; I^2 = 69%), with substantial heterogeneity. In the sensitivity analysis, excluding the cross-over study (Chau et al., 2014), the pooled effect showed a similar reduction of 51 minutes per day on average (95% CI: -86, -15; I^2 = 78%) as in the main analysis, with considerable heterogeneity. In the subgroup analysis, the interventions aimed at restricting access to the TV using television control devices reduced TV viewing by on average 128 minutes per day (95% CI: -170, -85; I^2 = 0%). The subgroup analysis did not show a significant reduction for multicomponent interventions (Laska et al., 2016, Gomersall et al., 2015a) and educational interventions (De Cocker et al., 2016).

Five studies reported TV viewing at medium-term follow-up (French et al., 2011, Gomersall et al., 2015a, Laska et al., 2016, Rockette-Wagner et al., 2015, Lakerveld et al., 2013). The pooled effect size estimate showed a mean reduction of 11 minutes per day (95% CI: -20, -2; I^2 = 49%), with moderate heterogeneity. All five studies included in this analysis evaluated the effectiveness of multicomponent interventions.

Three studies reported TV viewing at long-term follow-up (Laska et al., 2016, Rockette-Wagner et al., 2015, Lakerveld et al., 2013). The pooled analysis of these studies did not show a significant reduction in TV viewing time (d = -2 min/day; 95% CI: -17, 13; I^2 = 80%). All three studies included in this analysis evaluated the effectiveness of multicomponent interventions.

We also performed sensitivity analysis by modifying the cut-offs for short, medium- and long-term follow-up. The effect sizes were similar for all the follow-up categories; however, the reduction in TV viewing time for medium-term follow-up was no longer significant.

In the studies that were not included in the pooled analysis, Steeves et al. (2012), found that participants in both stepping and walking groups during TV commercial breaks reduced TV viewing by 60 minutes at 6 months follow-up. Similarly, Tomayko et al. (2017), reported a half an hour reduction in TV viewing for a healthy lifestyle toolkit delivered either by mail or in-home mentoring.

Group by Intervention type	Study name	Difference in means	Lower limit	Upper limit	p-Value	Sample size Intervention	Sample size control
TV viewing short-term follow up							
	De Cocker et al. 2016	-15.00	-64.01	34.01	0.549	22	8
	De Cocker et al. 2016	-16.00	-65.35	33.35	0.525	41	8
Educational		-15.50	-50.27	19.28	0.382		
	Laska et al. 2016	-6.00	-22.63	10.63	0.479	194	194
	Gomersall et al. 2015	-52.00	-92.82	-11.18	0.013	37	19
	Gomersall et al. 2015	-49.00	-97.26	-0.74	0.047	37	18
Multicomponent		-30.61	-65.48	4.26	0.085		
	Raynor et al. 2013	-162.00	-289.88	-34.12	0.013	12	12
	Raynor et al. 2013	-72.00	-225.36	81.36	0.357	14	14
	Otten et al. 2010	-128.40	-175.30	-81.50	0.000	20	16
TV restricting		-127.79	-170.10	-85.47	0.000		
	Chau et al. 2014	-67.00	-96.12	-37.88	0.000	21	21
Workplace		-67.00	-96.12	-37.88	0.000		
Overall		-55.61	-72.79	-38.43	0.000		
TV viewing medium-term follow-up							
	Lakerveld et al. 2013	-6.70	-15.33	1.93	0.128	249	253
	Laska et al. 2016	6.00	-10.63	22.63	0.480	188	184
	Rockette-Wagner et al. 2015	-15.00	-22.78	-7.22	0.000	1079	1077
	Gomersall et al. 2015	-17.00	-55.26	21.26	0.384	37	17
	Gomersall et al. 2015	-13.00	-58.91	32.91	0.579	36	17
	French et al. 2011	-32.77	-56.29	-9.25	0.006		
Multicomponent		-10.75	-19.69	-1.81	0.018		
TV viewing long-term follow-up							
	Lakerveld et al. 2013	3.80	-3.63	11.23	0.316	242	248
	Laska et al. 2016	12.00	-6.59	30.59	0.206	179	174
Multicomponent		4.93	-1.97	11.83	0.161		

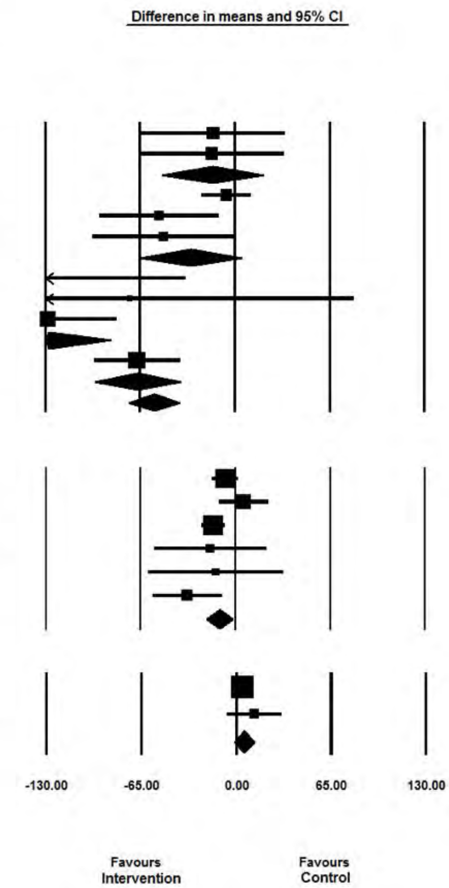

Figure 10: Forrest plot showing effects of intervention on television (TV) viewing sitting time

5.3.4.3 Outcome: Leisure computer use

We pooled three studies reporting leisure computer use at short-term follow-up (De Cocker et al., 2016, Chau et al., 2014, Laska et al., 2016). The meta-analysis did not find a significant pooled effect size (d = 2 min/day; 95% CI: -11, 16; I^2 = 0%, figure 11).

Lakerveld et al. (2013) reported a non-significant reduction of -2 minutes/day (95% CI: -9.4, 5.4) in leisure computer use at medium-term follow-up.

Two studies reported leisure computer use at long-term (Laska et al., 2016, Lakerveld et al., 2013). The pooled effect size was not significant (d = 5 min/day; 95% CI: -2, 12; I^2 = 0%).

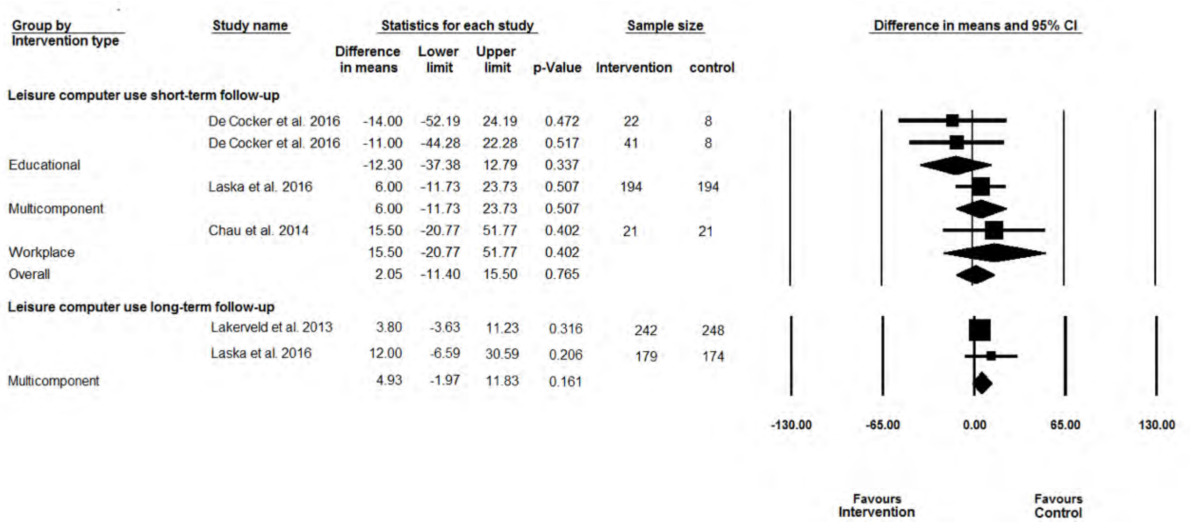

Figure 11: Forrest plot showing effects of interventions on leisure computer use sitting time

5.3.4.4 Outcome: Total transport sitting time

We pooled three studies reporting transport sitting time at short-term follow-up (De Cocker et al., 2016, Chau et al., 2014, Gomersall et al., 2015a). The pooled effect size was not significant (d = -5 min/day; 95% CI: -19, 9; I^2 = 0%, figure 12).

Gomersall et al. (2015a) reported a non-significant reduction of 5 minutes/day (95% CI: -12, 22) in transport sitting time at medium-term follow up.

No study reported total transport sitting time at long-term follow-up.

Group by Intervention type	Study name	Difference in means	Lower limit	Upper limit	p-Value	Sample size: Intervention	Sample size: control
Transport sitting time short-term follow up							
	De Cocker et al. 2016	-1.00	-64.37	62.37	0.975	22	8
	De Cocker et al. 2016	-1.00	-56.21	54.21	0.972	41	8
Educational		-1.00	-42.63	40.63	0.962		
	Gomersall et al. 2014	-1.00	-24.66	22.66	0.934	37	18
	Gomersall et al. 2014	-9.00	-34.00	16.00	0.480	37	19
Multicomponent		-4.78	-21.96	12.40	0.586		
	Chau et al. 2014	-8.00	-41.96	25.96	0.644	21	21
Workplace		-8.00	-41.96	25.96	0.644		
Overall		-4.91	-19.29	9.48	0.504		

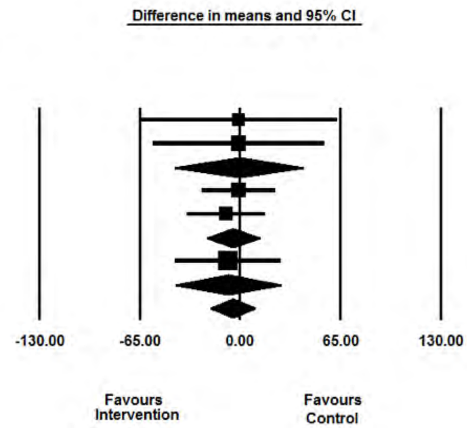

Figure 12: Forrest plot showing effects of intervention on total transport sitting time

5.3.4.5 Interventions in older adults

We did not find any RCTs with participants older than 60 years.

5.4. Discussion

The findings of this review show that interventions may reduce sedentary leisure time in the medium-term and TV viewing in short- to medium-term. However, we found no evidence of long-term efficacy for any intervention. Furthermore, the heterogeneity in reported outcomes, interventions and control arms (usual care/another active intervention) prevented us to perfom a robust meta-analysis and draw firm conclusions. The quality of evidence was very low to low for all outcomes (Supplementary table 4).

Currently, most adults spend a significant amount of time in front of the TV (U.S. Department of Labor, 2016). Therefore, even a small reduction in TV viewing might result in significant public health benefits (Wijndaele et al., 2017). One of the strategy for reducing TV viewing time was restricting access to the TV using a television control device. It seems that such an intervention for reducing TV viewing time is likely to be effective in the short to medium term. However, the practical usability and acceptability of such devices remains unclear and questionable. Our findings are consistent with those of two systematic reviews (Wu et al., 2016, Ramsey Buchanan et al., 2016) that primarily included studies that assessed restricting access to TV using television control devices. We found that other interventions may have an impact on TV viewing, but that it is potentially somewhat smaller than for the interventions using the TV control device.

Interestingly, Chau et al. (2014), reported a decrease in TV viewing time by implementing a sit-stand workstation. Similar findings were reported by De Cocker et al. (2016), by implementing a web-based, interactive, computer-tailored intervention in a workplace setting. It was previously hypothesized that reducing occupational sedentary time will result in compensatory effects (i.e., increase in non-occupational sedentary time) (Mansoubi et al., 2016). However, findings of Chau et al. (2014) and De Cocker et al. (2016), studies do not support this hypothesis. It might be that SB interventions at work made people aware of the potential hazards of sitting and they not only reduced sitting at work but also outside of work. Further research on the topic is warranted.

We did not find significant pooled effects of interventions on transport sitting time. This might be because none of the interventions was specifically aimed at reducing transport sitting time. Various interventions for increasing active travel (such as walking and cycling) might serve as a possible avenue for reducing SB, and their effects on transport sitting time, therefore, should be investigated in future studies (Saunders et al., 2013). Furthermore, no evidence was available on the efficacy of interventions on sedentary time among older adults. A recently published review by Copeland et al. (2017). concluded that SB interventions were feasible and effective in reducing sedentary time in older adults. However, there were only two pre-post studies that reported leisure time SB

(Asaoka et al., 2007, Lewis et al., 2016). Hence, interventions targeting reduction in specific domains of leisure time SB in older adults need to be designed and tested using an RCT in a larger sample of participants.

Though educational interventions seem to be promising, there was no significant reduction in SB with such interventions. Multicomponent interventions were found to be only effective in reducing TV viewing time in the medium term. However, these finding needs to be interpreted with scrutiny as there were very few studies in each analysis.

Furthermore, there is very little evidence available about the contribution of newer technologies, such as smartphones and tablets, to SB. It is unknown if reducing their use may have an impact on population SB. Various other strategies to reduce leisure sitting time like standing during commercial breaks (Busschaert et al., 2016), using active gaming platforms (Ramsey Buchanan et al., 2016) and use of new technologies (e.g., apps delivered on smartphones and tablets) (Hadgraft and Owen, 2017, Spring et al., 2012, King et al., 2013, Stephenson et al., 2017) may also need to be considered and examined in future trials.

Evidence on health outcomes of SB seems to be equivocal. For example, a recent large intervention trial by Healy et al. (2017), did not find significant effects of reducing sitting time on most cardiometabolic risk biomarkers considered in the study (Healy et al., 2017), whilst several observational studies reported a favorable association of reallocating SB to light or moderate-to-vigorous intensity PA with cardio metabolic biomarkers (Whitaker et al., 2017, Buman et al., 2014, Falconer et al., 2015), depressive symptoms (Mekary et al., 2013) and mortality risk (Wijndaele et al., 2017, Loprinzi and Loenneke, 2017, Fishman et al., 2016). The observational studies suggested that for reallocating 30 minutes of SB to light PA one can expect 1.9% lower triglycerides (Buman et al., 2014), 2.4% lower insulin (Buman et al., 2014) and a 20% reduction in the mortality risk at 5 years follow up (Fishman et al., 2016). Although in a short term such reallocations seem to be attainable, we did not find any evidence showing the potential of interventions to sustain such reallocations over a longer period.

It is important to note that some SBs (e.g., socializing/reading) may provide health benefits, such as improved mental well-being, despite being conducted in a seated position (Alpass and Neville, 2003, Hertzog et al., 2008). SB, therefore, cannot be characterised as ultimately ‘unhealthy’. Recent theoretical frameworks suggest that a right balance between the amounts of time spent sleeping, in SB, and in PA may be needed for good health (Pedišić et al., 2017, Pedišić, 2014). Effectiveness of different strategies for achieving the optimal balance between these behaviours may be an interesting topic for future intervention trials.

Most SB interventions aimed at reducing one or two domains of SB. However, any reduction in one domain of SB does not mean it will be replaced with only light or moderate PA. It is also possible that it will lead to an increase in other SBs (e.g., TV viewing may be replaced by listening to music while sitting or seated computer use) (Biddle et al., 2014). Therefore, future leisure SB interventions should consider having components targeting each domain separately and consider ways to be replacing one SB with a more active alternative.

A review by Gardner et al. (2016), indicated that interventions for adults that are primarily aimed at reducing SB rather than increasing PA seem to be most promising in reducing SB. We could not test their hypothesis, because of the small number of studies included in each meta-analysis. Although reducing total sedentary time by 30 minutes/day was suggested to have a potential to produce clinically meaningful positive effects on health (Buman et al., 2014, Falconer et al., 2015, Fishman et al., 2016, Loprinzi and Loenneke, 2017, Mekary et al., 2013, Whitaker et al., 2017, Wijndaele et al., 2017), in most intervention studies, it was not clear to which component of time-use was non-occupational sedentary time reallocated, because they did not assess all the remaining activity- and inactivity-related components of the 24-hour day; that is, sleeping, quiet standing, light PA, and moderate-to-vigorous PA. The distribution of time spent in SB, sleep, light PA and moderate-to-vigorous PA seems to be significantly associated with a variety of health outcomes (Chastin et al., 2015). It would seem that focusing solely on one of these components of time-use might be misguided; rather the focus should be on achieving a sustainable balance in all components (Pedišić, 2014). Furthermore, it has been shown that clustering of unhealthy lifestyle behaviors, such as low PA, high SB and poor sleep duration may be associated with obesity (Cassidy et al., 2017). Future intervention trials might, therefore, need to consider tracking not only the reduction/increase in a specific behavior but also, the distribution of time over all the above-mentioned time-use components.

The major limitations of this review are the small number of included studies and significant heterogeneity between them. Most of the studies had methodological limitations including small sample size and failure to blind outcome accessor. Most studies included in the meta-analyses assessed SB using self-reports. While self-reports may have lower reliability than some device-based measures of SB, they have significant comparative advantages for assessing domain- and type-specific sitting time (Healy et al., 2011). This is especially the case for the activities that are performed on a regular basis, such as TV viewing (Healy et al., 2011). A limitation of accelerometers and similar device-based measures is that, without the support of self-reports, their data does not allow for discerning between domains of sitting time (Pedisic and Bauman, 2015). Additionally, motion sensors which do not have inbuilt inclinometers might have questionable validity as they often cannot distinguish between quiet standing and sitting and may, therefore, overestimate sitting time (Pedisic and Bauman, 2015). Future intervention trials should, therefore, consider using both device-based measurement and self-reports to gather more robust and complete data. Furthermore, from the studies on TV viewing and computer use, very often it could not be discerned whether the screen time was spent sitting or standing. The same methodological issue was also found in the studies on SB in the transport domain. Future studies evaluating the effectiveness of interventions to reduce screen time and transport-related SB should select measures that allow for better differentiation between sitting and standing.

5.5. Conclusions

Our findings suggest that it is possible to reduce non-occupational SB in short to medium-term through targeted interventions in adults. However, it is still unclear whether such behavioral change is feasible and sustainable over long term to attain health benefits. Higher quality studies in larger sample of participants are required to determine the approaches that will be most effective at inducing a reduction in non-occupational SB in long-term conditions. The future studies should also consider addressing the optimum balance between all activity- and inactivity-related behaviors; sleep, SB, light intensity and moderate-to-vigorous intensity PA, to attain healthy lifestyle.

References

AADAHL, M., LINNEBERG, A., MOLLER, T. C., ROSENORN, S., DUNSTAN, D. W., WITTE, D. R. & JORGENSEN, T. 2014. Motivational counseling to reduce sitting time: a community-based randomized controlled trial in adults. *Am J Prev Med,* 47**,** 576-86.

ALPASS, F. M. & NEVILLE, S. 2003. Loneliness, health and depression in older males. *Aging Ment Health,* 7**,** 212-6.

ASAOKA, S., FUKUDA, K., TSUTSUI, Y. & YAMAZAKI, K. 2007. Does television viewing cause delayed and/or irregular sleep–wake patterns? *Sleep and Biological Rhythms,* 5**,** 23-27.

AUSTRALIAN BUREAU OF STATISTICS 2009. Environmental issues: Waste management and transport use. *(accessed 15 June 2017). Available onlione: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4602.0.55.002Main+Features1Mar%202009*

BENNIE, J. A., PEDISIC, Z., TIMPERIO, A., CRAWFORD, D., DUNSTAN, D., BAUMAN, A., VAN UFFELEN, J. & SALMON, J. 2015. Total and domain-specific sitting time among employees in desk-based work settings in Australia. *Aust N Z J Public Health,* 39**,** 237-42.

BIDDLE, S. J., PETROLINI, I. & PEARSON, N. 2014. Interventions designed to reduce sedentary behaviours in young people: a review of reviews. *Br J Sports Med,* 48**,** 182-6.

BRIAN, M. & RAPINO, M. 2011. Commuting in the United States: 2009. (accessed 15 June 2017). https://www.census.gov/prod/2011pubs/acs-15.pdf *American Community Survey Reports.* Washington, DC: ACS-15. U.S. Census Bureau.

BUMAN, M. P., WINKLER, E. A., KURKA, J. M., HEKLER, E. B., BALDWIN, C. M., OWEN, N., AINSWORTH, B. E., HEALY, G. N. & GARDINER, P. A. 2014. Reallocating time to sleep, sedentary behaviors, or active behaviors: associations with cardiovascular disease risk biomarkers, NHANES 2005-2006. *Am J Epidemiol,* 179**,** 323-34.

BUSSCHAERT, C., RIDGERS, N. D., DE BOURDEAUDHUIJ, I., CARDON, G., VAN CAUWENBERG, J. & DE COCKER, K. 2016. Socio-Demographic, Social-Cognitive, Health-Related and Physical Environmental Variables Associated with Context-Specific Sitting Time in Belgian Adolescents: A One-Year Follow-Up Study. *PLoS One,* 11**,** e0167553.

CAMPBELL, M. K., MOLLISON, J. & GRIMSHAW, J. M. 2001. Cluster trials in implementation research: estimation of intracluster correlation coefficients and sample size. *Stat Med,* 20**,** 391-9.

CASSIDY, S., CHAU, J. Y., CATT, M., BAUMAN, A. & TRENELL, M. I. 2017. Low physical activity, high television viewing and poor sleep duration cluster in overweight and obese adults; a cross-sectional study of 398,984 participants from the UK Biobank. *Int J Behav Nutr Phys Act,* 14**,** 57.

CHASTIN, S. F., PALAREA-ALBALADEJO, J., DONTJE, M. L. & SKELTON, D. A. 2015. Combined Effects of Time Spent in Physical Activity, Sedentary Behaviors and Sleep on Obesity and Cardio-Metabolic Health Markers: A Novel Compositional Data Analysis Approach. *PLoS One,* 10**,** e0139984.

CHAU, J. Y., DALEY, M., DUNN, S., SRINIVASAN, A., DO, A., BAUMAN, A. E. & VAN DER PLOEG, H. P. 2014. The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act,* 11**,** 127.

CHU, A. H., NG, S. H., TAN, C. S., WIN, A. M., KOH, D. & MULLER-RIEMENSCHNEIDER, F. 2016. A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obes Rev,* 17**,** 467-81.

COPELAND, J. L., ASHE, M. C., BIDDLE, S. J., BROWN, W. J., BUMAN, M. P., CHASTIN, S., GARDINER, P. A., INOUE, S., JEFFERIS, B. J., OKA, K., OWEN, N., SARDINHA, L. B., SKELTON, D. A., SUGIYAMA, T. & DOGRA, S. 2017. Sedentary time in older adults: a critical review of measurement, associations with health, and interventions. *Br J Sports Med*.

DE COCKER, K., DE BOURDEAUDHUIJ, I., CARDON, G. & VANDELANOTTE, C. 2016. The effectiveness of a web-based computer-tailored intervention on workplace sitting: A randomized controlled trial. *J Med Internet Res,* 18**,** e96.

DRENOWATZ, C., GRIBBEN, N., WIRTH, M. D., HAND, G. A., SHOOK, R. P., BURGESS, S. & BLAIR, S. N. 2016. The Association of Physical Activity during Weekdays and Weekend with Body Composition in Young Adults. *J Obes,* 2016**,** 8236439.

DUTTA, N., KOEPP, G. A., STOVITZ, S. D., LEVINE, J. A. & PEREIRA, M. A. 2014. Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health,* 11**,** 6653-65.

FALCONER, C. L., PAGE, A. S., ANDREWS, R. C. & COOPER, A. R. 2015. The Potential Impact of Displacing Sedentary Time in Adults with Type 2 Diabetes. *Med Sci Sports Exerc,* 47**,** 2070-5.

FISHMAN, E. I., STEEVES, J. A., ZIPUNNIKOV, V., KOSTER, A., BERRIGAN, D., HARRIS, T. A. & MURPHY, R. 2016. Association between Objectively Measured Physical Activity and Mortality in NHANES. *Med Sci Sports Exerc,* 48**,** 1303-11.

FRENCH, S. A., GERLACH, A. F., MITCHELL, N. R., HANNAN, P. J. & WELSH, E. M. 2011. Household obesity prevention: Take Action--a group-randomized trial. *Obesity (Silver Spring),* 19**,** 2082-8.

FU, R., VANDERMEER, B. W., SHAMLIYAN, T. A., O'NEIL, M. E., YAZDI, F., FOX, S. H. & C., M. S. 2013. *Handling Continuous Outcomes in Quantitative Synthesis. Methods Guide for Comparative Effectiveness Reviews,* Rockville, MD, Agency for Healthcare Research and Quality.

GARDNER, B., SMITH, L., LORENCATTO, F., HAMER, M. & BIDDLE, S. J. 2016. How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychol Rev,* 10**,** 89-112.

GOMERSALL, S., MAHER, C., ENGLISH, C., ROWLANDS, A. & OLDS, T. 2015a. Time regained: when people stop a physical activity program, how does their time use change? A randomised controlled trial. *PLoS One,* 10**,** e0126665.

GOMERSALL, S. R., NORTON, K., MAHER, C., ENGLISH, C. & OLDS, T. S. 2015b. In search of lost time: When people undertake a new exercise program, where does the time come from? A randomized controlled trial. *J Sci Med Sport,* 18**,** 43-8.

GUYATT, G., OXMAN, A. D., AKL, E. A., KUNZ, R., VIST, G., BROZEK, J., NORRIS, S., FALCK-YTTER, Y., GLASZIOU, P., DEBEER, H., JAESCHKE, R., RIND, D., MEERPOHL, J., DAHM, P. & SCHUNEMANN, H. J. 2011a. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol,* 64**,** 383-94.

GUYATT, G. H., OXMAN, A. D., KUNZ, R., BROZEK, J., ALONSO-COELLO, P., RIND, D., DEVEREAUX, P. J., MONTORI, V. M., FREYSCHUSS, B., VIST, G., JAESCHKE, R.,

WILLIAMS, J. W., JR., MURAD, M. H., SINCLAIR, D., FALCK-YTTER, Y., MEERPOHL, J., WHITTINGTON, C., THORLUND, K., ANDREWS, J. & SCHUNEMANN, H. J. 2011b. GRADE guidelines 6. Rating the quality of evidence--imprecision. *J Clin Epidemiol,* 64**,** 1283-93.

HADGRAFT, N. & OWEN, N. 2017. Sedentary Behavior and Health: Broadening the Knowledge Base and Strengthening the Science. *Res Q Exerc Sport,* 88**,** 123-129.

HARVEY, J. A., CHASTIN, S. F. & SKELTON, D. A. 2015. How Sedentary are Older People? A Systematic Review of the Amount of Sedentary Behavior. *J Aging Phys Act,* 23**,** 471-87.

HEALY, G. N., CLARK, B. K., WINKLER, E. A., GARDINER, P. A., BROWN, W. J. & MATTHEWS, C. E. 2011. Measurement of adults' sedentary time in population-based studies. *Am J Prev Med,* 41**,** 216-27.

HEALY, G. N., WINKLER, E. A. H., EAKIN, E. G., OWEN, N., LAMONTAGNE, A. D., MOODIE, M. & DUNSTAN, D. W. 2017. A Cluster RCT to Reduce Workers' Sitting Time: Impact on Cardiometabolic Biomarkers. *Med Sci Sports Exerc,* 49**,** 2032-2039.

HERTZOG, C., KRAMER, A. F., WILSON, R. S. & LINDENBERGER, U. 2008. Enrichment Effects on Adult Cognitive Development: Can the Functional Capacity of Older Adults Be Preserved and Enhanced? *Psychol Sci Public Interest,* 9**,** 1-65.

HIGGINS, J. P. T. & GREEN, S. 2011. Cochrane handbookfor systematic reviews of interventions version 5.1.0[updated March 2011]. *The Cochrane Collaboration. Available Online* www.cochrane-handbook.org.

HU, G., TIAN, H., ZHANG, F., LIU, H., ZHANG, C., ZHANG, S., WANG, L., LIU, G., YU, Z., YANG, X., QI, L., ZHANG, C., WANG, H., LI, M., LENG, J., LI, Y., DONG, L. & TUOMILEHTO, J. 2012. Tianjin Gestational Diabetes Mellitus Prevention Program: study design, methods, and 1-year interim report on the feasibility of lifestyle intervention program. *Diabetes Res Clin Pract,* 98**,** 508-17.

KING, A. C., HEKLER, E. B., GRIECO, L. A., WINTER, S. J., SHEATS, J. L., BUMAN, M. P., BANERJEE, B., ROBINSON, T. N. & CIRIMELE, J. 2013. Harnessing different motivational frames via mobile phones to promote daily physical activity and reduce sedentary behavior in aging adults. *PLoS One,* 8**,** e62613.

LAKERVELD, J., BOT, S. D., VAN DER PLOEG, H. P. & NIJPELS, G. 2013. The effects of a lifestyle intervention on leisure-time sedentary behaviors in adults at risk: the Hoorn Prevention Study, a randomized controlled trial. *Prev Med,* 57**,** 351-6.

LASKA, M. N., LYTLE, L. A., NANNEY, M. S., MOE, S. G., LINDE, J. A. & HANNAN, P. J. 2016. Results of a 2-year randomized, controlled obesity prevention trial: Effects on diet, activity and sleep behaviors in an at-risk young adult population. *Prev Med,* 89**,** 230-6.

LEE, I. M., SHIROMA, E. J., LOBELO, F., PUSKA, P., BLAIR, S. N., KATZMARZYK, P. T. & LANCET PHYSICAL ACTIVITY SERIES WORKING, G. 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet,* 380**,** 219-29.

LEWIS, L. K., ROWLANDS, A. V., GARDINER, P. A., STANDAGE, M., ENGLISH, C. & OLDS, T. 2016. Small Steps: Preliminary effectiveness and feasibility of an incremental goal-setting intervention to reduce sitting time in older adults. *Maturitas,* 85**,** 64-70.

LOPRINZI, P. D. & LOENNEKE, J. P. 2017. Mortality risk and perceived quality of life as a function of waking time in discretionary movement-based behaviors: isotemporal substitution effects. *Qual Life Res,* 26**,** 343-348.

LOYEN, A., VAN DER PLOEG, H. P., BAUMAN, A., BRUG, J. & LAKERVELD, J. 2016. European Sitting Championship: Prevalence and Correlates of Self-Reported Sitting Time in the 28 European Union Member States. *PLoS One,* 11**,** e0149320.

MANSOUBI, M., PEARSON, N., BIDDLE, S. J. & CLEMES, S. A. 2016. Using Sit-to-Stand Workstations in Offices: Is There a Compensation Effect? *Med Sci Sports Exerc,* 48**,** 720-5.

MCCORMACK, G. R. & VIRK, J. S. 2014. Driving towards obesity: a systematized literature review on the association between motor vehicle travel time and distance and weight status in adults. *Prev Med,* 66**,** 49-55.

MEKARY, R. A., LUCAS, M., PAN, A., OKEREKE, O. I., WILLETT, W. C., HU, F. B. & DING, E. L. 2013. Isotemporal substitution analysis for physical activity, television watching, and risk of depression. *Am J Epidemiol,* 178**,** 474-83.

MOHER, D., LIBERATI, A., TETZLAFF, J., ALTMAN, D. G. & GROUP, P. 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol,* 62**,** 1006-12.

NG, S. W. & POPKIN, B. M. 2012. Time use and physical activity: a shift away from movement across the globe. *Obes Rev,* 13**,** 659-80.

OTTEN, J. J., JONES, K. E., LITTENBERG, B. & HARVEY-BERINO, J. 2009. Effects of television viewing reduction on energy intake and expenditure in overweight and obese adults: a randomized controlled trial. *Arch Intern Med,* 169**,** 2109-15.

PEDIŠIĆ, Ž. 2014. Measurement issues and por adjustments for physical activity and sleep undermine sedentary behaviour research —The focus should shift to the balance between sleep, sedentary behaviour, standing and activity. *Kinesiology,* 1**,** 135-46.

PEDISIC, Z. & BAUMAN, A. 2015. Accelerometer-based measures in physical activity surveillance: current practices and issues. *Br J Sports Med,* 49**,** 219-23.

PEDIŠIĆ, Ž., DUMUID, D. & OLDS, T. 2017. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology,* 49**,** 1-18.

PESOLA, A. 2016. *Reduced Muscle Inactivity, Sedentary: Effectiveness of a One-Year Family-Based Cluster Randomized Controlled Trial.* PhD, University of Jyväskylä.

PETERSEN, C. B., SEVERIN, M., HANSEN, A. W., CURTIS, T., GRONBAEK, M. & TOLSTRUP, J. S. 2012. A population-based randomized controlled trial of the effect of combining a pedometer with an intervention toolkit on physical activity among individuals with low levels of physical activity or fitness. *Prev Med,* 54**,** 125-30.

RAMSEY BUCHANAN, L., ROOKS-PECK, C. R., FINNIE, R. K., WETHINGTON, H. R., JACOB, V., FULTON, J. E., JOHNSON, D. B., KAHWATI, L. C., PRATT, C. A., RAMIREZ, G., GLANZ, K. & COMMUNITY PREVENTIVE SERVICES TASK, F. 2016. Reducing Recreational Sedentary Screen Time: A Community Guide Systematic Review. *Am J Prev Med,* 50**,** 402-15.

RAYNOR, H. A., STEEVES, E. A., BASSETT, D. R., JR., THOMPSON, D. L., GORIN, A. A. & BOND, D. S. 2013. Reducing TV watching during adult obesity treatment: two pilot randomized controlled trials. *Behav Ther,* 44**,** 674-85.

REZENDE, L. F., SA, T. H., MIELKE, G. I., VISCONDI, J. Y., REY-LOPEZ, J. P. & GARCIA, L. M. 2016. All-Cause Mortality Attributable to Sitting Time: Analysis of 54 Countries Worldwide. *Am J Prev Med,* 51**,** 253-63.

ROCKETTE-WAGNER, B., EDELSTEIN, S., VENDITTI, E. M., REDDY, D., BRAY, G. A., CARRION-PETERSEN, M. L., DABELEA, D., DELAHANTY, L. M., FLOREZ, H., FRANKS, P. W., MONTEZ, M. G., RUBIN, R., KRISKA, A. M. & DIABETES PREVENTION PROGRAM RESEARCH, G. 2015. The impact of lifestyle intervention on sedentary time in individuals at high risk of diabetes. *Diabetologia,* 58**,** 1198-202.

SALLIS, J. F., CERVERO, R. B., ASCHER, W., HENDERSON, K. A., KRAFT, M. K. & KERR, J. 2006. An ecological approach to creating active living communities. *Annu Rev Public Health,* 27**,** 297-322.

SAUNDERS, L. E., GREEN, J. M., PETTICREW, M. P., STEINBACH, R. & ROBERTS, H. 2013. What are the health benefits of active travel? A systematic review of trials and cohort studies. *PLoS One,* 8**,** e69912.

SHRESTHA, N., KUKKONEN-HARJULA, K. T., VERBEEK, J. H., IJAZ, S., HERMANS, V. & BHAUMIK, S. 2016. Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev,* 3**,** CD010912.

SHUVAL, K., GABRIEL, K. P. & LEONARD, T. 2013. TV viewing and BMI by race/ethnicity and socio-economic status. *PLoS One,* 8**,** e63579.

SPRING, B., SCHNEIDER, K., MCFADDEN, H. G., VAUGHN, J., KOZAK, A. T., SMITH, M., MOLLER, A. C., EPSTEIN, L. H., DEMOTT, A., HEDEKER, D., SIDDIQUE, J. & LLOYD-JONES, D. M. 2012. Multiple behavior changes in diet and activity: a randomized controlled trial using mobile technology. *Arch Intern Med,* 172**,** 789-96.

STEEVES, J. A., BASSETT, D. R., FITZHUGH, E. C., RAYNOR, H. A. & THOMPSON, D. L. 2012. Can sedentary behavior be made more active? A randomized pilot study of TV commercial stepping versus walking. *Int J Behav Nutr Phys Act,* 9**,** 95.

STEPHENSON, A., MCDONOUGH, S. M., MURPHY, M. H., NUGENT, C. D. & MAIR, J. L. 2017. Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act,* 14**,** 105.

STERNFELD, B., BLOCK, C., QUESENBERRY, C. P., JR., BLOCK, T. J., HUSSON, G., NORRIS, J. C., NELSON, M. & BLOCK, G. 2009. Improving diet and physical activity with ALIVE: a worksite randomized trial. *Am J Prev Med,* 36**,** 475-83.

SUGIYAMA, T., DING, D. & OWEN, N. 2013. Commuting by car: weight gain among physically active adults. *Am J Prev Med,* 44**,** 169-73.

THORP, A. A., OWEN, N., NEUHAUS, M. & DUNSTAN, D. W. 2011. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. *Am J Prev Med,* 41**,** 207-15.

THRAEN-BOROWSKI, K. M., ELLINGSON, L. D., MEYER, J. D. & CADMUS-BERTRAM, L. 2017. Nonworksite Interventions to Reduce Sedentary Behavior among Adults: A Systematic Review. *Translational Journal of the American College of Sports Medicine,* 2**,** 68-78.

TOMAYKO, E. J., PRINCE, R. J., CRONIN, K. A. & ADAMS, A. K. 2017. The Healthy Children, Strong Families intervention promotes improvements in nutrition, activity, and body weight in American Indian families with young children - ERRATUM. *Public Health Nutr,* 20**,** 380.

U.S. DEPARTMENT OF LABOR 2016. American time use survey summary. . *(accessed 15 June 2017). Available online:* www.bls.gov/news.release/atus.nr0.htm.

VERWEIJ, L. M., PROPER, K. I., WEEL, A. N., HULSHOF, C. T. & VAN MECHELEN, W. 2012. The application of an occupational health guideline reduces sedentary behaviour and increases fruit intake at work: results from an RCT. *Occup Environ Med,* 69**,** 500-7.

WHITAKER, K. M., BUMAN, M. P., ODEGAARD, A. O., CARPENTER, K. C., JACOBS, D. R., SIDNEY, S. & PEREIRA, M. A. 2017. Sedentary Behaviors and Cardiometabolic Risk, an Isotemporal Substitution Analysis. *Am J Epidemiol*.

WIJNDAELE, K., SHARP, S. J., WAREHAM, N. J. & BRAGE, S. 2017. Mortality Risk Reductions from Substituting Screen Time by Discretionary Activities. *Med Sci Sports Exerc,* 49**,** 1111-1119.

WU, L., SUN, S., HE, Y. & JIANG, B. 2016. The effect of interventions targeting screen time reduction: A systematic review and meta-analysis. *Medicine (Baltimore),* 95**,** e4029.

Chapter 6: Workplace intervention for reducing sitting at work (Study 2)

Chapter outline: This chapter investigates the effectiveness of interventions for reducing occupational SB in mental health professionals by systematically reviewing studies in the general adult population.

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;

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Chapter 7: Effectiveness of other types of physical activity and sedentary behavior interventions

Chapter outline: This chapter investigates the topics that were not summarized in the literature review and systematic reviews conducted as a part of this thesis.

a. Effectiveness of digital interventions for increasing PA and/or reducing SB
b. Effectiveness of PA interventions in changing the attitude and practices of mental health professionals

7.1 Effectiveness of digital interventions for increasing physical activity and/or reducing sedentary behaviour

Recent years has seen a large growth of digital technology such as smartphones, tablets, and wearables and its ownership among people all over the world (Statista, 2016, Deloitte, 2017). In the year 2019, it was estimated that more than 2.5 billion people around the world owned smartphones (Statista, 2016). Australia is amongst the forerunners with approximately 88% population having ownership of smartphones. There is an unprecedented rise in ownership in low- and middle-income countries as well in recent years (Deloitte, 2017, Poushter, 2016). These smartphones and wearables have inbuilt sensors that are paired with machine learning algorithms to design tailored interventions aimed at promoting health behaviour change (Patrick et al., 2016, Sanders et al., 2016, Dijkhuis et al., 2018). Various behaviour change interventions can be delivered using smartphones, such as providing self-monitoring, reminders, and real-time feedback. For example, one can use the commonly used application google calendar to set personal goals into the digital calendar (Google, 2016). These days, thousands of health and fitness applications are available on Google play store and iTunes with features that are not only acceptable but also enjoyable for individuals to use (Conroy et al., 2014, Middelweerd et al., 2014). Additionally, these smartphones and wearables also provide objective data that are available immediately for analysis (Lathia et al., 2013). These apps were found to include on average five BCTs which includes goal setting, providing feedback and self-monitoring (Middelweerd et al., 2014). Few systematic reviews (Buckingham et al., 2019, Direito et al., 2017, Davies et al., 2012) have assessed the effectiveness of these digital interventions in increasing PA. These reviews have pointed out the huge potential of these interventions in the promotion of physical activities. One of the meta-analysis reported a small increase in PA levels (0.14, 95% CI 0.09, 0.19) in participants receiving the web-based PA intervention compared to control arms (Davies et al., 2012). Thirteen (Blake et al., 2012, Campbell et al., 2002, Carr et al., 2016, Cook et al., 2007, Dadaczynski et al., 2017, Marshall et al., 2003, Morgan et al., 2011, Napolitano et al., 2003, Reijonsaari et al., 2012, Slootmaker et al., 2009, Spittaels et al., 2007, Sternfeld et al., 2009, van Wier et al., 2009, Hager et al., 2002) studies in the review of intervention in increasing PA at worksite were found to include web-based tailored PA advice or PA advice using email. Another quite popular intervention is the delivery of PA promotion messages through telephones, and the effectiveness of the telephone-based intervention reported in studies vary from moderate to strong (Goode et al., 2012). The findings related to telephone-based or web-based interventions are consistent with our findings for health promotion messages/information interventions for increasing PA at worksite (0.122, 95% CI 0.005 to 0.239).

Digital interventions are not only popular in promoting PA but are also popular tools in reducing SB. In the review on interventions for reducing sitting at work (chapter 6) eight studies were included that had a technological element involving computer prompts (Donath et al., 2015, Evans et al., 2012, Pedersen et al., 2014, Urda et al., 2016, Swartz et al., 2014), web-based intervention (Gordon, 2013, De Cocker et al., 2016), and activity tracker (Brakenridge et al., 2016). These interventions were found to be effective in reducing sitting time at work by 14, 19 and 6.60 minutes/day respectively. However, a review by Stephenson et al. (2017) on effectiveness of computer, mobile, and wearable technology found a reduction of 37 min/day in total SB that included a pooled analyses of 15 studies at follow-up to 6 months. Similarly, another systematic review that assessed 26 studies that used wearable activity trackers within PA and/or SB interventions, either singly or as a part of multicomponent intervention (Brickwood et al., 2019), found low quality evidence for their effectiveness in increasing PA. The same review did not find evidence for effectiveness of wearable activity trackers in reducing SB (Brickwood et al., 2019). There seems to be variability in the effectiveness of digital interventions that comprises computers, mobiles, and wearable technology and needs to be investigated in future studies. The affordability, ease of implementation and easier reach among a larger group of people makes these interventions an attractive prospect for future large-scale studies. However, these interventions often fail to include an educational component, thereby failing to raise awareness of the hazards of SB (Hutchinson et al., 2018).

7.2 Effectiveness of physical activity interventions in changing the attitudes and practices of mental health professionals

Few studies have investigated mental health professionals' perspectives on physical health care (Robson and Haddad, 2012) and beliefs about PA recommendation (Stanton et al., 2015). A study among mental health nurses found that they had a positive attitude and were confident in providing instructions on diet and exercise. This was more evident in those trained in physical health care

(Robson and Haddad, 2012). Similarly, a survey conducted amongst Australian mental health professionals (n= 51) reported that although 57% of participants were aware of the therapeutic benefit of PA, only 40% had prescribed PA to their clients (Phongsavan et al., 2007). In an uncontrolled pre-post study, a lifestyle counselling intervention with a PA component and nutritional counselling delivered to mental health staff (both clinical and non-clinical) improved their knowledge of and attitudes towards physical health issues in their clients (Rosenbaum et al., 2020).

Several barriers have been identified in promoting PA by clinicians, including insufficient time during the clinical visit, simultaneous urgent tasks and priorities, lack of knowledge on PA counselling, lack of effective counselling skills, perceived disruption to the therapeutic relationship and insufficient organizational support and financial incentives to provide PA counselling (Glowacki et al., 2019, Hebert et al., 2012). Moreover providing PA counselling to people with mental illness might be challenging due to nature of their illness (low mood, motivation, impaired decision making), comorbidities and adverse effects of medication (weight gain, fatigue) (Vancampfort et al., 2015). This might be related to perceived barriers such as people with clients will not adhere if the health professionals recommend PA. With the increasing recognition of importance of PA promotion in treatment of mental illness and incorporation of PA in therapeutic guidelines in the management of mental illness, there is an opportunity to train mental health professionals on how to recommend PA for mental health. A systematic scoping review by Glowacki et al. (2019) analysed barriers and facilitators for mental health professionals in recommending PA to their clients according to elements of the Theoretical Domains Framework (TDF). The TDF is an integrative framework of behaviour change which encompasses all the factors such as affective, cognitive and socio-environmental that can influence behaviour

(Glowacki et al., 2019). Two domains of the TDF, ‘Beliefs about the Consequences’, and ‘Environmental Context & Resources’, were the most reported domains for both facilitators and barriers to PA promotion in the included studies in this review (Glowacki et al., 2019). In the Beliefs about the consequence’s domain studies reported ‘clients will not adhere if the health professionals recommend PA’ as barrier and physical and mental health benefits of PA as facilitator (Glowacki et al., 2019). Similarly, in the environmental context & resources domain included studies cited lack of training as a barrier whereas previous PA education/training was cited as facilitator in the included studies (Glowacki et al., 2019).

Health care professionals are regarded as role models in the promotion of healthy lifestyles (Blake et al., 2012). The role of health professionals’ in PA promotion is further bolstered due to frequent contact with their clients and skills in behaviour change (Happell et al., 2011, Happell et al., 2013). Despite this, evidence suggests that the majority of health care professionals fail to achieve sufficient levels of PA (Jinks et al., 2003). Not only does this have personal physical and mental health consequences for these clinicians, it has implications for their clients, given that clinicians with a higher level of PA are more likely to recommend PA to their clients than those with lower levels (Hebert et al., 2012). Canadian Academy of Sport and Exercise Medicine has emphasized the role of physicians in promoting PA, which is also endorsed by Australasian College of Sports and Exercise Physicians. The statement emphasized the need for inquiring patient’s PA along with other chronic disease risk factors by a clinician (Thornton et al., 2016).

There is limited evidence for the effectiveness of behaviour change interventions in changing attitudes and practices of healthcare professionals. However, the general consensus is providing information only like printed materials and information provided through websites seems to be ineffective, although their role in raising awareness in a multicomponent intervention cannot be debated. Similarly, interactive meetings and workshops are generally more effective compared to conferences, lectures, workshops, seminars, and symposia in changing clinicians' practice (Breimaier et al., 2013, Chauhan et al., 2017). An overview of 138 reviews found that multi-disciplinary models' of care involving physicians, nurses and pharmacist was effective in improving practice of healthcare professionals (Chauhan et al., 2017). The same review found that continuous medical education training which are interactive and provides assistance in clinical decision making was also effective in improving practice of healthcare professionals (Chauhan et al., 2017).

A systematic review by Flodgren et al. (2017) assessed the effectiveness of interventions aimed at changing the behaviour of healthcare professionals to promote weight reduction in children and adults with overweight and obesity. The interventions that were assessed were educating primary care physicians in weight management, providing tailored interventions for health care professionals to follow obesity management guidelines, and provision of clinical decision support tools. However, there was limited evidence for the effectiveness of all these different types of intervention in promoting weight loss in children and adults with overweight and obesity. Similarly, a pre-post study examined the effectiveness of PA education sessions on practices of family physicians in recommending PA to their clients (Windt et al., 2015). The study reported a significant increase in the proportion of family physicians (difference = 28%) recommending PA to their clients at one-month follow-up. It also reported an increase in self-reported knowledge and confidence in PA prescription; however, there was no significant change in self-reported PA levels in physicians (Windt et al., 2015). Similar results were seen in another study in Canada (O'Brien et al., 2017), where a significant proportion of physicians attending a PA education session reported an intention to change their practices in prescribing PA. Although there is limited evidence, it can be assumed that interventions for increasing PA among mental health professionals have the potential to be effective in changing their attitudes towards and practices in recommending PA to their clients.

References

BLAKE, H., MO, P. K., LEE, S. & BATT, M. E. 2012. Health in the NHS: lifestyle behaviours of hospital employees. *Perspect Public Health,* 132**,** 213-5.

BRAKENRIDGE, C. L., FJELDSOE, B. S., YOUNG, D. C., WINKLER, E. A., DUNSTAN, D. W., STRAKER, L. M. & HEALY, G. N. 2016. Evaluating the effectiveness of organisational-level strategies with or without an activity tracker to reduce office workers' sitting time: a cluster-randomised trial. *Int J Behav Nutr Phys Act,* 13**,** 115.

BREIMAIER, H. E., HALFENS, R. J., WILBORN, D., MEESTERBERENDS, E., HAASE NIELSEN, G. & LOHRMANN, C. 2013. Implementation interventions used in nursing homes and hospitals: A descriptive, comparative study between Austria, Germany, and The Netherlands. *ISRN Nurs,* 2013**,** 706054.

BRICKWOOD, K.-J., WATSON, G., O'BRIEN, J. & WILLIAMS, A. D. 2019. Consumer-Based Wearable Activity Trackers Increase Physical Activity Participation: Systematic Review and Meta-Analysis. *JMIR Mhealth Uhealth,* 7**,** e11819.

BUCKINGHAM, S. A., WILLIAMS, A. J., MORRISSEY, K., PRICE, L. & HARRISON, J. 2019. Mobile health interventions to promote physical activity and reduce sedentary behaviour in the workplace: A systematic review. *Digit Health,* 5**,** 2055207619839883.

CAMPBELL, M. K., TESSARO, I., DEVELLIS, B., BENEDICT, S., KELSEY, K., BELTON, L. & SANHUEZA, A. 2002. Effects of a tailored health promotion program for female blue-collar workers: health works for women. *Prev Med,* 34**,** 313-23.

CARR, L. J., LEONHARD, C., TUCKER, S., FETHKE, N., BENZO, R. & GERR, F. 2016. Total Worker Health Intervention Increases Activity of Sedentary Workers. *Am J Prev Med,* 50**,** 9-17.

CHAUHAN, B. F., JEYARAMAN, M. M., MANN, A. S., LYS, J., SKIDMORE, B., SIBLEY, K. M., ABOU-SETTA, A. M. & ZARYCHANSKI, R. 2017. Behavior change interventions and policies influencing primary healthcare professionals' practice-an overview of reviews. *Implement Sci,* 12**,** 3.

CONROY, D. E., YANG, C. H. & MAHER, J. P. 2014. Behavior change techniques in top-ranked mobile apps for physical activity. *Am J Prev Med,* 46**,** 649-52.

COOK, R. F., BILLINGS, D. W., HERSCH, R. K., BACK, A. S. & HENDRICKSON, A. 2007. A field test of a web-based workplace health promotion program to improve dietary practices, reduce stress, and increase physical activity: randomized controlled trial. *J Med Internet Res,* 9**,** e17.

DADACZYNSKI, K., SCHIEMANN, S. & BACKHAUS, O. 2017. Promoting physical activity in worksite settings: results of a German pilot study of the online intervention Healingo fit. *BMC Public Health,* 17**,** 696.

DAVIES, C. A., SPENCE, J. C., VANDELANOTTE, C., CAPERCHIONE, C. M. & MUMMERY, W. K. 2012. Meta-analysis of internet-delivered interventions to increase physical activity levels. *Int J Behav Nutr Phys Act,* 9**,** 52.

DE COCKER, K., DE BOURDEAUDHUIJ, I., CARDON, G. & VANDELANOTTE, C. 2016. The effectiveness of a web-based computer-tailored intervention on workplace sitting: A randomized controlled trial. *J Med Internet Res,* 18**,** e96.

DELOITTE 2017. Mobile consumer survey: The Australian cut. *(accessed 28 September 2019); Available online: https://www2.deloitte.com/au/mobile-consumer-survey*.

DIJKHUIS, T. B., BLAAUW, F. J., VAN ITTERSUM, M. W., VELTHUIJSEN, H. & AIELLO, M. 2018. Personalized physical activity coaching: A machine learning approach. *Sensors (Basel),* 18.

DIREITO, A., CARRACA, E., RAWSTORN, J., WHITTAKER, R. & MADDISON, R. 2017. mHealth technologies to influence physical activity and sedentary behaviors: behavior change techniques, systematic review and meta-analysis of randomized controlled trials. *Ann Behav Med,* 51**,** 226-239.

DONATH, L., FAUDE, O., SCHEFER, Y., ROTH, R. & ZAHNER, L. 2015. Repetitive daily point of choice prompts and occupational sit-stand transfers, concentration and neuromuscular performance in office workers: an RCT. *Int J Environ Res Public Health,* 12**,** 4340-53.

EVANS, R. E., FAWOLE, H. O., SHERIFF, S. A., DALL, P. M., GRANT, P. M. & RYAN, C. G. 2012. Point-of-choice prompts to reduce sitting time at work: a randomized trial. *Am J Prev Med,* 43**,** 293-7.

FLODGREN, G., GONCALVES-BRADLEY, D. C. & SUMMERBELL, C. D. 2017. Interventions to change the behaviour of health professionals and the organisation of care to promote weight reduction in children and adults with overweight or obesity. *Cochrane Database Syst Rev,* 11**,** CD000984.

GLOWACKI, K., WEATHERSON, K. & FAULKNER, G. 2019. Barriers and facilitators to health care providers' promotion of physical activity for individuals with mental illness: A scoping review. *Ment Health Phys Act,* 16**,** 152-168.

GOODE, A. D., REEVES, M. M. & EAKIN, E. G. 2012. Telephone-delivered interventions for physical activity and dietary behavior change: an updated systematic review. *Am J Prev Med,* 42**,** 81-8.

GOOGLE 2016. Google Goals. *(accessed on 28 September 2019); Available online: https://www.blog.google/products/calendar/find-time-goals-google-calendar/*.

GORDON, A. 2013. A theory-based pilot study to decrease sitting timein the workplace. A theory-based pilot study to decrease sittingtime in the workplace. *Msc Thesis. Arizona: Arizona StateUniversity*.

HAGER, R. L., HARDY, A., ALDANA, S. G. & GEORGE, J. D. 2002. Evaluation of an internet, stage-based physical activity intervention. *Am J Health Educ,* 33**,** 329-337.

HAPPELL, B., PLATANIA-PHUNG, C. & SCOTT, D. 2011. Placing physical activity in mental health care: a leadership role for mental health nurses. *Int J Ment Health Nurs,* 20**,** 310-8.

HAPPELL, B., PLATANIA-PHUNG, C. & SCOTT, D. 2013. Survey of Australian mental health nurses on physical activity promotion. *Int J Ment Health Promot,* 15**,** 148-161.

HEBERT, E. T., CAUGHY, M. O. & SHUVAL, K. 2012. Primary care providers' perceptions of physical activity counselling in a clinical setting: a systematic review. *Br J Sports Med,* 46**,** 625-31.

HUTCHINSON, J., HEADLEY, S., MATTHEWS, T., SPICER, G., DEMPSEY, K., WOOLEY, S. & JANSSEN, X. 2018. Changes in sitting time and sitting fragmentation after a workplace sedentary behaviour intervention. *Int J Environ Res Public Health,* 15.

JINKS, A. M., LAWSON, V. & DANIELS, R. 2003. A survey of the health needs of hospital staff: implications for health care managers. *J Nurs Manag,* 11**,** 343-50.

LATHIA, N., PEJOVIC, V., RACHURI, K. K., MASCOLO, C., MUSOLESI, M. & RENTFROW, P. J. 2013. Smartphones for large-scale behavior change interventions. *IEEE Pervasive Computing,* 12**,** 66-73.

MARSHALL, A. L., LESLIE, E. R., BAUMAN, A. E., MARCUS, B. H. & OWEN, N. 2003. Print versus website physical activity programs: a randomized trial. *Am J Prev Med,* 25**,** 88-94.

MIDDELWEERD, A., MOLLEE, J. S., VAN DER WAL, C. N., BRUG, J. & TE VELDE, S. J. 2014. Apps to promote physical activity among adults: a review and content analysis. *Int J Behav Nutr Phys Act,* 11**,** 97.

MORGAN, P. J., COLLINS, C. E., PLOTNIKOFF, R. C., COOK, A. T., BERTHON, B., MITCHELL, S. & CALLISTER, R. 2011. Efficacy of a workplace-based weight loss program for overweight male shift workers: the Workplace POWER (Preventing Obesity Without Eating like a Rabbit) randomized controlled trial. *Prev Med,* 52**,** 317-25.

NAPOLITANO, M. A., FOTHERINGHAM, M., TATE, D., SCIAMANNA, C., LESLIE, E., OWEN, N., BAUMAN, A. & MARCUS, B. 2003. Evaluation of an internet-based physical activity intervention: a preliminary investigation. *Ann Behav Med,* 25**,** 92-9.

O'BRIEN, M. W., SHIELDS, C. A., OH, P. I. & FOWLES, J. R. 2017. Health care provider confidence and exercise prescription practices of Exercise is Medicine Canada workshop attendees. *Appl Physiol Nutr Metab,* 42**,** 384-390.

PATRICK, K., HEKLER, E. B., ESTRIN, D., MOHR, D. C., RIPER, H., CRANE, D., GODINO, J. & RILEY, W. T. 2016. The pace of technologic change: Implications for digital health behavior intervention research. *Am J Prev Med,* 51**,** 816-824.

PEDERSEN, S. J., COOLEY, P. D. & MAINSBRIDGE, C. 2014. An e-health intervention designed to increase workday energy expenditure by reducing prolonged occupational sitting habits. *Work,* 49**,** 289-95.

PHONGSAVAN, P., MEROM, D., BAUMAN, A. & WAGNER, R. 2007. Mental illness and physical activity: therapists' beliefs and practices. *Aust N Z J Psychiatry,* 41**,** 458-459.

POUSHTER, J. 2016. Smartphone ownership and internet usage continues to climb in emerging economies. *Pew Research Center,* 22.

REIJONSAARI, K., VEHTARI, A., KAHILAKOSKI, O. P., VAN MECHELEN, W., ARO, T. & TAIMELA, S. 2012. The effectiveness of physical activity monitoring and distance counseling in an occupational setting - results from a randomized controlled trial (CoAct). *BMC Public Health,* 12**,** 344.

ROBSON, D. & HADDAD, M. 2012. Mental health nurses' attitudes towards the physical health care of people with severe and enduring mental illness: the development of a measurement tool. *Int J Nurs Stud,* 49**,** 72-83.

ROSENBAUM, S., WARD, P. B., BALDEO, R., FIBBINS, H., JARMAN, R., LEDERMAN, O., PERRAM, A., POOLE, J., ROSSIMEL, E., SMITH, G., TEASDALE, S., WADE, T., WATKINS, A., WHITE, A., PEARCE, D. & CURTIS, J. 2020. Changing health workforce attitudes to promote improved physical health in mental health service users: Keeping our Staff in Mind (KoSiM). *Health Promot J Austr*.

SANDERS, J. P., LOVEDAY, A., PEARSON, N., EDWARDSON, C., YATES, T., BIDDLE, S. J. & ESLIGER, D. W. 2016. Devices for self-monitoring sedentary time or physical activity: A scoping review. *J Med Internet Res,* 18**,** e90.

SLOOTMAKER, S. M., CHINAPAW, M. J., SCHUIT, A. J., SEIDELL, J. C. & VAN MECHELEN, W. 2009. Feasibility and effectiveness of online physical activity advice based on a personal activity monitor: randomized controlled trial. *J Med Internet Res,* 11**,** e27.

SPITTAELS, H., DE BOURDEAUDHUIJ, I., BRUG, J. & VANDELANOTTE, C. 2007. Effectiveness of an online computer-tailored physical activity intervention in a real-life setting. *Health Educ Res,* 22**,** 385-96.

STANTON, R., HAPPELL, B. & REABURN, P. 2015. Investigating the exercise-prescription practices of nurses working in inpatient mental health settings. *Int J Ment Health Nurs,* 24**,** 112-20.

STATISTA 2016. Number of smartphone users worldwide from 2014 to 2020 (in Billions). *(accessed 28 September 2019); Available online: https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/*.

STEPHENSON, A., MCDONOUGH, S. M., MURPHY, M. H., NUGENT, C. D. & MAIR, J. L. 2017. Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act,* 14**,** 105.

STERNFELD, B., BLOCK, C., QUESENBERRY, C. P., JR., BLOCK, T. J., HUSSON, G., NORRIS, J. C., NELSON, M. & BLOCK, G. 2009. Improving diet and physical activity with ALIVE: a worksite randomized trial. *Am J Prev Med,* 36**,** 475-83.

SWARTZ, A. M., ROTE, A. E., WELCH, W. A., MAEDA, H., HART, T. L., CHO, Y. I. & STRATH, S. J. 2014. Prompts to disrupt sitting time and increase physical activity at work, 2011-2012. *Prev Chronic Dis,* 11**,** E73.

THORNTON, J. S., FREMONT, P., KHAN, K., POIRIER, P., FOWLES, J., WELLS, G. D. & FRANKOVICH, R. J. 2016. Physical activity prescription: a critical opportunity to address a modifiable risk factor for the prevention and management of chronic disease: a position statement by the Canadian Academy of Sport and Exercise Medicine. *Br J Sports Med,* 50**,** 1109-14.

URDA, J. L., LYNN, J. S., GORMAN, A. & LAROUERE, B. 2016. Effects of a minimal workplace intervention to reduce sedentary behaviors and improve perceived wellness in middle-aged women office workers. *J Phys Act Health,* 13**,** 838-44.

VAN WIER, M. F., ARIENS, G. A., DEKKERS, J. C., HENDRIKSEN, I. J., SMID, T. & VAN MECHELEN, W. 2009. Phone and e-mail counselling are effective for weight management in an overweight working population: a randomized controlled trial. *BMC Public Health,* 9**,** 6.

VANCAMPFORT, D., STUBBS, B., WARD, P. B., TEASDALE, S. & ROSENBAUM, S. 2015. Integrating physical activity as medicine in the care of people with severe mental illness. *Aust N Z J Psychiatry,* 49**,** 681-2.

WINDT, J., WINDT, A., DAVIS, J., PETRELLA, R. & KHAN, K. 2015. Can a 3-hour educational workshop and the provision of practical tools encourage family physicians to prescribe physical activity as medicine? A pre-post study. *BMJ Open,* 5**,** e007920.

Chapter 8: Summary of evidence from literature reviews that informed PA and SB interventions for mental health professionals

Chapter outline: This chapter summarises the effective strategies informed by the literature review and systematic reviews that were used in designing the intervention entitled "Move More for Mental Health and Wellbeing" for mental health professionals

PA and SB interventions are effective in increasing PA and reducing SB in general population of adults and these findings would therefore also apply to mental health professionals. An intervention for mental health professionals based on literature reviews and systematic reviews conducted as part of this thesis was developed and implemented as a pre-post intervention study. Several discussions were held within the research team (Team members: Danijel Jurakic, Alexandra Parker, Stuart J. H. Biddle, Željko Pedišić and Nipun Shrestha) to design the intervention that was evidence informed and at the same time, was feasible for the budget and duration of the PhD project. The intervention entitled "Move More for Mental Health and Wellbeing" consisted of a one-hour group behaviour change session, delivered by a registered psychologist, an information booklet containing evidence-based strategies for sitting less and moving more, and weekly reminders/consultation sessions.

The intervention for this PhD project was designed to encourage mental health professionals to rearrange their work schedules to engage in more PA and use available opportunities to become less sedentary and more active throughout the day. A group based behaviour change session was suitable for delivering the information on potential strategies for increasing PA, which was applicable to every participant, with the addition of peer support. A systematic review assessed effectiveness of weight management interventions in group settings compared to the same intervention delivered individually (Paul-Ebhohimhen and Avenell, 2009). The review reported significant weight loss in participants assigned to group-based intervention compared to an individually delivered intervention (Paul-Ebhohimhen and Avenell, 2009). Although the evidence for improvements in health outcomes for behaviour change interventions implemented in group settings among health care professionals is scarce (Hoddinott et al., 2010), there is some evidence of their effectiveness in changing practices of health care professionals (Breimaier et al., 2013, Chauhan et al., 2017). The group behaviour change meeting was therefore chosen based on feasibility and its effectiveness in previous clinical settings.

The information booklet that was designed for the intervention incorporated 24 possible strategies for sitting less and moving more in the domains of leisure, home, work, and transport. Most of the strategies that were incorporated were informed by the literature reviews and systematic reviews included in this thesis, such as encouraging those participants who already has access to a sit-stand desk to use these or for those without a sit-stand desk, to construct one out of boxes. The review on reducing workplace SB (Chapter 6) found sit-stand desks are effective in reducing sitting time in employees by an average of 100 minutes/day. Similarly, a range of practical recommendations for breaking up sitting time (e.g., using smaller water bottles that need to be refilled, placing bins further away from desks) and the use of fitness apps were also strategies included in the booklet, given that breaking up sitting time and replacing it with light PA or standing may have beneficial effects on cardiometabolic health (Benatti and Ried-Larsen, 2015). The use of prompts as reminder to break up sitting time was also included as this has been found to be effective in reducing number of prolonged periods of sitting which lasted for more than 30 minutes (Evans et al., 2012). The use of activity trackers or fitness apps is quite popular with more than 15 thousand health and fitness apps available in both Apple iTunes (iOS) (Apple Inc, Cupertino, Calif) and Google Play (Android OS) (Google, Inc, Mountain View, Calif) (Apple, 2020, Google Play, 2020). Though there is limited evidence on effectiveness of these activity trackers and apps, they may serve as low cost interventions to reach a large portion of the population. Similarly, restricting access to TV automatically after 30 minutes as a reminder to take regular activity breaks was recommended in the booklet to reduce SB at home. The systematic review assessing non-occupational SB interventions (Chapter 5) identified restriction to TV as an effective strategy in reducing SB in leisure time. Recent studies have highlighted physical and mental health benefits of enjoyment and social support while engaging in PA (Teychenne et al., 2020). Therefore, activities such as using PA as reward, setting a family fitness challenge, joining an exercise group or trying new physical activities were also recommended strategies included in the booklet. The intervention also included weekly reminders for participants by inquiring whether participants adhered to their personalised PA plan that was developed in the group behaviour change session and identifying and assisting participants in overcoming barriers in following their PA plan. Reminding people over telephone, SMS messages and/or emails has been found to have beneficial effects in promoting health behavior change (Shapiro et al., 2012). The components of the intervention and content of booklet were evidence based to increase the likelihood that the intervention will be useful in increasing the participants' own PA and reducing their SB, as well as increasing their knowledge and attitudes towards recommending PA within their clinical practice.

References

APPLE 2020. iTunes Preview. App Store "Health & Fitness". . *(accessed 30 July 2020). Available online: https://itunes.apple.com/us/genre/ios-health-fitness/id6013?mt1/48&ls1/41&v01/4www-iphone-5s-appstore-health-fitness*.

BENATTI, F. B. & RIED-LARSEN, M. 2015. The Effects of Breaking up Prolonged Sitting Time: A Review of Experimental Studies. *Med Sci Sports Exerc,* 47**,** 2053-61.

BREIMAIER, H. E., HALFENS, R. J., WILBORN, D., MEESTERBERENDS, E., HAASE NIELSEN, G. & LOHRMANN, C. 2013. Implementation interventions used in nursing homes and hospitals: A descriptive, comparative study between Austria, Germany, and The Netherlands. *ISRN Nurs,* 2013**,** 706054.

CHAUHAN, B. F., JEYARAMAN, M. M., MANN, A. S., LYS, J., SKIDMORE, B., SIBLEY, K. M., ABOU-SETTA, A. M. & ZARYCHANSKI, R. 2017. Behavior change interventions and policies influencing primary healthcare professionals' practice-an overview of reviews. *Implement Sci,* 12**,** 3.

EVANS, R. E., FAWOLE, H. O., SHERIFF, S. A., DALL, P. M., GRANT, P. M. & RYAN, C. G. 2012. Point-of-choice prompts to reduce sitting time at work: a randomized trial. *Am J Prev Med,* 43**,** 293-7.

GOOGLE PLAY 2020. Android apps: health and fitness. *(accessed 30 July 2020). Available online: https://play.google.com/store/apps/category/HEALTH_AND_FITNESS?hl1/4en. .*

HODDINOTT, P., ALLAN, K., AVENELL, A. & BRITTEN, J. 2010. Group interventions to improve health outcomes: a framework for their design and delivery. *BMC Public Health,* 10**,** 800.

PAUL-EBHOHIMHEN, V. & AVENELL, A. 2009. A systematic review of the effectiveness of group versus individual treatments for adult obesity. *Obes Facts,* 2**,** 17-24.

SHAPIRO, J. R., KORO, T., DORAN, N., THOMPSON, S., SALLIS, J. F., CALFAS, K. & PATRICK, K. 2012. Text4Diet: a randomized controlled study using text messaging for weight loss behaviors. *Prev Med,* 55**,** 412-7.

TEYCHENNE, M., WHITE, R. L., RICHARDS, J., SCHUCH, F. B., ROSENBAUM, S. & BENNIE, J. A. 2020. Do we need physical activity guidelines for mental health: What does the evidence tell us? *Mental Health and Physical Activity,* 18**,** 100315.

Chapter 9: Physical activity and sedentary behaviour counselling: attitudes and practices of mental health professionals (Study 3)

Chapter outline: This chapter investigates the attitudes and practices of mental health professionals in recommending more PA and less SB to their clients, and to inform professional education/training and future interventions that can be implemented in mental health facilities and enhance mental health treatment.

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DECLARATION OF CO-AUTHORSHIP AND CO-CONTRIBUTION: PAPERS INCORPORATED IN THESIS

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

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2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;

3. There are no other authors of the publication according to these criteria;

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Name(s) of Co-Author(s)	Contribution (%)	Nature of Contribution	Signature	Date
Alexandra Parker	10%	Developing the research question Determining the research	[redacted]	29 July 2020
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Abstract

Background

Despite recent interest in the mental health benefits of increasing physical activity (PA) and reducing sedentary behaviour (SB), little is known about PA and SB counselling provided by mental health professionals. Therefore, the aim of this study was to explore the attitudes and practices of mental health professionals in recommending more PA and less SB to their clients.

Methods

A mixed-methods study was conducted among 17 mental health professionals, who were involved in a four-week pre-post intervention trial entitled "Move More for Mental Health and Wellbeing" Data at baseline were collected using a modified version of the Exercise in Mental Illness Questionnaire in a sample of 17 Australian mental health professionals. Additionally, in focus group discussions, 10 mental health professionals provided in-depth information about their clinical practice, facilitators, and perceived barriers in recommending more PA and less SB. They also provided suggestions on how to potentially improve their PA and SB counselling practices.

Results

Only 35.3% of participants have undergone formal training in recommending PA in the treatment of mental illness. Most participants (64.7%) ranked PA counselling among the top three types of mental health treatment. All participants reported recommending PA to their clients at least "occasionally", while 88% percent of them also provided SB counselling. However, the recommendations provided were usually not specific. The most commonly reported barriers for providing PA and SB counselling were a lack of knowledge and confidence. Participants also believed that, if they were more active themselves, they would be in a better position to recommend

PA to their clients, by sharing their own experience of evidence-informed strategies designed to increase PA and reduce SB.

Conclusion

We found that mental health professionals commonly provide generic PA and SB counselling to their clients. PA and SB counselling in the mental health setting could be improved by: including training on PA and SB counselling in formal education and continued professional training for mental health professionals; implementing interventions to increase PA and reduce SB among mental health professionals themselves; and ensuring support from an exercise or PA promotion specialist as a part of a multi-disciplinary approach to mental health care.

9.1 Introduction

Promoting more physical activity (PA) and less sedentary behavior (i.e. sitting or reclining while awake with low energy expenditure; SB) has been a key strategy in the primary and secondary prevention of non-communicable diseases (Piercy et al., 2018). Although significant efforts have been made in the promotion of PA, around 30% of people still do not meet the required levels of PA recommended in public health guidelines (Guthold et al., 2018, Hallal et al., 2012). Moreover, the increasing levels of sedentary behavior across the world and its impact on health and wellbeing is concerning, given that with a large number of adults already spend more than 8 hours per day in SB (Dunstan et al., 2012, Aadahl et al., 2013, Ng and Popkin, 2012).

People with mental disorders are less likely to be sufficiently physically active, compared with the general population (Vancampfort et al., 2017). PA promotion has been regarded as a cost-effective strategy in the prevention and management of mental disorders (Bailey et al., 2018). However, health care professionals, including mental health professionals, find it difficult to implement this strategy in routine clinical consultations and treatment sessions, even when they perceive their clients would benefit from engaging in more PA (Keyworth et al., 2018, Keyworth et al., 2019). Previous studies have found that most health professionals (~60%) do not routinely provide PA counselling to their patients or clients (Lobelo and de Quevedo, 2016). In an Australian national survey, only 18% of participants reported receiving PA recommendation from their clinician in the past 12 months (Short et al., 2016). It seems this pattern also occurs with mental health professionals as many do not provide PA recommendation to their clients (Phongsavan et al., 2007, Stanton et al., 2015b).

Several studies have explored the barriers and facilitators experienced by health professionals in recommending PA to their clients (Hebert et al., 2012, Glowacki et al., 2019, Huijg et al., 2015).

The key barriers were a lack of confidence; lack of time; lack of training on how to recommend PA; competing clinical priorities; and perception of health professionals that their clients would not adhere to PA recommendations. The key facilitators were higher levels of PA engagement in health professionals themselves and greater relevant professional knowledge and skills (Hebert et al., 2012, Glowacki et al., 2019, Huijg et al., 2015).

In addition to the identified barriers for health professionals generally, mental health professionals may experience specific barriers to recommending PA, due to their client's mental health conditions, co-morbidities, and adverse effects of medications (Glowacki et al., 2019). This study, therefore, explored the attitudes and practices of mental health professionals in recommending more PA and less SB to their clients, to inform professional education/training and future interventions that can be implemented in mental health services and with the potential to enhance the outcomes of routine mental health treatment.

9.2 Methods

9.2.1 Study design and participants

We conducted a mixed-methods study among 17 mental health professionals, who were involved in a four-week pre-post intervention trial entitled "Move More for Mental Health and Wellbeing" (clinical trial registration reference: ISRCTN43608761). Mixed methods study is a systematic integration of qualitative and quantitative data for synergistic and in depth understanding of the research question (Wisdom and Creswell, 2013, Shorten and Smith, 2017). The study occurred from September to October 2019 in two headspace centres, located in Melbourne, that are part of Australia's national youth mental health service network (Rickwood et al., 2019). These centres provide mental health services to youth aged 12-25 years (Rickwood et al., 2015). Ethics approval was obtained from the Victoria University Human Ethics Research Committee [HRE18-123]. We conducted the study by following the Consolidated Standards of Reporting Trials (CONSORT) (Schulz et al., 2010). Orygen, which is the lead agency of the headspace centres included in the study, provided general oversight of adverse events and participant safety during the study.

9.2.2 Procedure and measures

Data on attitudes and practices of the participating mental health professionals in recommending more PA and less SB to their clients were collected prior to the intervention using a modified Exercise in Mental Illness Questionnaire (version for health professionals) (Stanton et al., 2014). In the section on general beliefs, participants were asked to express the level of their agreement with six statements (e.g. "People with a mental illness know that PA is good for their mental health") using a Likert-type response scale with five levels. In the same section, participants were also asked to rank the importance of "increasing PA" and "reducing SB" among a total of 11 treatment strategies for people with mental illness. In the section on perceived barriers for recommending PA to their clients, participants were asked to express their agreement with 11 statements (e.g. "My workload is already too excessive to include recommending PA to people with a mental illness") on a Likert-type response scale with five levels. Participants were then asked how often (on the scale: "Never"; "Occasionally"; "Most of the time"; and "Always") they recommend PA to their clients and how often they recommend reducing SB to their clients. The final set of questions was about specific strategies the participants use to promote PA among their clients. Stanton et al. (Stanton et al., 2014) found that the questionnaire has good measurement properties. For the purpose of this study, we added two items on SB to the questionnaire and used the term "physical activity" instead of "exercise", to capture all types of PA that mental health professionals can promote among people with mental illness. The questionnaire also included items about age, gender, marital status, the length of employment in the mental health profession, whether they were a private practitioner/provider or employed by headspace (i.e., salaried staff), whether they had a clinical role at any other service in addition to headspace; whether their headspace role was their main job; and any formal training for recommending PA they may have taken.

To get a more detailed insight into the variables of interest, after the intervention, participants were invited to take part in one of two focus groups. Using a semi-structured guide, focus group participants were asked about: 1) their practices in recommending more PA and less SB to their clients; 2) facilitators for recommending more PA and less SB to their clients; 3) barriers for recommending PA and less SB to their clients; and 4) factors that could improve PA and SB counselling practice (Supplementary table 6). Each focus group was attended by five participants and lasted for 45-60 minutes. The focus groups were facilitated by a lead moderator, while an assistant moderator took field notes and audio-recorded the discussion.

9.2.3 Data analysis

Participants' sociodemographic characteristics and responses to questionnaire items regarding attitudes and practices in recommending PA to people with mental illness were reported using percentages (for categorical data) and means and standard deviations (for numerical data). Responses to questionnaire items on beliefs and perceived barriers were analysed individually, because they were not designed to be combined into a summary score (Stanton et al., 2014). The analysis was done in version 23 of the IBM Statistical Package for the Social Sciences (SPSS). For the focus group data, interview transcripts and notes were coded and analysed using thematic analysis (Braun and Clarke, 2006). The themes were generated through an iterative process of screening and categorising raw data. During the process, the themes were discussed in four meetings, to reach consensus between the researchers (NS, AP and ZP). The participant's responses were classified into themes based on the principles of realist epistemology (Fletcher, 2017). The coding was facilitated using NVivo software, version 12.

9.3 Results

9.3.1 Sample characteristics

The mean age of participants was 38 years. On average, they had worked in the mental health profession for 8 years. Most of the mental health professionals in the study sample were females, married or in a de facto relationship, and their role in the headspace centre was their main job (76.5% for all). Most of the participants were psychologist (82.3%) and nearly half of participants (47%) had a clinical role at another centre. Most of the participants obtained their highest degree in Australia and were directly employed by the headspace centre (82.3% for both). Around one third of participants (35.3%) had undergone formal training in recommending PA in the treatment of mental illness (Table 7).

Table 7: Characteristics of respondents

Characteristics	Mean ± SD
Age	37.9 ± 9.8
Years in profession	7.8 ± 7
	Percentage of respondents
Male gender	23.5%
Not married	23.5%
Completed highest overseas	17.7%
Non-salaried staff	17.7%
Does not work in a clinical role at any another service	53.0%
Does not consider the role in headspace as the main job	23.5%
Did not undergo formal training in recommending physical activity	64.7%
Role at headspace center	
Nurse	11.8%
Psychologist	70.6%
Social worker	5.9%
Clinical lead/psychologist	11.8%

9.3.2 Quantitative findings

Most participants rated the value of recommending PA in the treatment of mental illness as equal or higher than the value of other established treatments (Table 8). Most participants (64.7%) ranked PA counselling among the top three treatment modalities. Only 17.7% of participants ranked SB counselling among the top three treatment modalities (Supplementary table 7). Nearly all participants agreed or strongly agreed that PA is valuable for patients hospitalised with a mental illness in the same manner as outpatients (94.1%). Most participants agreed that mental health benefits of PA for people with mental illness are long lasting (76.4%). Around half of participants agreed or strongly agreed that people with a mental illness know that PA is good for their physical health (52.9%) and that people with a mental illness do not engage in PA because they don't think they can (47.1%). Forty-one percent of participants agreed with the statement that people with a mental illness know that PA is good for their mental health. Participants were generally unsure whether people with a mental illness who are recommended PA will adhere to the recommendation or not.

Table 8:Value of physical activity counselling compared with other types of treatment for mental illness, as perceived by mental health professionals

	Significantly less than physical activity	*Somewhat less than physical activity*	*Of equal value to physical activity*	*Somewhat better than physical activity*	*Significantly better than physical activity*
Medication	5.9%	23.5%	52.9%	17.7%	0%
Social support	0%	11.8%	41.2%	47%	0%
Family therapy	11.8%	17.7%	29.4%	41.2%	0%
Social skill training	5.9%	23.5%	47%	23.5%	0%
Cognitive behavioural therapy	0%	11.8%	47%	41.2%	0%
Vocational rehabilitation	0%	29.4%	58.8%	11.8%	0%
Electroconvulsive therapy	17.7%	35.3%	23.5%	23.5%	0%
Bright light therapy	29.4%	52.9%	17.7%	0%	0%

Most participants disagreed or strongly disagreed with all but one statement on barriers for recommending PA as a treatment for mental illness. The most prevalent perceived barriers were a lack of knowledge in PA prescription ("I do not know how to recommend PA to people with a mental illness" and "Prescription of PA to people with mental illness is best delivered by an exercise professional such as an exercise physiologist") and a belief that people with a mental illness will not adhere to a PA program (Table 9).

Table 9: Attitudes and practices of mental health professionals in recommending more physical activity and less sedentary behaviour to their clients

Beliefs	***Strongly disagree***	***Disagree***	***Neither disagree nor agree***	***Agree***	***Strongly agree***
People with a mental illness know that PA is good for their physical health	0%	17.7%	29.4%	41.2%	11.7%
People with a mental illness know that PA is good for their mental health	0%	29.4%	29.4%	41.2%	0%
People with a mental illness do not engage in PA because they don't think they can	0%	25.5%	29.4%	41.2%	5.9%
PA is valuable for patients hospitalised with a mental illness in the same manner as outpatients	0%	0%	5.9%	70.6%	23.5%
The physical and mental health benefits of PA for people with a mental illness are not long lasting	11.7%	64.7%	11.7%	11.7%	0%
People with a mental illness who are recommended PA will not adhere to it	0%	29.4%	41.2%	29.4%	0%
Perceived barriers					
Their mental health makes it impossible for them to participate in PA	35.3%	47.0%	11.7%	5.9%	0%
I'm concerned PA might make their condition worse	58.8%	35.3%	5.9%	0%	0%
I am not interested in recommending PA for people with a mental illness	58.8%	41.2%	0%	0%	0%
I don't believe PA will help people with a mental illness	64.7%	35.3%	0%	0%	0%
Their physical health makes it impossible for them to participate in PA	35.3%	52.9%	5.9%	5.9%	0%
I'm concerned they might get injured while engaging in PA	47.0%	35.3%	17.7%	0%	0%

People with a mental illness won't adhere to a PA program	29.4%	23.5%	23.5%	23.5%	0%
My workload is already too excessive to include recommending PA to people with a mental illness	29.4%	35.3%	17.7%	17.7%	0%
Recommending PA to people with a mental illness is not part of my job	53.0%	47.0%	0%	0%	0%
I do not know how to recommend PA to people with a mental illness	35.3%	17.7%	11.7%	29.4%	0%
Prescription of PA to people with mental illness is best delivered by an exercise professional such as an exercise physiologist	23.5%	11.8%	35.3%	23.5%	5.9%
Practices	***Never***	***Occasionally***	***Most of the time***	***Always***	
Do you recommend physical activity to people with a mental illness?	0%	17.6%	41.2%	41.2%	
Do you recommend reducing sedentary behaviour (time spent sitting/screen time) to people with a mental illness?	11.8%	23.5%	41.2%	23.5%	

All participants reported that they recommend PA to their clients at least “occasionally”. Eighty-eight percent of them reported at least “occasionally” suggesting their clients to reduce SB. Personal discussion was the most frequently used strategy to promote PA (88.2%), followed by referral to community-based programs (35.3%) and referral to an exercise physiologist / physiotherapist for recommendation was reported by 17.6% of participants (Supplementary table 2). The most commonly recommended frequency of PA was “As often as you can” and “On most days of the week” (35.3% for both). The most frequently recommended PA intensity for people with mental illness was “At a level that makes you feel good” (47%). One in three participants reported they do not recommend a specific intensity of PA (29.4%). Aerobic exercise was the most commonly prescribed mode of PA (82.4%), followed by team sports (41.2%), and relaxation exercises such as yoga or Tai Chi (41.2%) (Supplementary table 8).

9.3.3 Qualitative findings

In the transcripts from the focus group discussions, common themes were identified, including: 1) type of recommendations provided to clients; 2) information resources for PA and SB counselling; 3) facilitators for PA and SB counselling; 4) barriers for PA and SB counselling; and 5) factors that could improve PA and SB counselling practice.

Type of physical activity and sedentary behaviour recommendations provided to clients

Participants believed that, as clinicians, they were responsible not only for the mental health but also for the physical health of their clients, and they were interested in incorporating PA and SB counselling routinely in the treatment of mental illness. Although they motivated their clients to move more and spend less time in SB, they tended not to make specific recommendations for type, duration, and frequency of PA or detailed guidance on how to reduce SB. They emphasised that instead of structured exercise, they are more likely to recommend incorporating PA into everyday activities, such as active transport (e.g., walking to the shop instead of driving).

> *"We often talk to young people who spend lot of time sleeping or on their phone and discuss with them what would be the benefit of moving more in general or doing something else that they enjoy, which by default they're going to do more of anyway. So actually, exploring other ways that they can do things which may not necessarily be for the purpose of increasing their movement, but by default, getting them to move more"*
>
> *(Clinician 1).*

Mental health professionals try to create a narrative by explaining to their clients the ways in which increasing PA and reducing SB led to improvements and by providing examples of success stories from other young clients.

> *"I try to create a narrative around 'Why would it be helpful for this specific person at this specific time?'... Like, 'It will help in these ways' and 'This is what people said helped from past, but this will also help you."*
>
> *(Clinician 2)*

Mental health professionals also recommended their clients use smartphone applications to increase their motivation for and engagement in PA.

> *"I use different apps; for example, the ones for people interested in getting into running… Let's download a running app and make it fun! Or, other things they can use on their phone like pedometers, to make it interactive with their phone, because I guess they are going to be on the phone anyway."*
>
> *(Clinician 3)*

<u>Information resources for physical activity and sedentary behaviour counselling</u>

Participants generally did not have the opportunity to participate in formal education, training, or continued professional development for providing recommendations on PA and SB to their clients. Instead, they relied on other sources of information, such as internet websites and smartphone applications. They also shared knowledge with colleagues and engaged in clinical review meetings and supervision to utilise each other's experience for integrating PA in treating clients.

> *"I think just from my own browsing, hearing stuff and also mental health apps."*
>
> *(Clinician 3)*

> *"It's just kind of word of mouth."*

(Clinician 3)

Facilitators of physical activity and sedentary behaviour counselling

Mental health professionals stated that their increased awareness of young people engaging in excessive SB was an important facilitator for recommending more PA and less SB to their clients. There was a shared belief that technology has contributed to increasing the amount of time young people spend in sedentary behaviours, including computer gaming and mobile phone use. Clinicians also perceived that some of their young clients were not as active as they would like to be. This increased awareness was described by clinicians as a motivating factor to discuss possible strategies to increase PA and reduce SB with their clients.

> *"There is bit more of awareness around sedentary behaviour and screen time. And I guess that has a kind of flow-on effect of awareness that our clients may be not moving as much as other young people and young people from previous generations. There is a lot more insight on phone and computer activity. I think I have definitely noticed that. Young people seem to have insight into that. But I don't know how much insight they have of the flow-on effects on mental health."*
>
> *(Clinician 3)*

Participants also believed that, if they are more active themselves, they would be in a better position to recommend PA to their clients and share their experiences in maintaining sufficient levels of PA.

> *"If you believe in something because you've done it and you also know the evidence base, then it's easy enough to 'sell it'."*
>
> *(Clinician 2)*

> *"If I am moving more myself, I can bring it to the work that I do with young people."*
>
> *(Clinician 4)*

<u>Barriers for physical activity and sedentary behaviour counselling</u>

Several barriers for recommending more PA and less SB to people with mental illness were identified during the focus group discussions. For clients with complex mental health needs, clinicians rarely included PA and SB interventions within treatment. In such cases, they generally gave precedence to other types of mental health treatment, such as cognitive behaviour therapy. Moreover, clinicians reported a lack of confidence and competence for providing recommendations on PA and SB to clients with complex clinical needs. Some mental health professionals believed it was inappropriate for them to attend to what may be perceived as less critical or urgent concerns, such as levels of PA, when focusing on the treatment of a mental disorder.

"I think it just drops off the priority list, even though we may think this would be really helpful."

(Clinician 3)

"My confidence [for recommending PA] kind of wanes a little bit when there is more pointy mental health stuff going on."

(Clinician 1)

Two barriers stemming from clients' knowledge and perceptions were identified. Mental health professionals stated that young people they work with are typically unaware of the importance of PA for mental health. They also believed that their clients assume that mental health professionals do not have the knowledge and capacity to recommend PA as part of mental health treatment.

"They visit us with a preconceived idea of coming to sit in room and talk about how they feel and how they can feel better, not necessarily thinking that physical activity is something they could do."

(Clinician 1)

"This is often seen as just an afterthought rather than what you are going to see a mental health specialist for."

(Clinician 5)

Furthermore, there was a shared perception that including PA in treatment may feel disruptive to clients and potentially damage rapport or the therapeutic alliance. Although participants generally considered PA as a beneficial intervention for mental disorders, their views favoured the need for counselling practices to focus on the presenting issues and concerns of clients.

"People come to me having been alienated by mental health clinicians trying to make them quit smoking. Like physical activity, quitting smoking can be associated with positive mental health outcomes. But it's not what they came for."

(Clinician 6)

<u>Factors that could improve physical activity and sedentary behaviour counselling practice</u>

Participants believed that continued professional development would help them better integrate PA and SB counselling in mental health treatment, with intervention manuals or booklets to present the evidence and provide guidance on how to integrate PA and SB counselling into their therapeutic frameworks specifically identified as helpful to facilitate this.

"I was going to say professional development. You know we are really interested in getting some manuals for integrating [PA and SB counselling] with cognitive behaviour therapy."

(*Clinician 7)*

"'…if you can make an obvious link between what they are currently experiencing and how it [PA or SB intervention] will help. So, having that sort of evidence base and rationale would be useful for different sorts of presenting issues."

(Clinician 2)

Participants also thought that education on PA and SB counselling should be a part of formal mental health clinical training. This was discussed as a way to increase the capacity of the future mental health workforce and broaden the reach and application of PA and SB interventions within mental health services. It was acknowledged, however, that addressing this would require significant investment.

"I see it as a systemic issue, because people coming out of university have not been told about that important thing, as a component of therapy. Consequently, they are not offering this important component even if they themselves are quite convinced that it should be."

(Clinician 5)

Some mental health professionals also believed that having access to an exercise specialist, such as an accredited exercise physiologist, would benefit their clinical work with young people. An exercise professional could either directly provide exercise interventions to clients or provide professional guidance to mental health clinicians on recommending and integrating PA interventions.

> *"It would be amazing to have access to an exercise physiologist, even for a secondary consultation."*
>
> *(Clinician 7)*

9.4 Discussion

In this mixed-methods study, we found that most mental health professionals recognised the benefits of PA within mental health treatment, despite a perceived lack of knowledge about and confidence in providing PA and SB counselling to their clients. Mental health professionals considered PA counselling as an important treatment strategy in the treatment of mental illness in young people. However, their assessment of the value of SB counselling was not so favourable. The prevalence of mental health professionals who provide PA and SB counselling "always" or "most of the time" was somewhat higher than that reported in previous studies (Radovic et al., 2018, Phongsavan et al., 2007). This may be because the recommendation for PA has relatively recently been incorporated into the Royal Australian and New Zealand College of Psychiatrists' guidelines for the management of mental disorders (Galletly et al., 2016, Malhi et al., 2015) and is suggested in the NICE guidelines for youth depression (NICE, 2019). However, it should be noted that both quantitative and qualitative findings further revealed that clinicians did not provide specific recommendations for PA or SB and made only general suggestions. This might be because these guidelines do not provide such specific instructions on recommending PA recommendation within current treatment frameworks (Galletly et al., 2016, Malhi et al., 2015) and may be an area for improving the integration of PA and SB counselling within mental health treatment. Although mental health clinicians are well placed to use the skills they have in behaviour change techniques, findings indicated that they perhaps have not considered how to apply these skills to PA interventions, as almost half of the participants agreed to the statement that people with a mental illness do not engage in PA because they 'don't think they can'.

The fear of potentially disrupting the therapeutic relationship was cited as a major barrier for PA and SB counselling, with the perception that clients would not be interested in receiving such advice when accessing a mental health service and would not adhere to recommendations. However, empirical evidence demonstrates the opposite; clients who received PA recommendation from a clinician were more likely to engage in PA, compared with those who did not receive such a recommendation (Orrow et al., 2012, Pelletier et al., 2017). Given that the mental health professionals indicated a need for greater accessibility to the evidence-base to support clinical decisions, the dissemination of the evidence on PA recommendations in mental health treatment needs to be improved using different strategies such as educational seminars, team meetings, and prompt and reminder on the clinical guidelines. This may assist in addressing the identified barriers of lack of resources, competing priorities, lack of knowledge and skills regarding how to and where to find the information (Barzkar et al., 2018).

The finding that mental health professionals either do not provide any recommendations about the intensity of PA or link this to the experience of positive affect is consistent with previous studies with health care professionals (Stanton et al., 2015a, Stanton et al., 2018). Engaging in PA at a self-selected intensity that makes one 'feel good' has been found to have significant, positive effects on physical fitness (Parfitt et al., 2012) and mental health (Pascoe et al., 2020). With recent evidence suggesting that apart from PA itself, other associated factors such as enjoyment of the activity, personal preference, choice of activities, and opportunities for social interaction may also be important for mental health benefits (Teychenne et al., 2020), mental health professionals should be encouraged to recommend a focus on the enjoyment of physical activities rather than the intensity.

Engaging in structured or unstructured activities, either during leisure time or while commuting, has been identified as important in promoting mental wellbeing (Teychenne et al., 2017, Teychenne et al., 2020). We found that mental health professionals were more confident in providing recommendations to their clients on unstructured PA that are part of daily living. For recommendations on structured PA, such as exercise, they thought that advice or assistance from an exercise specialist would be helpful. In addition, recommending other resources for PA, such as interactive websites and smartphone apps, were identified as possible strategies. Such apps can provide support, motivation, and guidance to people with mental illness for increasing their leisure time PA.

A previous study found that health professionals who are more physically active are more likely to recommend PA to their clients (Fie et al., 2013). Consistent with this finding, the mental health professionals in our study believed that being more physically active themselves would increase their confidence in providing PA counselling to their clients. Such a practical exposure to evidence-informed strategies to increase PA and reduce SB may also address their concerns on how to effectively consult their clients about PA and SB. It may, therefore, be that an intervention to increase PA and reduce SB among mental health professionals would have indirect positive effects on their PA and SB counselling practices. This hypothesis is supported by the results of a recent study which found improvements in perceived barriers, attitudes, knowledge and confidence in promoting physical health in clients following a lifestyle intervention among clinical and non-clinical mental health staff in mental health treatment settings in Australia (Rosenbaum et al., 2020).

An important barrier for PA and SB counselling identified in this study was perceived lack of knowledge and skills. Only around one third of participants in our study reported having formal PA intervention training and they lacked confidence and perceived competence for providing recommendations on PA and SB to their clients. Mental health professionals in this study reported informally seeking information from online web-based sources or their colleagues. It may not always be easy to locate a reliable source of information for this purpose, and such approach may be too time-consuming for mental health professionals who are already burdened with many other responsibilities. It would therefore be useful to have information on PA and SB counselling when 'on the job' but crucial to ensure it is provided earlier during tertiary training. One of the key perceived barriers was also a concern that PA recommendations may detract from the presenting issues and concerns of clients and potentially damage the therapeutic rapport with clients. Adequate strategies need to be implemented in mental health centres to help clinicians overcome these perceived barriers and facilitate PA and SB counselling.

As indicated by mental health professionals in our study, the therapeutic role of PA in mental health and PA and SB counselling modules should be considered for inclusion within undergraduate and postgraduate training to ensure greater knowledge and confidence in clinical practice. Similarly, for existing service providers, training should be integrated into continuing professional development to improve knowledge, skills, and attitudes of clinicians regarding PA counselling (Wattanapisit et al., 2019).

Mental health professionals in our study believed that having access to an exercise physiologist would improve the effectiveness of their PA counselling, which is consistent with previous studies (Radovic et al., 2018, Faulkner and Biddle, 2001). PA counselling may be time consuming and hard to fit in the limited number of routine clinical visits available under current funding arrangements. Receiving assistance from exercise professionals would allow more time for mental health professionals to provide other types of treatment. Therefore, a further exploration of multi-disciplinary models of mental health care, including support from PA counsellors or exercise specialists, is warranted.

The strength of this study is its mixed-methods design, which allowed us to gain a deep understanding of mental health professionals' attitudes towards and practices in recommending more PA and less SB to their clients. The limitations of the present study should also be acknowledged. Firstly, the clinicians in our sample were recruited from youth mental health services. Therefore, they may not be representative of all Australian mental health professionals working across a range of clinical settings. Secondly, the focus group discussions took place after the mental health professionals received an intervention to increase their PA and reduce SB. Although in the focus group sessions we inquired about their common practices and attitudes prior to the intervention, it may be that the intervention affected some of the responses. It is important to note that this limitation only refers to the qualitative component of the study, because the survey was conducted before the intervention.

9.5 Conclusion

We found that mental health professionals highly value PA counselling, compared with other established treatments for mental illness. Although most mental health professionals regularly provide PA and SB counselling to their clients, recommendations are usually not specific or detailed. The most common perceived barriers were a lack of knowledge and confidence in providing PA and SB counselling. Mental health professionals shared a perception that people with a mental illness would not adhere to a PA program, that including PA in treatment may feel disruptive to clients and potentially damage rapport or the therapeutic alliance, and PA may be challenging to include for clients with complex needs. Based on our findings, the integration of PA and SB counselling within mental health treatment could be improved by: including training on PA and SB counselling in formal education and continued professional training for mental health professionals; ensuring support from an exercise or PA specialist within a multi-disciplinary approach to mental health care; and implementing interventions to increase PA and reduce SB among mental health professionals themselves.

References

Australian Bureau of Statistics 2013, Australian Health Survey: physical activity 2011-12. Australian Bureau of Statistics, Canberra.

AADAHL, M., ANDREASEN, A. H., HAMMER-HELMICH, L., BUHELT, L., JORGENSEN, T. & GLUMER, C. 2013. Recent temporal trends in sleep duration, domain-specific sedentary behaviour and physical activity. A survey among 25-79-year-old Danish adults. *Scand J Public Health,* 41**,** 706-11.

BAILEY, A. P., HETRICK, S. E., ROSENBAUM, S., PURCELL, R. & PARKER, A. G. 2018. Treating depression with physical activity in adolescents and young adults: a systematic review and meta-analysis of randomised controlled trials. *Psychol Med,* 48**,** 1068-1083.

BARZKAR, F., BARADARAN, H. R. & KOOHPAYEHZADEH, J. 2018. Knowledge, attitudes and practice of physicians toward evidence-based medicine: A systematic review. *Journal of Evidence-Based Medicine,* 11**,** 246-251.

BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3**,** 77-101.

DUNSTAN, D. W., HOWARD, B., HEALY, G. N. & OWEN, N. 2012. Too much sitting--a health hazard. *Diabetes Res Clin Pract,* 97**,** 368-76.

FAULKNER, G. & BIDDLE, S. 2001. Exercise and mental health: it's just not psychology! *J Sports Sci,* 19**,** 433-44.

FIE, S., NORMAN, I. J. & WHILE, A. E. 2013. The relationship between physicians' and nurses' personal physical activity habits and their health-promotion practice: A systematic review. *Health Education Journal,* 72**,** 102-119.

FLETCHER, A. J. 2017. Applying critical realism in qualitative research: methodology meets method. *International Journal of Social Research Methodology,* 20**,** 181-194.

GALLETLY, C., CASTLE, D., DARK, F., HUMBERSTONE, V., JABLENSKY, A., KILLACKEY, E., KULKARNI, J., MCGORRY, P., NIELSSEN, O. & TRAN, N. 2016. Royal Australian and New Zealand College of Psychiatrists clinical practice guidelines for the management of schizophrenia and related disorders. *Aust N Z J Psychiatry,* 50**,** 410-72.

GLOWACKI, K., WEATHERSON, K. & FAULKNER, G. 2019. Barriers and facilitators to health care providers' promotion of physical activity for individuals with mental illness: A scoping review. *Mental Health and Physical Activity,* 16**,** 152-168.

GUTHOLD, R., STEVENS, G. A., RILEY, L. M. & BULL, F. C. 2018. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *Lancet Glob Health,* 6**,** e1077-e1086.

HALLAL, P. C., ANDERSEN, L. B., BULL, F. C., GUTHOLD, R., HASKELL, W. & EKELUND, U. 2012. Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet,* 380**,** 247-257.

HEBERT, E. T., CAUGHY, M. O. & SHUVAL, K. 2012. Primary care providers' perceptions of physical activity counselling in a clinical setting: a systematic review. *Br J Sports Med,* 46**,** 625-31.

HUIJG, J. M., GEBHARDT, W. A., VERHEIJDEN, M. W., VAN DER ZOUWE, N., DE VRIES, J. D., MIDDELKOOP, B. J. & CRONE, M. R. 2015. Factors influencing primary health care professionals' physical activity promotion behaviors: a systematic review. *Int J Behav Med,* 22**,** 32-50.

KEYWORTH, C., EPTON, T., GOLDTHORPE, J., CALAM, R. & ARMITAGE, C. J. 2018. Are healthcare professionals delivering opportunistic behaviour change interventions? A multi-professional survey of engagement with public health policy. *Implement Sci,* 13**,** 122.

KEYWORTH, C., EPTON, T., GOLDTHORPE, J., CALAM, R. & ARMITAGE, C. J. 2019. 'It's difficult, I think it's complicated': Health care professionals' barriers and enablers to providing opportunistic behaviour change interventions during routine medical consultations. *Br J Health Psychol,* 24**,** 571-592.

LOBELO, F. & DE QUEVEDO, I. G. 2016. The Evidence in Support of Physicians and Health Care Providers as Physical Activity Role Models. *Am J Lifestyle Med,* 10**,** 36-52.

MALHI, G. S., BASSETT, D., BOYCE, P., BRYANT, R., FITZGERALD, P. B., FRITZ, K., HOPWOOD, M., LYNDON, B., MULDER, R., MURRAY, G., PORTER, R. & SINGH, A. B. 2015. Royal Australian and New Zealand College of Psychiatrists clinical practice guidelines for mood disorders. *Aust N Z J Psychiatry,* 49**,** 1087-206.

NG, S. W. & POPKIN, B. M. 2012. Time use and physical activity: a shift away from movement across the globe. *Obes Rev,* 13**,** 659-80.

NICE 2019. National Institute for Health and Care Excellence. NICE Guideline. Depression in children and young people: Identification and management. National Institute for Health and Care Excellence.

ORROW, G., KINMONTH, A. L., SANDERSON, S. & SUTTON, S. 2012. Effectiveness of physical activity promotion based in primary care: systematic review and meta-analysis of randomised controlled trials. *BMJ,* 344**,** e1389.

PARFITT, G., ALRUMH, A. & ROWLANDS, A. V. 2012. Affect-regulated exercise intensity: does training at an intensity that feels 'good' improve physical health? *J Sci Med Sport,* 15**,** 548-53.

PASCOE, M. C., BAILEY, A. P., CRAIKE, M., CARTER, T., PATTEN, R., STEPTO, N. K. & PARKER, A. G. 2020. Exercise interventions for mental disorders in young people: a scoping review. *BMJ Open Sport Exerc Med,* 6**,** e000678.

PELLETIER, L., SHANMUGASEGARAM, S., PATTEN, S. B. & DEMERS, A. 2017. Self-management of mood and/or anxiety disorders through physical activity/exercise. *Health Promot Chronic Dis Prev Can,* 37**,** 149-159.

PHONGSAVAN, P., MEROM, D., BAUMAN, A. & WAGNER, R. 2007. Mental illness and physical activity: therapists' beliefs and practices. *Aust N Z J Psychiatry,* 41**,** 458-9.

PIERCY, K. L., TROIANO, R. P., BALLARD, R. M., CARLSON, S. A., FULTON, J. E., GALUSKA, D. A., GEORGE, S. M. & OLSON, R. D. 2018. The Physical Activity Guidelines for Americans. *JAMA,* 320**,** 2020-2028.

RADOVIC, S., MELVIN, G. A. & GORDON, M. S. 2018. Clinician perspectives and practices regarding the use of exercise in the treatment of adolescent depression. *Journal of Sports Sciences,* 36**,** 1371-1377.

RICKWOOD, D., PARASKAKIS, M., QUIN, D., HOBBS, N., RYALL, V., TRETHOWAN, J. & MCGORRY, P. 2019. Australia's innovation in youth mental health care: The headspace centre model. *Early Interv Psychiatry,* 13**,** 159-166.

RICKWOOD, D. J., TELFORD, N. R., MAZZER, K. R., PARKER, A. G., TANTI, C. J. & MCGORRY, P. D. 2015. The services provided to young people through the headspace centres across Australia. *Med J Aust,* 202**,** 533-6.

ROSENBAUM, S., WARD, P. B., BALDEO, R., FIBBINS, H., JARMAN, R., LEDERMAN, O., PERRAM, A., POOLE, J., ROSSIMEL, E., SMITH, G., TEASDALE, S., WADE, T.,

WATKINS, A., WHITE, A., PEARCE, D. & CURTIS, J. 2020. Changing health workforce attitudes to promote improved physical health in mental health service users: Keeping our Staff in Mind (KoSiM). *Health Promotion Journal of Australia,* n/a.

SCHULZ, K. F., ALTMAN, D. G., MOHER, D. & GROUP, C. 2010. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMJ,* 340**,** c332.

SHORT, C. E., HAYMAN, M., REBAR, A. L., GUNN, K. M., DE COCKER, K., DUNCAN, M. J., TURNBULL, D., DOLLMAN, J., VAN UFFELEN, J. G. & VANDELANOTTE, C. 2016. Physical activity recommendations from general practitioners in Australia. Results from a national survey. *Aust N Z J Public Health,* 40**,** 83-90.

SHORTEN, A. & SMITH, J. 2017. Mixed methods research: expanding the evidence base. *Evid Based Nurs,* 20**,** 74-75.

STANTON, R., HAPPELL, B. & REABURN, P. 2014. The development of a questionnaire to investigate the views of health professionals regarding exercise for the treatment of mental illness. *Mental Health and Physical Activity,* 7**,** 177-182.

STANTON, R., HAPPELL, B. & REABURN, P. 2015a. Investigating the exercise-prescription practices of nurses working in inpatient mental health settings. *Int J Ment Health Nurs,* 24**,** 112-20.

STANTON, R., REABURN, P. & HAPPELL, B. 2015b. Barriers to exercise prescription and participation in people with mental illness: the perspectives of nurses working in mental health. *J Psychiatr Ment Health Nurs,* 22**,** 440-8.

STANTON, R., ROSENBAUM, S., LEDERMAN, O. & HAPPELL, B. 2018. Implementation in action: how Australian Exercise Physiologists approach exercise prescription for people with mental illness. *J Ment Health,* 27**,** 150-156.

TEYCHENNE, M., ABBOTT, G., LAMB, K. E., ROSENBAUM, S. & BALL, K. 2017. Is the link between movement and mental health a two-way street? Prospective associations between physical activity, sedentary behaviour and depressive symptoms among women living in socioeconomically disadvantaged neighbourhoods. *Preventive Medicine,* 102**,** 72-78.

TEYCHENNE, M., WHITE, R. L., RICHARDS, J., SCHUCH, F. B., ROSENBAUM, S. & BENNIE, J. A. 2020. Do we need physical activity guidelines for mental health: What does the evidence tell us? *Mental Health and Physical Activity,* 18**,** 100315.

VANCAMPFORT, D., FIRTH, J., SCHUCH, F. B., ROSENBAUM, S., MUGISHA, J., HALLGREN, M., PROBST, M., WARD, P. B., GAUGHRAN, F., DE HERT, M., CARVALHO, A. F. & STUBBS, B. 2017. Sedentary behavior and physical activity levels in people with schizophrenia, bipolar disorder and major depressive disorder: a global systematic review and meta-analysis. *World Psychiatry,* 16**,** 308-315.

WATTANAPISIT, A., PETCHUAY, P., WATTANAPISIT, S. & TUANGRATANANON, T. 2019. Developing a training programme in physical activity counselling for undergraduate medical curricula: a nationwide Delphi study. *BMJ Open,* 9**,** e030425.

WISDOM, J. & CRESWELL, J. W. 2013. *Integrating Quantitative and Qualitative Data Collection and Analysis While Studying Patient-Centered Medical Home Models. Rockville, MD: Agency for Healthcare Research and Quality.* [Online]. [Accessed 18 November 2020].

Chapter 10: Improving attitudes and practices of mental health professionals in recommending more physical activity and less sedentary behaviour to their clients: findings of a mixed-method intervention trial (Study 4)

Chapter outline: This chapter investigates the effects of engaging mental health professionals in an intervention to increase physical activity and reduce sedentary behaviour on their attitudes towards and practices in recommending more physical activity and less sedentary behaviour to their clients.

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DECLARATION OF CO-AUTHORSHIP AND CO-CONTRIBUTION: PAPERS INCORPORATED IN THESIS

This declaration is to be completed for each conjointly authored publication and placed at the beginning of the thesis chapter in which the publication appears.

1. PUBLICATION DETAILS (to be completed by the candidate)

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Institute: Institute for Health and Sport Candidate's Contribution (%): 60%

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

Nipun Shrestha Digitally signed by Nipun Shrestha Date: 2020.07.28 16:41:33 +10'00'	28 July 2020
Signature	**Date**

3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;

2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;

3. There are no other authors of the publication according to these criteria;

4. Potential conflicts of interest have been disclosed to a) granting bodies, b) the editor or publisher of journals or other publications, and c) the head of the responsible academic unit; and

5. The original data will be held for at least five years from the date indicated below and is stored at the following **location(s)**:

The datasets generated during and/or analysed during the current study will be stored in a non-publically available repository (Victoria University Research Repository, http://vuir.vu.edu.au).

Name(s) of Co-Author(s)	**Contribution (%)**	**Nature of Contribution**	**Signature**	**Date**
Alexandra Parker	10%	Developing the research question Determining the research	[redacted]	29 July 2020
Danijel Jurakic	5%	Assisting in development of intervention materials to be used	[redacted]	30 July 2020
Stuart J. H. Biddle	5%	Developing the research question Determining the research	[redacted]	31 July 2020
Zeljko Pedisic	10%	Developing the research question Determining the research	[redacted]	28 July 2020
Nipun Shrestha	60%	Developing the research question Determining the research	[redacted]	28 July 2020

Updated: September 2019

Abstract

Background:

We hypothesised that mental health professionals would be more likely to promote more physical activity (PA) and less sedentary behaviour (SB) to their clients, if they themselves are more physically active. In this context, we evaluated the effectiveness of a PA and SB intervention among mental health professionals and investigated the effects of engaging mental health professionals in this intervention on their attitudes towards and practices in recommending more PA and less SB to their clients.

Methods:

We used a mixed-methods study design comprising of a four-week pre-post intervention trial and focus group discussions. The study was conducted with 17 mental health professionals (mean ± standard deviation of age = 37.9 ± 9.8 years) employed in two youth mental health services (headspace centres) in Melbourne, Australia. The intervention entitled "Move More for Mental Health and Wellbeing" consisted of a single-session group-based behaviour change intervention, which targeted how to increase PA and reduce SB and included goal setting, followed by weekly reminders. Baseline and follow-up data were collected using a modified Exercise in Mental Illness Questionnaire (Health Professionals version) and GENEActiv accelerometers. Two focus group discussions were conducted after the intervention period.

Results:

There was no significant overall change in PA and SB among mental health professionals, but the intervention had a positive effect on their attitudes towards recommending more PA and less SB to their clients. The mental health professionals who increased their own PA during the intervention (compared to those who did not) significantly increased the frequency of recommending more PA (p=0.009) and less SB (p=0.005) to their clients. In focus group discussions, participants stated that the intervention made them feel more confident in consulting with their clients about PA and SB, but that its effectiveness in changing their activity levels could be further improved by introducing more reminders/follow-up calls.

Conclusion:

These results show that a relatively simple, low-cost intervention, consisting of group behaviour change counselling, goal setting and positive feedback, may improve mental health professionals' attitudes towards and practices in recommending more PA and less SB to their clients.

Trial registration: ISRCTN, ISRCTN43608761. Registered 03 July 2020 - Retrospectively registered, https://www.isrctn.com/ISRCTN43608761

10.1 Background

People with mental illness have an increased risk of chronic diseases and shorter life expectancy compared to the general population (Ribe et al., 2014, Gardner-Sood et al., 2015, Vancampfort et al., 2015). Pooled estimates of 148 studies found mortality rates were two to three times higher in people with severe mental illness (Walker et al., 2015). Interventions for increasing physical activity (PA) might not only reduce the risk of chronic diseases, but also improve outcomes of treatment and management of severe mental health illness (Bailey et al., 2018). In their updated guidelines for treatment and management of psychosis and schizophrenia in adults, the National Institute for Health and Care Excellence in the United Kingdom encouraged mental health professionals to recommend a combined healthy eating and PA program to their clients with psychosis or schizophrenia, especially to those taking antipsychotic medications (NICE, 2014). A similar recommendation has been made by the Royal Australian and New Zealand College of Psychiatrists in their guidelines for the management of schizophrenia and related disorders (Galletly et al., 2016).

Health professionals have been regarded as role models in the promotion of a healthy lifestyle. It has been found that clinicians were more likely to prescribe PA to their clients, if they themselves engaged in regular PA (Hebert et al., 2012). The evidence, however, suggests that most health care professionals do not achieve a sufficient level of PA (Jinks et al., 2003). This may, therefore, be an avenue for indirect promotion of PA for patients or clients of mental health services.

The potential role of mental health professionals' in PA promotion is further bolstered by their regular contact with clients and their skills in applying behaviour change techniques (Happell et al., 2013, Happell et al., 2011). The integration of PA counselling as an essential component of mental health services depends, in part, on the mental health professionals' attitudes towards PA and culture within mental health clinics (Rosenbaum et al., 2016).

The transtheoretical model (TTM) has been applied extensively for assessing individual's readiness to modify PA behavior (Han et al., 2017). The four core constructs of TTM are stages of change, self-efficacy, decisional balance, and processes of change. Stages of changes include 1) precontemplation: people at this stage do not intend to change their behaviour in the near future), 2) contemplation: at this stage people think there is some problem, 3) preparation: people now set goals to make the change, 4) action: people have changed their behaviour in the last six months and maintenance: people have maintained a new behaviour for more than six months (Prochaska and DiClemente, 1983). It has been postulated that people move back and forth through the stages in an attempt to modify PA behaviour and perceive more benefits than disadvantages associated with increasing PA and reducing SB as they advance through the later stages (Han et al., 2015).

It can be hypothesised based on previous studies that helping mental health professionals to formulate a PA plan and increase their own engagement in PA would improve their attitudes towards recommending PA to their clients (Howard and Gamble, 2011, Terry and Cutter, 2013, Jinks et al., 2003). The aim of this study was to evaluate the effectiveness of PA and sedentary behaviour (SB) intervention among mental health professionals and investigate the effects of engaging mental health professionals in this intervention on their attitudes towards, and practices in recommending, more PA and less SB to their clients. To inform future studies, it is important to investigate the reasons why an intervention was effective or ineffective and to find out what could improve its effectiveness. Therefore, we also used qualitative research methods to explore: (1) what motivated mental health professionals to participate in the intervention; (2) perceived effects of the intervention on participants' own PA and SB; (3) perceived effects of the intervention on the practices of mental health professionals in recommending more PA and less SB to their clients; and (4) what participants perceive would have improved the intervention.

10.2 Methods:

10.2.1 Study design

We used a mixed-methods study design comprising of a four-week pre-post intervention trial and focus group discussions. The study was conducted in two centres that are part of Australia's national youth mental health service network (Rickwood et al., 2019) (headspace Glenroy and headspace Sunshine) in Melbourne, Australia, from September to October 2019. Headspace centres provide services to young people aged 12 to 25 years, including psychological and psychiatric assessment and treatment, counselling, primary health care and substance-use treatment (Rickwood et al., 2015). The study overview is presented in Supplementary figure 3. Ethics approval was granted by the Victoria University Human Ethics Research Committee [HRE18-123], Melbourne, Australia. The study was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) (Schulz et al., 2010). The lead agency of the two headspace centres, Orygen (The National Centre of Excellence in Youth Mental Health), provided general oversight of safety and adverse events during the course of the trial.

10.2.2 Participants

We recruited 17 mental health professionals that satisfied the following eligibility criteria: aged 18–65 years; ambulatory; non-pregnant and engaged in clinical practice (Figure 80) This study sample was large enough to achieve a statistical power of 80% in a one-way repeated measures analysis of variance (ANOVA) with two repeated measurements, probability of type I error of <0.05, correlation between the measurements of 0.80, and the expected effect of at least medium size ($f>0.25$) according to Cohen (Cohen, 1992).

Prior to the commencement of the study, members of the research team were invited to attend a headspace centre research meeting, to inform the headspace centre managers about the study. Further details were provided via subsequent email communication. These managers then sent an invitation email to the clinicians who were working in their centres to take part in the study. The clinicians who expressed interest to participate in the study were provided with a participant information statement and consent form, which they signed and returned prior to commencement of the intervention. Although 28 mental health professionals expressed initial interest in participating in the study, 11 were excluded for the following reasons: three participants did not meet the inclusion criteria, seven participants declined to participate, and one left their clinical position.

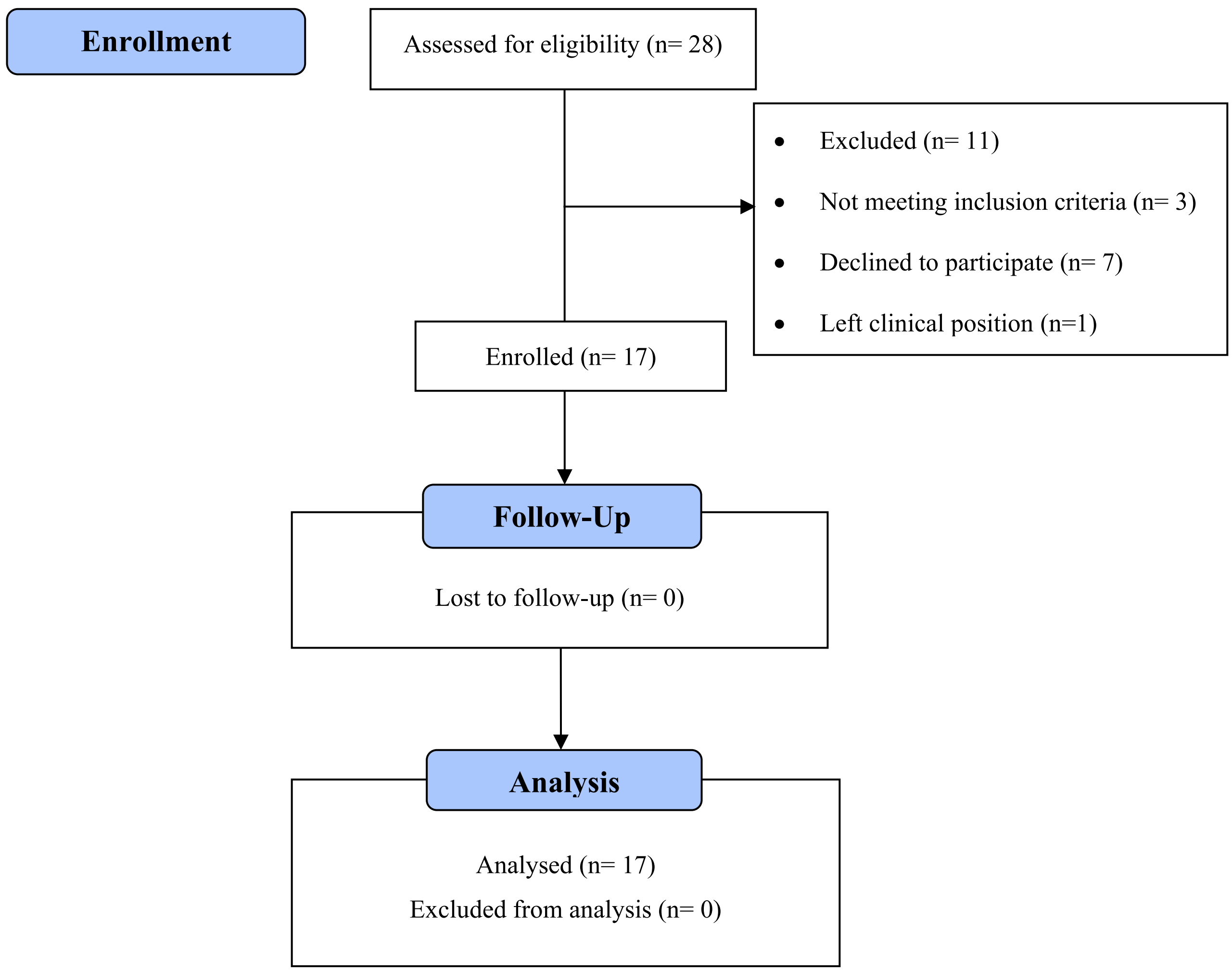


Figure 80: Consort flow diagram

10.2.3 Intervention

The intervention entitled "Move More for Mental Health and Wellbeing" was primarily grounded in the Theory of Planned Behaviour (TPB) (Ajzen, 1991). According to the TPB, an individual's intention to spend time in PA is a key determinant of their PA. The proximal determinants of this intention are attitudes, subjective norms, and perceived behavioural control. Attitudes towards PA and SB represent, for example, what an individual think of as benefits or harms of being physically active or sedentary, and how important these are. Subjective norms reflect an individual's perception of social support to engage in PA and SB. Perceived behavioural control for PA and

SB is an individual's perception of the extent to which they have control over their engagement and time spent in these behaviours. Our intervention addressed all three groups of proximal determinants of PA and SB. The intervention aimed to make a positive change in attitudes towards PA and SB via group behaviour change counselling. In regard to subjective norms, group discussion was encouraged for the participants, to exchange their thoughts on PA and SB, and they received positive feedback from the researchers. To influence their perceived behavioural control, participants were encouraged to set their goals at the beginning of the intervention and received reminder texts/calls during the intervention. The goal setting was conducted according to the SMART goals approach, to make sure that the goals are specific, measurable, achievable, relevant, and time bound.

The intervention consisted of a one-hour group behaviour change meeting, delivered by a registered psychologist and weekly reminders/consultation sessions. At the beginning of the intervention, a group session was held to discuss the benefits of increasing PA and reducing SB, and to present various strategies that can be adopted to achieve this. A printed information booklet containing 24 such strategies was provided to the participants. Participants were also provided an online version of the booklet. At the meeting, the participants set individuals goals and designed their weekly plan to achieve their desired levels of PA and reduce SB. This was followed by weekly reminder emails/text messages and telephone calls, to determine whether the participant followed their PA plan, identify any difficulties in achieving the set goals, and assist participants in revising their plan and selecting strategies to overcoming such barriers in the following week.

10.2.4 Information booklet

Several meetings of the research team were held to develop and design the information booklet. A thorough review of academic and grey literature was conducted to identify possible strategies for sitting less and moving more in the domains of leisure, home, work, and transport. The research team discussed the strategies and made a selection based on their simplicity, feasibility in the context of mental health professionals, and appropriateness for different groups according to age, ethnicity and adiposity status. The selected strategies were low cost, with strong potential to incorporate into daily life. Within the booklet, each of the 24 selected strategies was briefly described in lay language. Visual elements of the booklet were selected in collaboration with a professional graphic designer. In addition to the elements included in the printed version of the booklet, the online version included links to websites where participants could find more information about some of the strategies.

10.2.5 Focus groups

Focus groups were conducted to understand what factors were crucial in changing the PA and SB among the participants and what aspects of the intervention could be improved in future studies (Moore et al., 2015). At the end of the intervention, participants were invited to participate in 45- to 60-minute focus group interviews. Ten participants agreed to participate. To encourage participant interaction, two focus group sessions were organised, each including five participants. The focus group moderator used a set of predetermined questions to collect data in a semi-structured interview format. The focus group questions can be found in the Supplementary table 6. Participants were asked to share their views on a range of topics related to their motives for participating in the study, experience of the intervention, changes in their attitudes towards and practices in recommending more PA and less SB to their clients, and how the intervention could be improved.

The focus discussion was audio-recorded. Additionally, written notes were also taken to supplement the recordings. Participants provided informed consent that the discussion would be audio-recorded and transcribed verbatim by the researcher and that their personal identity would remain confidential. The transcript and notes were coded and later analysed using thematic analysis, as it allows flexibility in capturing the themes that address the research question (Braun and Clarke, 2006). The coding was completed using NVivo software.

*10.2.6 Outcome*s

Attitudes towards and practices in recommending more PA and less SB to clients were assessed using a modified version of the Exercise in Mental Illness Questionnaire - Health Professional version (Stanton et al., 2014). The section of the questionnaire on general beliefs asked participants to express their agreement with six statements (e.g. "People with a mental illness do not engage in PA, because they don't think they can") on a 5-level Likert-type response scale. It also asked participants to rank 11 treatment strategies, including increasing PA and reducing SB, according to their importance in the care of people with mental illness. The section on perceived barriers for recommending PA to people with mental illness asked participants to express their agreement with 11 statements (e.g. "I do not know how to recommend PA to people with a mental illness") on a 5-level Likert-type response scale. The section on practices included the following two items: "Do you recommend PA to people with a mental illness?"; and "Do you recommend reducing SB (time spent sitting/screen time) to people with a mental illness?", with the following response options:

"Never"; "Occasionally"; "Most of the time"; and "Always". A previous study found the questionnaire has good measurement properties (Stanton et al., 2014). Permission to modify terms included in the questionnaire was received from the author (R. Stanton, personal communication, 25 September 2019). In the modified version of the questionnaire used in this study, we replaced the term "exercise" with "physical activity", to capture a whole range of PA types that mental health professionals can recommend to their clients and added two items about SB counselling. The questionnaire also included questions on: gender; age; marital status; number of years of employment in mental health profession; in which country they completed their highest educational degree; how is their headspace role funded ("employed by headspace [salaried staff]" or "private provider"); whether they currently work in a clinical role at another service in addition to headspace; whether they consider the headspace role as their main job; and whether they have undergone formal training in recommending PA.

Physical activity was assessed by a GENEActiv Original accelerometer (Activinsights Ltd, Cambridgeshire, United Kingdom) worn on the dominant wrist continuously for 5-7 days in the week before the intervention and in the week after the intervention. These waterproof tri-axial accelerometers record accelerations and decelerations at a sampling frequency of 10-100Hz. For the purpose of this study, the sampling frequency was set at 80Hz. The accelerometer can be worn during sleep and waking time, which allows for 24-hour continuous monitoring of movement and non-movement behaviours. The data obtained for 10 or more hours a day during waking hours on at least 4 days was considered to be valid (Pedisic and Bauman, 2015). The GENEActiv data were analysed using the GENEActiv PC software version 3.2 and the associated Microsoft Excel macros (Activinsights, 2019). This study used the cut-points for GENEActiv accelerometers proposed by Esliger et al. (Esliger et al., 2011), to classify activities into: SB (<217 counts/min) and PA (≥217 counts/min) The remaining time was categorised as bedtime (included sleep and other bed time), using the algorithms provided in Excel Macros provided by the manufacturer. Prior to statistical analysis, the time-use components were re-scaled proportionally to add up to 24 hours. A relatively high validity has been found for GENEActiv accelerometer data as assessed against indirect calorimetry (Esliger et al., 2011).

10.2.7 Statistical analyses

Statistical analyses were conducted using the *robCompositions* package (Templ et al., 2011) in R Statistical Software (R Foundation for Statistical Computing, Vienna, Austria) and IBM Statistical Package for the Social Sciences (SPSS) software, version 23 (SPSS Inc., an IBM Company, Chicago, IL, USA). Baseline characteristics of the study participants are presented as means ± standard deviations (SD) or percentages. The amounts of time spent in PA, SB and bedtime are parts of a time-use composition. They were, therefore, analysed using compositional data analysis, as recommended in previous methodological papers (Dumuid et al., 2018, Pedišić, 2014, Pedišić et al., 2017). We calculated compositional means and variation matrix for the time-use compositions at baseline and follow-up. In the next step, the amounts of time participants spent in PA, SB and bedtime at baseline and follow-up, were expressed as two specific isometric log ratios (*ilr*s) called pivot coordinates that explain the whole variance of the raw time-use composition. To test the overall effect of the intervention on the time-use composition, we used a two-way repeated measures multivariate analysis of variance (MANOVA) on the two *ilr*s. These procedures are explained in more detail in previous papers (Chastin et al., 2015, Dumuid et al., 2020, Gupta et al., 2018, Pedišić et al., 2017, Matricciani et al., 2018). Furthermore, to assess the changes in beliefs, perceived barriers, and practices from baseline to follow up in the overall sample, we used a set of one-way repeated measures ANOVAs. This was followed by a set of two-way repeated measures ANOVAs, to test the difference in changes in beliefs, perceived barriers and practices between participants who increased their PA and reduced SB compared to those who did not.

10.3 Results

10.3.1 Sample characteristics

Participants had a mean age of 37.9 years and had worked in the mental health profession for an average of 7.8 years (Table 10). Most of the participants were female (76.5%), married/de facto (76.5%), directly employed by the headspace centre, as opposed to being a private provider (82.3%), and completed their highest qualification in Australia (82.3%).

Table 10: Characteristics of respondents

Characteristics	Mean ± SD
Age	37.9 ± 9.8
Years in profession	7.8 ± 7
	Percentage of respondents
Female gender	76.5%
Married/de facto	76.5%
Completed highest degree in Australia	82.3%
Salaried staff	82.3%
Currently works in a clinical role at another service	47%
Considers the role in headspace as the main job	76.5%
Undergone formal training in recommending physical activity	35.3%

10.3.2 Quantitative findings

At baseline, the participants spent on average 546 minutes/day in SB (570 minutes/day at follow up) and 338 minutes/day in PA (327 minutes/day at follow up), including the time spent in light-, moderate-, and vigorous-intensity physical activities (Table 11). Variability of time-use components is presented in Supplementary Table 9. Repeated measures MANOVA found no significant difference (p=0.513) between the baseline and follow-up time-use compositions.

Table 11: Time-use composition at baseline and follow-up

Part	Baseline		Follow-up	
	Compositional mean in proportions	***Compositional mean in hours/day***	***Compositional mean in proportions***	***Compositional mean in hours/day***
Sedentary behaviour	0.38	9.10	0.40	9.49
Physical activity*	0.23	5.64	0.23	5.45
Bedtime	0.39	9.27	0.38	9.06

* Overall physical activity, including the time spent in light, moderate, and vigorous physical activity

In regard to general beliefs about recommending PA to clients, for the overall sample there was a significant decrease from baseline to follow-up in the agreement with the statement "People with a mental illness who are recommended PA will not adhere to it" (Supplementary table 10). In regard to perceived barriers for recommending PA to clients, there was a significant decrease in participants' agreement with the following statements: "People with mental illness won't adhere to a PA program" and "My workload is already too excessive for recommending PA". We found no significant changes in the remaining general beliefs and perceived barriers of mental health professionals for recommending PA to their clients. We also found no significant changes from baseline to follow-up in how mental health professionals ranked the value of PA and SB in comparison with other forms of treatment for mental illness, including medication, social support, electroconvulsive therapy, bright light therapy, family therapy, social skills training, cognitive behavioural therapy, vocational rehabilitation, and hospitalisation (Supplementary Table 10).

Post hoc analyses revealed that participants who increased their own PA during the intervention, compared to those who did not, significantly increased the frequency of recommending more PA and less SB to their clients (Table 12). However, we found no significant differences between the two groups in the effects of the intervention on their general beliefs about, and perceived barriers for, recommending PA to their clients.

Table 12: Changes in general beliefs, perceived barriers and practices among mental health professionals who increased their physical activity or reduced sedentary behaviour during the intervention and among those who did not

	Increased physical activity					**Reduced sedentary behaviour**				
	No; mean (SD)		**Yes**; mean (SD)		*p**	**No**; mean (SD)		**Yes**; mean (SD)		*p**
	Pre†	Post‡	Pre†	Post‡		Pre†	Post‡	Pre†	Post‡	
Beliefs										
People with a mental illness know that physical activity is good for their physical health	3.33 (1.23)	3.89 (0.93)	3.63 (0.52)	3.63 (1.06)	0.289	3.11 (0.93)	3.44 (0.88)	3.88 (0.84)	4.13 (0.99)	0.876
People with a mental illness know that physical activity is good for their mental health	2.89 (0.93)	3.00 (0.87)	3.38 (0.74)	2.75 (0.70)	0.094	3.00 (0.87)	2.89 (0.60)	3.25 (0.87)	2.88 (0.99)	0.565
People with a mental illness do not engage in physical activity, because they don't think they can	3.56 (0.73)	3.67 (0.50)	3.00 (1.06)	3.38 (0.74)	0.488	3.33 (0.70)	3.44 (0.73)	3.25 (1.17)	3.63 (0.52)	0.488
Physical activity is valuable for patients *hospitalised* with a mental illness in the same manner as for outpatients	4.00 (0.50)	4.22 (0.44)	4.38 (0.52)	4.13 (0.64)	0.115	4.00 (0.50)	4.22 (0.67)	4.38 (0.52)	4.13 (0.35)	0.115
The physical and mental health benefits of physical activity for people with a mental illness are not long lasting	2.33 (0.87)	2.11 (0.60)	2.13 (0.84)	2.25 (0.70)	0.550	2.22 (0.97)	2.22 (0.83)	2.25 (0.7)	2.13 (0.35)	0.830
People with a mental illness who are recommended physical activity will not adhere to it	3.11 (0.78)	2.56 (0.73)	2.87 (0.84)	2.50 (0.76)	0.657	2.78 (0.67)	2.33 (0.50	3.25 (0.89)	2.75 (0.89)	0.892
How do you rank increasing physical activity compared to other forms of treatment?	3.44 (1.67)	3.11 (1.54)	3.38 (1.30)	4.38 (1.92)	0.154	3.67 (1.87)	3.89 (2.15)	3.13 (0.84)	3.50 (1.41)	0.874
How do you rank reducing sedentary behaviour compared to other forms of treatment?	6.33 (1.73)	5.44 (1.88)	5.00 (2.07)	6.38 (1.92)	0.060	5.22 (1.79)	5.78 (2.22)	6.25 (2.12)	6.00 (1.60)	0.526
Perceived barriers										
Their mental health makes it impossible for them to participate in physical activity	1.67 (0.70)	1.33 (0.50)	2.13 (0.99)	2.00 (1.06)	0.464	1.67 (0.87)	1.67 (0.7)	2.13 (0.84)	1.63 (1.06)	0.065
I'm concerned physical activity might make their condition worse	1.56 (0.73)	1.78 (0.97)	1.38 (0.52)	1.63 (0.52)	0.948	1.44 (0.53)	1.89 (0.93)	1.50 (0.76)	1.50 (0.54)	0.285
I am not interested in recommending physical activity for people with a mental illness	1.33 (0.50)	1.33 (0.70)	1.5 (0.54)	1.25 (0.46)	0.409	1.22 (0.44)	1.22 (0.44)	1.63 (0.52)	1.38 (0.74)	0.409
I don't believe physical activity will help people with a mental illness	1.33 (0.50)	1.22 (0.44)	1.38 (0.52)	1.25 (0.46)	0.955	1.22 (0.44)	1.22 (0.44)	1.50 (0.540	1.25 (0.46)	0.304
Their physical health makes it impossible for them to participate in physical activity	1.56 (0.53)	1.67 (0.70)	2.13 (0.99)	2.00 (0.76)	0.619	1.56 (0.53)	1.67 (0.7)	2.13 (0.99)	2.00 (0.76)	0.619
I'm concerned they might get injured while engaging in physical activity	1.56 (0.73)	1.44 (0.73)	1.88 (0.84)	1.63 (0.74)	0.736	1.44 (0.73)	1.33 (0.7)	2.00 (0.76)	1.75 (0.70)	0.736
People with a mental illness won't adhere to a physical activity program	2.22 (1.09)	1.78 (0.97)	2.63 (1.30)	2.00 (0.76)	0.707	1.67 (0.87)	1.44 (0.53)	3.25 (0.87)	2.38 (0.92)	0.161

My workload is already too excessive to include recommending physical activity to people with a mental illness	2.11 (1.05)	1.89 (0.78)	2.38 (1.12)	1.50 (0.76)	0.128	1.89 (1.05)	1.67 (0.87)	2.63 (1.06)	1.75 (0.70)	0.128
Recommending physical activity to people with a mental illness is not part of my job	1.56 (0.53)	1.56 (0.73)	1.38 (0.52)	1.38 (0.74)	1.000	1.33 (0.50)	1.44 (0.730	1.63 (0.52)	1.50 (0.76)	0.445
I do not know how to recommend physical activity to people with a mental illness	2.11 (1.27)	2 (1.0)	2.50 (1.41)	2.00 (1.07)	0.362	1.56 (1.00)	1.44 (0.53)	3.13 (1.13)	2.63 (1.06)	0.362
Prescription of physical activity to people with mental illness is best delivered by an exercise professional such as an exercise physiologist	2.78 (0.97)	2.56 (1.13)	2.75 (1.58)	2.38 (1.4)	0.661	2.11 (0.93)	1.89 (0.930	3.5 (1.20)	3.13 (1.25)	0.661
Practice										
Do you recommend physical activity to people with a mental illness?	3.44 (0.53)	2.89 (0.78)	3.00 (0.93)	3.38 (0.52)	**0.009**	3.44 (0.73)	3.33 (0.70)	3.00 (0.76)	2.87 (0.64)	0.972
Do you recommend reducing sedentary behaviour (time spent sitting/screen time) to people with a mental illness?	3.00 (1.00)	2.67 (1.00)	2.50 (0.93)	3.00 (0.93)	**0.005**	3.33 (0.70)	3.22 (0.83)	2.13 (0.84)	2.38 (0.92)	0.273

* *p*-value for the interaction between the group (No/Yes) and time (B/F) according to a two-way repeated measures univariate analysis of variance (ANOVA)

† Pre-intervention (i.e. at baseline)

‡ Post-intervention (i.e. at follow-up)

10.3.3 Qualitative findings

When asked about what motivated their participation in the trial, participants reported that the intervention provided them an opportunity to engage in a healthy behaviour as a team, with encouragement from their colleagues. They stated, for example:

> *"It's like professional development stuff. People identify something that might be helpful and say, like, 'let's all do this'."*
>
> *(Clinician 1)*

> *"We got that encouragement to push, I mean you know you can talk it for a while. But it may not actually happen, so that was kind of 'Oh! We are all in it now'."*
>
> *(Clinician 2)*

Some participants stated they were also motivated to participate because their experiences during the trial would assist or contribute to their work with their clients.

> *"Thinking this might be good stuff to pass onto our clients was probably a big motivator for actually turning up as well."*
>
> *(Clinician 1)*

Participants shared a perception that their levels of PA increased during the intervention. They reported trying different strategies to increase PA and reduce SB, such as setting up a sit-stand desk, organising walking meetings, or engaging in more movement that differed from what was originally planned or set as the weekly goal.

"Some of us had the experience of going out for walking meetings. Let's take this work outside."

(Clinician 3)

"I was doing things that were different from my plan, but still I did a lot more activity."

(Clinician 4)

When asked whether participating in the intervention resulted in any change in their PA counselling practices during the period, participants stated that the intervention increased their confidence in discussing various strategies to increase PA and reduce SB with their clients. Similarly, when asked about the intervention content they particularly liked and would implement in their practice, participants stated that, as a result of the intervention, they were more likely to recommend incidental PA (e.g. taking stairs instead of escalator) to their clients, as it is easier to implement and adhere to, compared with other types of PA.

"I talked about it a little bit more with some of my clients. I shared with them some of those strategies that you gave us. I did not give them the brochure, but I gave them some ideas. It made me feel more confident, because now I could be quite specific about some of those

ideas, whereas before it would have been more like 'Try to do a bit more what you are comfortable doing'."

(Clinician 1)

"It could be incidental exercise. Maybe that's the only stuff that I really stuck to. But I felt a little bit more motivated to use little tricks. Today I have got a water bottle, but I have been making effort to have just a glass of water on my desk, just little things like that, so that I am forcing myself to get up or tricking myself in doing more incidental exercises. I enjoyed that stuff and I felt like that those are the things that I truly felt confident of sharing with my clients."

(Clinician 1)

The participants found the strategies that were presented to them in the intervention session were helpful and easy to implement. However, they felt there should have been more reminders/follow-up calls. They also said that reflecting upon how they were progressing during the intervention period would have been helpful to bring them back on track. When asked what would have improved their adherence to the strategies to increase PA and reduce SB, the participants stated, for example:

"For me it would be like having more around to do exercise and may be with the follow-up call and also sending through reminders what to do."

(Clinician 5)

"Maybe even have a time to be realistic and reflect how we all are going a couple of weeks in would have been enough to get us back on track."

(Clinician 2)

In relation to the same question, a participant shared her experience how a follow-up call was helpful in finding alternative ways to increase her PA, that is, other than those that were planned in the SMART goals identified during the intervention period. She stated:

"I remember we had an email exchange, and I think at one point I was struggling to get a running routine happening and you said something like: "Have you tried park run?". Then I looked it up and there was one in the area, but it made me think about alternative ways to be motivated and that problem-solving aspect was really nice and felt very supported."

(Clinician 6)

10.4 Discussion

We found that a relatively simple intervention, consisting of a single-session group behaviour change counselling, goal setting and positive feedback, may improve attitudes of mental health professionals towards recommending more PA and less SB to their clients. The effects of the intervention on PA and SB of mental health professionals remains unclear. Nevertheless, the mental health professionals who increased their own PA during the intervention, significantly increased the frequency of recommending more PA and less SB to their clients. This finding supports the hypothesis that, by promoting PA among mental health professionals, we can indirectly improve their practices in recommending more PA and less SB to their clients. More follow-up calls and additional reminders were identified by the participants as a possible strategy to further improve the effectiveness of the intervention.

Previous studies provided mixed evidence on the effectiveness of lifestyle interventions for health professionals. A systematic review that assessed the effects of PA interventions among nurses found that six out of nine studies reported significant increases in PA or energy expenditure (Torquati et al., 2017). Only one study included in the review found a significant reduction in sitting time (Lavoie-Tremblay et al., 2014). In the current study, the average amounts of time spent in PA and SB before and after the intervention remained about the same. Nevertheless, PA increased more than 10 minutes a day among 47% of participants and SB decreased by more than 30 minutes a day among 29% of participants. It might be that this intervention is effective only among a specific group of mental health professionals. This should be elucidated in future studies using larger samples that would allow for exploring possible moderator effects.

From the participant feedback provided in the focus group sessions, it seems that the effectiveness of the intervention could be improved by introducing additional reminders and follow-up calls. Given that the frequency of follow-up calls was once a week, when designing and evaluating future interventions, researchers should consider implementing two or more follow-up calls per week. Additionally, a single group behaviour change session might not be sufficient to improve the attitudes and practices of mental health professionals in recommending PA and less SB to their clients. Thus, in future studies, researchers should also consider increasing the number of group behaviour change sessions. Text messages and emails might be a feasible way to remind mental health professionals more frequently to adhere to their chosen strategies. Furthermore, participants also mentioned that encouragement from their colleagues was an important factor for them to engage in the intervention. Motivating intervention participants to provide positive feedback to each other during the intervention may also be a way to achieve greater effectiveness. Similarly, a reflection on mental health professionals' own PA and SB and exploring ways to improve these behaviours during team meetings might be an effective strategy worth testing in future studies. Strategies involving greater social support warrant further study.

Health professionals generally have positive attitudes towards their role as promoters of a healthy lifestyle to their clients (Johansson et al., 2009, Valente et al., 1986, Wechsler et al., 1996). Nevertheless, various barriers have been reported for lifestyle counselling by health professionals, such as lack of confidence in their counselling skills (Orleans et al., 1985), lack of time (Cornuz et al., 2000), and little interest from patients on increasing their PA level (Cornuz et al., 2000, Orleans et al., 1985). In our study, however, we found that mental health professionals generally did not agree with the commonly reported barriers in the literature. This might be because mental health professionals are routinely trained in behaviour change counselling (RANZCP, 2012, RCPSYCH, 2013) and generally have positive attitudes towards its application (Bartlem et al., 2016, Howard and Gamble, 2011, Johnson et al., 2009, Robson et al., 2013). Although there was no significant overall change in PA and SB among mental health professionals, our intervention had a positive effect on their attitudes towards recommending more PA and less SB among their clients. Previous studies found that, despite having positive attitudes about recommending PA to their clients, many mental health professionals still do not consider it as an adjunctive treatment for mental illness (Faulkner and Biddle, 2001, Faulkner and Biddle, 2002). It should, therefore, be taken into consideration that changing attitudes of mental health professionals may not necessarily improve their practices in recommending more PA and less SB to their clients.

From the participant feedback received in the focus group sessions, it seems their attitudes were improved through increasing knowledge about and confidence to recommend PA. We found that those who increased their PA during the intervention started recommending PA and less SB more often to their clients. Providing more group behaviour change sessions and additional reminders and follow-ups might further improve the effectiveness of the intervention. However, this needs to be tested in future studies with larger samples of participants. From the findings of this study, it seems the intervention is worth scaling up and delivering to a larger number of mental health professionals working in Australian headspace centres. Even small intervention effects may lead to large public health benefits, given that approximately 100 thousand young people with mental health concerns access an Australian headspace centre per annum (headspace, 2019).

This intervention trial was subject to some limitations that need to be considered when interpreting our findings. Firstly, the study design did not include a ‘true’ control group, that is, a comparison group of mental health professionals that received no intervention. It may be, therefore, that some of the changes we observed in our study sample were not due to the intervention effects only. Second, the study only included two mental health services from the same national network of centres. The participants that were recruited into this study might not be representative of all mental health professionals in Australia, which limits the generalizability of our findings. Third, although the study sample was large enough to ensure adequate statistical power in the main analysis (i.e. one-way repeated measures ANOVA), it did not allow us to further explore possible moderator effects of sociodemographic and lifestyle variables. Finally, we examined only short-term effects of the intervention, because the follow-up measurement was conducted immediately after the intervention. We, therefore, cannot draw conclusions about potential impact of the intervention on attitudes and practices of mental health professionals over a longer term.

10.5 Conclusion

Our findings suggest that a relatively simple, 4-week intervention, consisting of single-session group counselling, goal setting and positive feedback, can improve attitudes and practices of mental health professionals in recommending more PA and less SB to their clients. It seems justified to further improve the intervention based on participant feedback we received and scale it up to promote more PA and less SB in mental health settings. This area would benefit from randomised controlled trials evaluating long-term effects of interventions that combine indirect and direct strategies to improve attitudes and practise of mental health professionals for promoting healthy lifestyle.

References

ACTIVINSIGHTS 2019. GeneActiv instructions manual version 1.4. *(accessed 20 March 2020). Available online:* https://49wvycy00mv416l561vrj345-wpengine.netdna-ssl.com/wp-content/uploads/2019/06/geneactiv_instruction_manual_v1.4.pdf.

AJZEN, I. 1991. The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50**,** 179-211.

BAILEY, A. P., HETRICK, S. E., ROSENBAUM, S., PURCELL, R. & PARKER, A. G. 2018. Treating depression with physical activity in adolescents and young adults: a systematic review and meta-analysis of randomised controlled trials. *Psychol Med,* 48**,** 1068-1083.

BARTLEM, K., BOWMAN, J., ROSS, K., FREUND, M., WYE, P., MCELWAINE, K., GILLHAM, K., DOHERTY, E., WOLFENDEN, L. & WIGGERS, J. 2016. Mental health clinician attitudes to the provision of preventive care for chronic disease risk behaviours and association with care provision. *BMC Psychiatry,* 16**,** 57.

BRAUN, V. & CLARKE, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology,* 3**,** 77-101.

CHASTIN, S. F., PALAREA-ALBALADEJO, J., DONTJE, M. L. & SKELTON, D. A. 2015. Combined Effects of Time Spent in Physical Activity, Sedentary Behaviors and Sleep on Obesity and Cardio-Metabolic Health Markers: A Novel Compositional Data Analysis Approach. *PLoS One,* 10**,** e0139984.

COHEN, J. 1992. A power primer. *Psychol Bull,* 112**,** 155-9.

CORNUZ, J., GHALI, W. A., DI CARLANTONIO, D., PECOUD, A. & PACCAUD, F. 2000. Physicians' attitudes towards prevention: importance of intervention-specific barriers and physicians' health habits. *Fam Pract,* 17**,** 535-40.

DUMUID, D., PEDISIC, Z., PALAREA-ALBALADEJO, J., MARTIN-FERNANDEZ, J. A., HRON, K. & OLDS, T. 2020. Compositional Data Analysis in Time-Use Epidemiology: What, Why, How. *Int J Environ Res Public Health,* 17.

DUMUID, D., STANFORD, T. E., MARTIN-FERNANDEZ, J. A., PEDISIC, Z., MAHER, C. A., LEWIS, L. K., HRON, K., KATZMARZYK, P. T., CHAPUT, J. P., FOGELHOLM, M., HU, G., LAMBERT, E. V., MAIA, J., SARMIENTO, O. L., STANDAGE, M., BARREIRA, T. V., BROYLES, S. T., TUDOR-LOCKE, C., TREMBLAY, M. S. & OLDS, T. 2018. Compositional data analysis for physical activity, sedentary time and sleep research. *Stat Methods Med Res,* 27**,** 3726-3738.

ESLIGER, D. W., ROWLANDS, A. V., HURST, T. L., CATT, M., MURRAY, P. & ESTON, R. G. 2011. Validation of the GENEA Accelerometer. *Med Sci Sports Exerc,* 43**,** 1085-93.

FAULKNER, G. & BIDDLE, S. 2001. Exercise and mental health: it's just not psychology! *J Sports Sci,* 19**,** 433-44.

FAULKNER, G. & BIDDLE, S. 2002. Mental health nursing and the promotion of physical activity. *J Psychiatr Ment Health Nurs,* 9**,** 659-65.

GALLETLY, C., CASTLE, D., DARK, F., HUMBERSTONE, V., JABLENSKY, A., KILLACKEY, E., KULKARNI, J., MCGORRY, P., NIELSSEN, O. & TRAN, N. 2016. Royal Australian and New Zealand College of Psychiatrists clinical practice guidelines for the management of schizophrenia and related disorders. *Aust N Z J Psychiatry,* 50**,** 410-72.

GARDNER-SOOD, P., LALLY, J., SMITH, S., ATAKAN, Z., ISMAIL, K., GREENWOOD, K. E., KEEN, A., O'BRIEN, C., ONAGBESAN, O., FUNG, C., PAPANASTASIOU, E., EBERHARD, J., PATEL, A., OHLSEN, R., STAHL, D., DAVID, A., HOPKINS, D.,

MURRAY, R. M., GAUGHRAN, F. & TEAM, I. M. 2015. Cardiovascular risk factors and metabolic syndrome in people with established psychotic illnesses: baseline data from the IMPaCT randomized controlled trial. *Psychol Med,* 45**,** 2619-29.

GUPTA, N., MATHIASSEN, S. E., MATEU-FIGUERAS, G., HEIDEN, M., HALLMAN, D. M., JORGENSEN, M. B. & HOLTERMANN, A. 2018. A comparison of standard and compositional data analysis in studies addressing group differences in sedentary behavior and physical activity. *Int J Behav Nutr Phys Act,* 15**,** 53.

HAN, H., GABRIEL, K. P. & KOHL, H. W. 2015. Evaluations of Validity and Reliability of a Transtheoretical Model for Sedentary Behavior among College Students. *Am J Health Behav,* 39**,** 601-9.

HAN, H., PETTEE GABRIEL, K. & KOHL, H. W., 3RD 2017. Application of the transtheoretical model to sedentary behaviors and its association with physical activity status. *PLoS One,* 12**,** e0176330.

HAPPELL, B., PLATANIA-PHUNG, C. & SCOTT, D. 2011. Placing physical activity in mental health care: a leadership role for mental health nurses. *Int J Ment Health Nurs,* 20**,** 310-8.

HAPPELL, B., PLATANIA-PHUNG, C. & SCOTT, D. 2013. Survey of Australian mental health nurses on physical activity promotion. *International Journal of Mental Health Promotion,* 15**,** 148-161.

HEADSPACE 2019. Australia's National Youth Mental Health Foundation. Year in review 2018-2019. *Available from: https://headspace.org.au/assets/HSP029-Year-in-Review-FA02.B-DIGITAL.pdf.*

HEBERT, E. T., CAUGHY, M. O. & SHUVAL, K. 2012. Primary care providers' perceptions of physical activity counselling in a clinical setting: a systematic review. *Br J Sports Med,* 46**,** 625-31.

HOWARD, L. & GAMBLE, C. 2011. Supporting mental health nurses to address the physical health needs of people with serious mental illness in acute inpatient care settings. *J Psychiatr Ment Health Nurs,* 18**,** 105-12.

JINKS, A. M., LAWSON, V. & DANIELS, R. 2003. A survey of the health needs of hospital staff: implications for health care managers. *J Nurs Manag,* 11**,** 343-50.

JOHANSSON, H., WEINEHALL, L. & EMMELIN, M. 2009. "It depends on what you mean": a qualitative study of Swedish health professionals' views on health and health promotion. *BMC Health Serv Res,* 9**,** 191.

JOHNSON, J. L., MALCHY, L. A., RATNER, P. A., HOSSAIN, S., PROCYSHYN, R. M., BOTTORFF, J. L., GROENING, M., GIBSON, P., OSBORNE, M. & SCHULTZ, A. 2009. Community mental healthcare providers' attitudes and practices related to smoking cessation interventions for people living with severe mental illness. *Patient Educ Couns,* 77**,** 289-95.

LAVOIE-TREMBLAY, M., SOUNAN, C., TRUDEL, J. G., LAVIGNE, G. L., MARTIN, K. & LOWENSTEYN, I. 2014. Impact of a pedometer program on nurses working in a health-promoting hospital. *Health Care Manag (Frederick),* 33**,** 172-80.

MATRICCIANI, L., BIN, Y. S., LALLUKKA, T., KRONHOLM, E., WAKE, M., PAQUET, C., DUMUID, D. & OLDS, T. 2018. Rethinking the sleep-health link. *Sleep Health,* 4**,** 339-348.

MOORE, G. F., AUDREY, S., BARKER, M., BOND, L., BONELL, C., HARDEMAN, W., MOORE, L., O'CATHAIN, A., TINATI, T., WIGHT, D. & BAIRD, J. 2015. Process

evaluation of complex interventions: Medical Research Council guidance. *BMJ,* 350**,** h1258.
NICE 2014. National Institute for Health and Care Excellence. Psychosis and schizophrenia in adults: Treatment and management. NICE clinical guideline 178. London: National Institute for Health and Care Excellence.
ORLEANS, C. T., GEORGE, L. K., HOUPT, J. L. & BRODIE, K. H. 1985. Health promotion in primary care: a survey of U.S. family practitioners. *Prev Med,* 14**,** 636-47.
PEDIŠIĆ, Z. 2014. Measurement issues and poor adjustments for physical activity and sleep undermine sedentary behaviour research—the focus should shift to the balance between sleep, sedentary behaviour, standing and activity. *Kinesiology,* 46**,** 135-46.
PEDISIC, Z. & BAUMAN, A. 2015. Accelerometer-based measures in physical activity surveillance: current practices and issues. *Br J Sports Med,* 49**,** 219-23.
PEDIŠIĆ, Ž., DUMUID, D. & OLDS, T. 2017. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. *Kinesiology,* 49**,** 252-69.
PROCHASKA, J. O. & DICLEMENTE, C. C. 1983. Stages and processes of self-change of smoking: toward an integrative model of change. *J Consult Clin Psychol,* 51**,** 390-5.
RANZCP 2012. The Royal Australian & New Zealand college of psychiatrists. Guide to psychotherapy training. Available from . https://www.ranzcp.org/files/prefellowship/2012-fellowship-program/guide-for-psychotherapy-training.aspx.
RCPSYCH 2013. Royal College of Psychiatrists. A competency based curriculum for specialist core training in psychiatry. Available from https://www.rcpsych.ac.uk/docs/default-source/training/curricula-and-guidance/core_psychiatry_curriculum_may_2019.pdf?sfvrsn=f8594b3e_4.
RIBE, A. R., LAURSEN, T. M., SANDBAEK, A., CHARLES, M., NORDENTOFT, M. & VESTERGAARD, M. 2014. Long-term mortality of persons with severe mental illness and diabetes: a population-based cohort study in Denmark. *Psychol Med,* 44**,** 3097-107.
RICKWOOD, D., PARASKAKIS, M., QUIN, D., HOBBS, N., RYALL, V., TRETHOWAN, J. & MCGORRY, P. 2019. Australia's innovation in youth mental health care: The headspace centre model. *Early Interv Psychiatry,* 13**,** 159-166.
RICKWOOD, D., TELFORD, N. R., MAZZER, K. R., PARKER, A. G., TANTI, C. J. & MCGORRY, P. D. 2015. The services provided to young people through the headspace centres across Australia. *Med J Aust,* 202**,** 533-6.
ROBSON, D., HADDAD, M., GRAY, R. & GOURNAY, K. 2013. Mental health nursing and physical health care: a cross-sectional study of nurses' attitudes, practice, and perceived training needs for the physical health care of people with severe mental illness. *Int J Ment Health Nurs,* 22**,** 409-17.
ROSENBAUM, S., WATKINS, A., WARD, P. B., PEARCE, D., FITZPATRICK, K., CURTIS, J. & KEEPING THE BODY IN MIND TEAM, S. 2016. Psychiatry HeAL thyself! *Aust N Z J Psychiatry,* 50**,** 600.
SCHULZ, K. F., ALTMAN, D. G., MOHER, D. & GROUP, C. 2010. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. *BMJ,* 340**,** c332.

STANTON, R., HAPPELL, B. & REABURN, P. 2014. The development of a questionnaire to investigate the views of health professionals regarding exercise for the treatment of mental illness. *Mental Health and Physical Activity,* 7**,** 177-182.

TEMPL, M., HRON, K. & FILZMOSER, P. 2011. robCompositions: An R-package for Robust Statistical Analysis of Compositional Data. *Compositional Data Analysis: Theory and Applications***,** 341-355.

TERRY, J. & CUTTER, J. 2013. Does education improve mental health practitioners' confidence in meeting the physical health needs of mental health service users? A mixed methods pilot study. *Issues Ment Health Nurs,* 34**,** 249-55.

TORQUATI, L., PAVEY, T., KOLBE-ALEXANDER, T. & LEVERITT, M. 2017. Promoting Diet and Physical Activity in Nurses. *Am J Health Promot,* 31**,** 19-27.

VALENTE, C. M., SOBAL, J., MUNCIE, H. L., JR., LEVINE, D. M. & ANTLITZ, A. M. 1986. Health promotion: physicians' beliefs, attitudes, and practices. *Am J Prev Med,* 2**,** 82-8.

VANCAMPFORT, D., STUBBS, B., MITCHELL, A. J., DE HERT, M., WAMPERS, M., WARD, P. B., ROSENBAUM, S. & CORRELL, C. U. 2015. Risk of metabolic syndrome and its components in people with schizophrenia and related psychotic disorders, bipolar disorder and major depressive disorder: a systematic review and meta-analysis. *World Psychiatry,* 14**,** 339-47.

WALKER, E. R., MCGEE, R. E. & DRUSS, B. G. 2015. Mortality in mental disorders and global disease burden implications: a systematic review and meta-analysis. *JAMA Psychiatry,* 72**,** 334-41.

WECHSLER, H., LEVINE, S., IDELSON, R. K., SCHOR, E. L. & COAKLEY, E. 1996. The physician's role in health promotion revisited--a survey of primary care practitioners. *N Engl J Med,* 334**,** 996-8.

Chapter 11: General discussion

The purpose of the final chapter is to (a) collate and summarise the main findings of the studies conducted, (b) identify the strengths and limitations of the studies included in this thesis, and (c) provide implications for research and practice.

Summary of Studies

11.1 Effectiveness of physical activity interventions

The purpose of the literature review (Chapter 4) was to summarize the evidence on the effectiveness of PA intervention in both workplace and community settings. At the workplace, counseling/support interventions and health promotion messages/information interventions appeared to be the most promising intervention. However, evidence of their sustained effectiveness in the long term is limited. Hence further research is needed a) to assess the effectiveness of these intervention over the long term and b) to assess the effectiveness of exercise intervention and environment restructuring interventions. Similarly, in community settings the evidence of the effectiveness of PA interventions is limited. This might be due to the complex nature of interventions that operate at multiple levels. Goal setting and self-monitoring of behaviour were the most commonly used and promising BCTs in the PA interventions. Similar findings were reported in a previous review by Samdal et al. (2017) assessing BCTs in PA interventions among overweight and obese adults. With the growth in mobile technology, smart phones and the app based health and fitness applications have become popular in health promotion as people are increasingly seeking health information through mobile (smart) devices (Guertler et al., 2015, Nikoloudakis et al., 2018). These applications can serve as low-cost interventions with the potential to reach a large portion of the population, however, challenges such as the ownership of smart phones and knowledge of the use of specific applications limits their applicability.

11.2 Effectiveness of interventions for reducing sedentary behaviour

Many studies have targeted restructuring the environment for reducing SB such as introducing sit-stand desks in the workplace. The findings of review (Chapter 6) shows that implementing changes in workstations such as sit-stand desks were effective in reducing sitting on an average by 100 minutes/day. Similar reductions in siting time (mean difference 77 minutes/day) was reported in another meta-analysis assessing changes in workstations such as sit-stand desks and treadmill desks (Neuhaus et al., 2014). Although there is some evidence of the effectiveness of these types of newer workstations, their affordability, feasibility and long-term effectiveness is questionable. A qualitative study among users of sit-stand desks in an Australian company revealed that employees were primarily motivated to use them for perceived musculoskeletal health benefits and were largely unaware of other benefits (Henderson et al., 2018). These participants also did not receive any training or instruction on the safe use of sit-stand desks (Henderson et al., 2018). Therefore the acceptability of these sit-stand desks among employees can be improved by providing training or instruction on their proper use and might also aid in their long term use by employees (Wilks et al., 2006). Future studies with long term follow-ups are needed to test the effectiveness of these changes in workstation in the long term to justify the investment in such costly intervention. So based on the available evidence, using cheaper alternatives such as cardboard sit-stand desk before deciding to buy this expensive furniture can be recommended.

Other assessed interventions include behavioural counselling, but their effectiveness remains largely inconclusive. A recent pilot study by Hutchinson et al. (2018) in which college employees in Massachusetts, USA (n= 36) received a personalized SB consultation and weekly follow-up e-mails. Objectively measured daily time spent in sitting was not changed, but the number of sitting bouts for more than 30 minutes was reduced by 0.52 bouts/day over 16 weeks. Thus, it seems these behavioural counseling interventions might be effective when combined with other strategies in reducing SB and needs to be assessed in future studies. There are still other potentially beneficial interventions that could be implemented easily in workplaces like standing or walking meetings, placing printers or dustbins away from the desks and using small refill cups for drinking water. These interventions, although untested in a controlled trial, might be the best buy for reducing sitting at work due to their affordability. Similarly, the review (Chapter 6) also indicated combination of intervention strategies including environmental restructuring, policy change, and information and counselling might be more effective than any intervention alone. A study by Evans et al. (2012) found that participants who received information and email prompts had a significant reduction in prolonged sitting bouts lasting 30 minutes or more (d= 1.1 bouts/day) compared to those who only received the information.

The review (Chapter 5) also found that workplace-based interventions were also successful in altering the participants' behaviour outside of work. It might be because participants had less control over their physical/social environment and actions within the confines of the workplace but outside the workplace no such restrictions existed. Therefore, participants were motivated to implement the knowledge they acquired from intervention into practice outside the workplace. Among various domains of non-occupational SB, screen time (which includes television viewing time, leisure computer use and more recently use of smartphones) (Ekelund et al., 2016, Ford and

Caspersen, 2012) and commuting by car (Sugiyama et al., 2016) has been consistently associated with poor health. There is some evidence for the effectiveness of interventions such as restricting access to the television by using TV control devices and educational interventions in reducing TV viewing time (Chapter 5). However, interventions were not effective in reducing time spent in leisure computer use. There has been a tremendous surge in smartphones use for sedentary activities, such as gaming and social media use, in the last decade (Mannikko et al., 2015, Unick et al., 2017). However, no studies were found which assessed the effectiveness of interventions for reducing smartphone use in leisure time. Similarly, interventions were not effective in reducing transport sitting time such as commuting by car. Though several interventions seem to be promising in reducing non-occupational SB, the effectiveness of individual intervention strategies could not be ascertained due to the limited number of studies.

Future research should aim to elucidate which interventions are most effective (restructuring the workspace, structured workshops, counselling or computer prompts), their frequency for use such as numbers of prompts and counselling sessions, optimum duration of intervention and an ideal combination of interventions that suits the target population. The available studies only reported the effectiveness of interventions in reducing one or two domains of SB. However, the possibility of one form of SB replacing another cannot be ruled out such as TV viewing replaced by leisure smartphone use. Hence, future studies should include strategies for reducing all domains of SB separately and replace it with a more active alternative.

11.3 The intervention "Move More for Mental Health and Wellbeing"

Health care professionals have an important role in the promotion of a healthy lifestyle, including PA promotion. Despite professional knowledge regarding healthy lifestyle choices and the effectiveness of PA recommended by health professionals, rates of PA counselling by health professionals remain low (Lewis et al., 1991, Walsh et al., 1999). This has been attributed to number of factors, out of which one of the frequently cited reason is health care professionals themselves do not engage in recommended levels of PA (Owoeye et al., 2016, Rye et al., 2012, Malik et al., 2011). Previous studies have reported on the impact of health professional's lifestyle behaviour on their practices (Frank et al., 2000, Patra et al., 2015). For example, Patra et al. (2015) reported health professionals who participated in sports were four times more likely to recommend PA to their clients. Therefore, helping mental health professionals to increase their own engagement in PA might improve their attitudes towards and practices in recommending PA to their clients (Howard and Gamble, 2011, Terry and Cutter, 2013, Jinks et al., 2003).

Mental health professionals were found to have positive attitude towards PA recommendation however they reported lack of skill and confidence in providing PA and SB counselling to their clients (Chapter 8). They recommended PA to their clients but refrained from making specific recommendations for PA or reducing SB and made only general recommendations, which suggests PA has not been seamlessly included within their treatment approach. Our findings corroborate with those reported in the review by Glowacki et al (2019) that used TDF for interpreting the barriers and facilitators of PA counselling by mental health professionals. Mental health professionals' own experiences in engaging in activities, client's awareness of PA, and use of technology, such as PA intervention or tracking apps, were identified as facilitators to including PA within treatment. Similarly, barriers to recommending PA included lack of confidence, competing priorities and beliefs that PA should be delivered by exercise professionals. The belief that 'clients will not adhere if the health professionals recommends PA' reported as a barrier in the 'Beliefs about the consequences' domain of the TDF framework might explain the perception that PA should be delivered by exercise professionals (Glowacki et al., 2019). PA interventions delivered by exercise professionals may be assumed to be more effective in increasing the uptake of PA in clients than recommending PA via a behaviour change intervention.

PA has been recommended for the management of mental disorders including schizophrenia by medical boards in the UK and Australia (RANZCP, 2012, NICE, 2014). However, integrating this potential therapeutic strategy into routine practice depends on the attitude of mental health professionals towards PA. Therefore, an intervention for mental health professionals was designed based on the literature review of PA intervention (Chapter 4) and systematic reviews of SB interventions (Studies 1 and Study 2) that were conducted as a part of this thesis. The strategies that were effective in increasing PA and reducing SB were incorporated in the intervention such as planning social support (group behaviour change meeting), goal setting, monitoring and encouragement to use sit-stand desk for participants who already owned them were incorporated in the intervention. in changing clinicians' practice. A group behaviour change meeting was specifically chosen for this intervention as its effectiveness in changing clinicians' practice has been demonstrated in previous studies (Breimaier et al., 2013, Chauhan et al., 2017). Additionally, use of digital technologies such as weekly reminder through telephone and/or emails and interactive online booklet of strategies was also implemented.

11.3.1 Results of the intervention

Mental health professionals experience overwhelming strain to set aside adequate time for clinical duties, professional growth and family duties, probably at the expense of time they could engage in PA which can make finding the time to engage in structured exercise a challenge. A strategy for addressing this can be carving out time to be less sedentary and more active throughout the day whenever there is an opportunity or rearranging work schedules to fit in PA. Moreover, sitting is the norm at work for most jobs; standing while colleagues are seated may be perceived as a violation of workplace culture. For this intervention targeting workplace culture through group behaviour change intervention like the one implemented in this PhD study might be effective. Such a workplace intervention also has an added advantage of social support, including visual prompt of others standing up at their workstation and shared decisions to plan activities such as walking meetings.

Participants in the focus groups shared that they were motivated to take part in the intervention for a range of reasons including wanting to address their own PA levels and using this as an opportunity to apply new knowledge within their clinical work. Participation in the intervention was reported as a positive experience, which lead to learning practical strategies to increase movement and reduce sedentary time, that could become part of their workplace culture, be shared with other colleagues, and influence the type of PA recommendations provided to their clients. The level of responsibility in managing their clients' mental health and safety and the pressure of working in services that struggle to keep up with the demand can lead to stress and professional burn-out among mental health professionals (Johnson et al., 2018, O'Connor et al., 2018). Engaging in PA may be an adaptive strategy to assist in in relieving stress and burn-out among mental health professionals (Weight et al., 2013).

Findings of this PhD study suggest that attitudes of mental health professionals towards recommending more PA and less SB might be improved with interventions aimed at increasing their own PA and reducing SB. Although the intervention did not change their overall PA, there was a modest increase in PA of about 10 minutes per day among 47% of participants. Few intervention studies on PA promotion amongst office workers also have failed to achieve the desired effect (Nooijen et al., 2020, Aittasalo et al., 2004). A study amongst office employees who participated in a similar counselling intervention, with one group receiving counselling for engaging in PA, access to a gym, and encouragement for walking during lunch break and another group receiving counselling for reducing SB and encouragement for engaging in standing- and walking-meetings showed no effects on PA and SB in both groups compared to a control group (Nooijen et al., 2020). Similarly, another study assessing effectiveness of PA counselling, PA counselling and fitness testing found no significant change in PA in both groups compared to control group (Aittasalo et al., 2004). Thus, it can be concluded that behaviour change intervention often fails to achieve desired effect, however since some of the participants actually increased their PA, the intervention can be improved to attain the desired change. From the participants' feedback, intervention might be improved by adding more reminders, prompts and support to remain physically active as it was perceived that it was easier to maintain an inactive lifestyle and a conscious effort than to remain motivated to engage in PA. Similarly, more than a single session of group behavior change meeting might be needed for changing PA behavior among mental health professionals.

Mental health professionals in the focus group sessions shared that they were interested in recommending PA and less SB to their clients. This was also supported by quantitative findings of an increase in the frequency of recommending more PA and less SB by mental health professionals who increased their own PA during the intervention to their clients. Participants also shared that rather than a structured exercise, they would be more tempted to recommend incidental exercises such as walking to the shops instead of driving to their clients. These activities can be easily incorporated into daily life and might rather be more enjoyable and benefit the mental health of their clients.

11.4 Strengths and limitations of the studies

The systematic reviews on the SB interventions were conducted based on an *a priori* protocol and used comprehensive search strategies to identify all the relevant studies. The interventions were categorised based on the ecological framework which were further grouped into short, medium- and long-term follow-up. The use of explicit methods in synthesizing the findings in the systematic reviews limits bias and increases confidence in the results. Further, the confidence in the evidence were assessed using GRADE methodology (Guyatt et al., 2011).

The main limitations of the two systematic reviews of SB interventions are that only a limited number of studies was available; hence definite conclusions on the effectiveness of various types of interventions for reducing SB could not be drawn, except for sit-stand desks. Most of the studies included in these reviews were considered to be at high risk of bias and therefore generated only low to very low ratings of quality of evidence. The methodological limitation in included studies were small sample size and blinding. The randomisation does not ensure equal distribution of the potential confounders across groups when the sample sizes are small. Further, blinding of personnel and participants was not possible in most studies due to the self-evident nature of the interventions. Effectiveness of PA and SB interventions in the long-term could not be concluded as there were very few studies that assessed effectiveness of these intervention in the long-term. Some of the interventions such as sit-stand are quite expensive, however if the long-term sustainability of these interventions can be established, the investment on such interventions might be justifiable.

It was hypothesized that participation in the intervention would increase PA and reduce SB from baseline to follow-up among mental health professionals in Study 4. However, there was no significant difference in PA and SB levels. It may be that the sample size was too small to have enough power to detect any effect that intervention had on PA and SB levels. Further research is warranted with larger samples to determine if a simple intervention consisting of a group behaviour change counselling, goal setting and positive feedback of 4-week duration is potent enough to produce a change in PA and SB among mental health professionals. Given that a single behaviour change session might be inadequate to have a considerable effect, future researchers are encouraged to have more than one group behaviour change sessions, as well as additional reminders and follow-up calls in their intervention. However, researchers must also be cautious as participants might lose interest in the intervention when there are multiple sessions of counselling intervention (Nooijen et al., 2020). The views presented in qualitative analysis in this PhD study are based on focus group discussions with mental health professionals working in youth mental health service network and might not reflect those experienced by mental health professionals working in different settings across Australia.

Though Study 3 aimed to investigate the attitudes and practices of mental health professionals towards recommending PA to their clients, the intervention might have affected their responses as the focus groups sessions were conducted after the completion of the intervention. This might limit the generalisbility of findings of Study 3 for mental health professionals' attitude towards and practices in recommending more PA and less SB to their clients. Similarly, in Study 4, we could not investigate facilitators for mental health professionals who increased their own PA or reduced

SB and barriers for those who did not increase PA or reduce SB during the intervention separately. This would have allowed us in understanding what facilitated and prevented participants in increasing their PA or reducing SB. Hence, future studies need to consider such comparisons to enable more detailed understanding of the barriers and facilitators to engage in PA or less SB and further elucidate the effective components of interventions to increase movement. The intervention could be further strengthened by incorporating strategies to examine the changes in clinical practice beyond self-report, such as file audit to determine if PA is recommended more post-intervention using a design such as an interrupted time series, or testing an implementation strategy within a step-wedge RCT to roll out the clinician PA intervention in multiple mental health services, such as headspace centres.

11.5 Implications for research and practice

Previous studies have reported difficulty in enrolling participants in interventions for increasing PA with less than 50% of employees showing interest in participation (Robroek et al., 2009, Rongen et al., 2013). Similar difficulty in enrolling the participants was experienced during the implementation of the intervention among mental health professionals in this PhD. Hence researchers need to formulate strategies that will enhance recruitment into these types of workplace-based studies, retain the participants, and benefit those participants who are at higher risks.

Based on the current findings, interventions that aim to inform mental health professionals of evidence-based strategies for engaging in PA or being less sedentary might be more effective in changing their own behaviours and in increasing the likelihood that they will include PA within mental health treatment, rather than providing information on the benefits of PA of which they already have knowledge. This practical exposure to strategies to increase PA may also address their concerns of how to effectively engage their clients, increase PA adherence and enhance their confidence in delivering this type of intervention in their clinical practice with clients that often have complex presentations. The use of experiential learning methods such as exposure to PA strategies used in this study, has been widely used in clinical skills training for health professionals (Cleland et al., 2009, Hargie et al., 2010). Experiential methods have been found more effective in changing clinical behaviours or attitudes and acquiring skills and strategies than the provision of information or instructions (Kurtz et al., 2005).

Mental health professionals typically do not undertake any formal training in PA counselling during the pre-service training or continuing education. While some have an opportunity to gain knowledge whilst undertaking professional development training, the integration of PA in the formal education and training/professional development opportunities might be effective in increasing the confidence of mental health professionals to implement PA recommendation in their clinical work. PA counselling demands considerable effort and time from already burdened mental health professionals. Moreover, mental health clinician reported PA counselling might shift the focus from the presenting issues and concerns of clients which might be detrimental to the therapeutic relationship with their clients. Therefore, multi-disciplinary models of mental health care, including support from PA counsellors and exercise specialists should be explored in future studies.

Given that Australian Headspace Centres provide service to approximately 100,000 young people in a year, significant public health benefits can be gained by even scaling up an intervention with small effects. Thus, this intervention can be scaled up and can be delivered as an online module for existing service providers or as a module integrated into undergraduate and/or postgraduate training for future mental health professionals.

11.6 Conclusion

The evidence presented in this thesis supports the importance of addressing PA and SB for physical and mental wellbeing. The studies included in this thesis found evidence for the effectiveness of PA interventions, such as counseling/support interventions and health promotion messages/information interventions, although this evidence is limited. Similarly, for SB in the workplace setting, implementing changes in workstations such as sit-stand desks were found to be effective. The effectiveness of other interventions such as behaviour change counseling and environmental restructuring remains inconclusive. However, there is limited evidence for the effectiveness of non-occupational SB interventions. The evidence from the systematic reviews and meta-analyses included in this thesis aided the development of the intervention “Move More for Mental Health and Wellbeing”, using the constructs of TPB. The design of intervention was informed by the strategies that were found effective in increasing PA and reducing SB in previous studies, such as planning social support within a group behaviour change session, goal setting, weekly reminders through telephone and/or email contact, and encouragement to use sit-stand desks. The group behaviour change session was used to influence attitudes and subjective norms, whereas goal setting and reminder calls/emails were used to influence the perceived behavioural control domain of TPB.

Mental health professionals can play a key role in the promotion of PA for physical and mental well-being of their clients with mental illness. Although mental health professionals are aware of the benefits of healthy lifestyle, including regular PA, they often themselves fail to engage in sufficient PA and do not routinely recommend PA to their clients. The mental health professionals reported lack of knowledge and confidence as key barriers for recommending PA to their clients. They mentioned that their own engagement in PA is a facilitator for recommending PA to their clients. The intervention provided mental health professionals with practical strategies for increasing their own PA and reducing SB. Although the intervention was not successful in increasing the self-reported and device-measured PA and SB behaviours among mental health professionals, the findings indicated that it might improve the attitudes of mental health professionals towards recommending more PA and less SB to their clients. This relatively simple PA and SB intervention could be scaled up to promote more PA and less SB in mental health settings with potential benefits for mental health professionals and their clients.

References

AITTASALO, M., MIILUNPALO, S. & SUNI, J. 2004. The effectiveness of physical activity counseling in a work-site setting. A randomized, controlled trial. *Patient Educ Couns,* 55**,** 193-202.

BREIMAIER, H. E., HALFENS, R. J., WILBORN, D., MEESTERBERENDS, E., HAASE NIELSEN, G. & LOHRMANN, C. 2013. Implementation interventions used in nursing homes and hospitals: A descriptive, comparative study between Austria, Germany, and The Netherlands. *ISRN Nurs,* 2013**,** 706054.

CHAUHAN, B. F., JEYARAMAN, M. M., MANN, A. S., LYS, J., SKIDMORE, B., SIBLEY, K. M., ABOU-SETTA, A. M. & ZARYCHANSKI, R. 2017. Behavior change interventions and policies influencing primary healthcare professionals' practice-an overview of reviews. *Implement Sci,* 12**,** 3.

CLELAND, J. A., ABE, K. & RETHANS, J. J. 2009. The use of simulated patients in medical education: AMEE Guide No 42. *Med Teach,* 31**,** 477-86.

EKELUND, U., STEENE-JOHANNESSEN, J., BROWN, W. J., FAGERLAND, M. W., OWEN, N., POWELL, K. E., BAUMAN, A., LEE, I. M., LANCET PHYSICAL ACTIVITY SERIES 2 EXECUTIVE, C. & LANCET SEDENTARY BEHAVIOUR WORKING, G. 2016. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet,* 388**,** 1302-10.

EVANS, R. E., FAWOLE, H. O., SHERIFF, S. A., DALL, P. M., GRANT, P. M. & RYAN, C. G. 2012. Point-of-choice prompts to reduce sitting time at work: a randomized trial. *Am J Prev Med,* 43**,** 293-7.

FORD, E. S. & CASPERSEN, C. J. 2012. Sedentary behaviour and cardiovascular disease: a review of prospective studies. *Int J Epidemiol,* 41**,** 1338-53.

FRANK, E., ROTHENBERG, R., LEWIS, C. & BELODOFF, B. F. 2000. Correlates of physicians' prevention-related practices. Findings from the Women Physicians' Health Study. *Arch Fam Med,* 9**,** 359-67.

GLOWACKI, K., WEATHERSON, K. & FAULKNER, G. 2019. Barriers and facilitators to health care providers’ promotion of physical activity for individuals with mental illness: A scoping review. *Ment Health Phys Act,* 16**,** 152-168.

GUERTLER, D., VANDELANOTTE, C., KIRWAN, M. & DUNCAN, M. J. 2015. Engagement and nonusage attrition with a free physical activity promotion program: The case of 10,000 steps Australia. *J Med Internet Res,* 17**,** e176.

GUYATT, G., OXMAN, A. D., AKL, E. A., KUNZ, R., VIST, G., BROZEK, J., NORRIS, S., FALCK-YTTER, Y., GLASZIOU, P., DEBEER, H., JAESCHKE, R., RIND, D., MEERPOHL, J., DAHM, P. & SCHUNEMANN, H. J. 2011. GRADE guidelines: 1. Introduction-GRADE evidence profiles and summary of findings tables. *J Clin Epidemiol,* 64**,** 383-94.

HARGIE, O., BOOHAN, M., MCCOY, M. & MURPHY, P. 2010. Current trends in Communication Skills Training in UK schools of medicine. *Med Teach,* 32**,** 385-91.

HENDERSON, B., STUCKEY, R. & KEEGEL, T. 2018. Current and ceased users of sit stand workstations: a qualitative evaluation of ergonomics, safety and health factors within a workplace setting. *BMC Public Health,* 18**,** 1374.

HOWARD, L. & GAMBLE, C. 2011. Supporting mental health nurses to address the physical health needs of people with serious mental illness in acute inpatient care settings. *J Psychiatr Ment Health Nurs,* 18**,** 105-12.

HUTCHINSON, J., HEADLEY, S., MATTHEWS, T., SPICER, G., DEMPSEY, K., WOOLEY, S. & JANSSEN, X. 2018. Changes in Sitting Time and Sitting Fragmentation after a Workplace Sedentary Behaviour Intervention. *Int J Environ Res Public Health,* 15.

JINKS, A. M., LAWSON, V. & DANIELS, R. 2003. A survey of the health needs of hospital staff: implications for health care managers. *J Nurs Manag,* 11**,** 343-50.

JOHNSON, J., HALL, L. H., BERZINS, K., BAKER, J., MELLING, K. & THOMPSON, C. 2018. Mental healthcare staff well-being and burnout: A narrative review of trends, causes, implications, and recommendations for future interventions. *Int J Ment Health Nurs,* 27**,** 20-32.

KURTZ, S., SILVERMAN, J. & DRAPER, J. 2005. *Teaching and learning communication skills in medicine, 2nd. Radcliffe*, Oxford.

LEWIS, C. E., CLANCY, C., LEAKE, B. & SCHWARTZ, J. S. 1991. The counseling practices of internists. *Ann Intern Med,* 114**,** 54-8.

MALIK, S., BLAKE, H. & BATT, M. 2011. How healthy are our nurses? New and registered nurses compared. *Br J Nurs,* 20**,** 489-96.

MANNIKKO, N., BILLIEUX, J. & KAARIAINEN, M. 2015. Problematic digital gaming behavior and its relation to the psychological, social and physical health of Finnish adolescents and young adults. *J Behav Addict,* 4**,** 281-8.

NEUHAUS, M., EAKIN, E. G., STRAKER, L., OWEN, N., DUNSTAN, D. W., REID, N. & HEALY, G. N. 2014. Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. *Obes Rev,* 15**,** 822-38.

NICE 2014. Psychosis and schizophrenia in adults: Treatment and management. NICE clinical guideline 178. London: National Institute for Health and Care Excellence.

NIKOLOUDAKIS, I. A., VANDELANOTTE, C., REBAR, A. L., SCHOEPPE, S., ALLEY, S., DUNCAN, M. J. & SHORT, C. E. 2018. Examining the correlates of online health information-seeking behavior among men compared with women. *Am J Mens Health,* 12**,** 1358-1367.

NOOIJEN, C., BLOM, V., EKBLOM, O., HEILAND, E., LARISCH, L., BOJSEN-MØLLER, E., EKBLOM, M. & LV, K. 2020. The effectiveness of multi-component interventions targeting physical activity or sedentary behaviour amongst office workers: a 3-arm cluster randomised controlled trial. *Preprint*.

O'CONNOR, K., MULLER NEFF, D. & PITMAN, S. 2018. Burnout in mental health professionals: A systematic review and meta-analysis of prevalence and determinants. *Eur Psychiatry,* 53**,** 74-99.

OWOEYE, O., TOMORI, A. & AKINBO, S. 2016. Pedometer-determined physical activity profile of healthcare professionals in a Nigerian tertiary hospital. *Niger Med J,* 57**,** 99-103.

PATRA, L., MINI, G. K., MATHEWS, E. & THANKAPPAN, K. R. 2015. Doctors' self-reported physical activity, their counselling practices and their correlates in urban Trivandrum, South India: should a full-service doctor be a physically active doctor? *Br J Sports Med,* 49**,** 413-6.

RANZCP 2012. The Royal Australian & New Zealand college of psychiatrists. Guide to psychotherapy training. . *(accessed Juky 28 2020). Available online:*

https://www.ranzcp.org/files/prefellowship/2012-fellowship-program/guide-for-psychotherapy-training.aspx.

ROBROEK, S. J., VAN LENTHE, F. J., VAN EMPELEN, P. & BURDORF, A. 2009. Determinants of participation in worksite health promotion programmes: a systematic review. *Int J Behav Nutr Phys Act,* 6**,** 26.

RONGEN, A., ROBROEK, S. J. W., VAN LENTHE, F. J. & BURDORF, A. 2013. Workplace health promotion: a meta-analysis of effectiveness. *Am J Prev Med,* 44**,** 406-415.

RYE, P. L., REESON, M. E., PEKRUL, C. M., ASFOUR, N. A., KUNDAPUR, R., WILSON, M. P., PAUSJENSSEN, A. M. & WILSON, T. W. 2012. Comparing health behaviours of internal medicine residents and medical students: an observational study. *Clin Invest Med,* 35**,** E40-4.

SAMDAL, G. B., EIDE, G. E., BARTH, T., WILLIAMS, G. & MELAND, E. 2017. Effective behaviour change techniques for physical activity and healthy eating in overweight and obese adults; systematic review and meta-regression analyses. *Int J Behav Nutr Phys Act,* 14**,** 42.

SUGIYAMA, T., WIJNDAELE, K., KOOHSARI, M. J., TANAMAS, S. K., DUNSTAN, D. W. & OWEN, N. 2016. Adverse associations of car time with markers of cardio-metabolic risk. *Prev Med,* 83**,** 26-30.

TERRY, J. & CUTTER, J. 2013. Does education improve mental health practitioners' confidence in meeting the physical health needs of mental health service users? A mixed methods pilot study. *Issues Ment Health Nurs,* 34**,** 249-55.

UNICK, J. L., LANG, W., TATE, D. F., BOND, D. S., ESPELAND, M. A. & WING, R. R. 2017. Objective estimates of physical activity and sedentary time among young adults. *J Obes,* 2017**,** 9257564.

WALSH, J. M., SWANGARD, D. M., DAVIS, T. & MCPHEE, S. J. 1999. Exercise counseling by primary care physicians in the era of managed care. *Am J Prev Med,* 16**,** 307-13.

WEIGHT, C. J., SELLON, J. L., LESSARD-ANDERSON, C. R., SHANAFELT, T. D., OLSEN, K. D. & LASKOWSKI, E. R. 2013. Physical activity, quality of life, and burnout among physician trainees: the effect of a team-based, incentivized exercise program. *Mayo Clin Proc,* 88**,** 1435-42.

WILKS, S., MORTIMER, M. & NYLEN, P. 2006. The introduction of sit-stand worktables; aspects of attitudes, compliance and satisfaction. *Appl Ergon,* 37**,** 359-65.

Supplement

Supplementary table 1: Chapter 4. Characteristics of included studies

Physical activity/exercise interventions				
Study	**Study population**	**BCTs used**	**Duration of Intervention**	**PA measurement tool/ unit of measure**
Coleman et al. (1999)	University, USA	Prompt self-monitoring of behaviour Instruction on how to carry out the behaviour Goal setting (behaviour) Agree behavioural contract Set graded tasks Stimulate anticipation of future rewards Rewards contingent on successful behaviour Feedback on performance Barrier identification/problem-solving	32 wks	Accelerometer and Diary self-report number of minutes of accelerometer activity/ self-reported activity ≥3.0 METs
Gilson et al. (2009)	universities in UK, Australia, Spain	Set graded tasks Information on where and when to carry out the behavior Use of follow-up prompts Prompt practice	10 wk	Steps taken/day recorded on a pedometer
von Thiele Schwarz et al. (2008)	six workplaces in a large public dental health care organization in Stockholm, Sweden	Instructions on how to carry out the behaviour	12 months	Subjects recorded average time spent per wk in PA h/wk

Pedersen et al.(2009)	Nine offices of a public administration authority in Denmark	Set graded tasks Instruction on how to carry out the behaviour Environmental restructuring Motivational interviewing Provision of information	1 year	a Danish version of the IPAQ Long Form Questionnaire MET min/wk
Counseling/support intervention				
Aittasalo et al. (2004)	Nine different companies from the city of Tampere, Finland	Goal setting (behaviour) Action planning Prompt review of behavioural goals Prompt self-monitoring of behaviour	12 months	IPAQ long form 7-d diary Pedometer min/wk
Campbell et al. (2002)	Nine worksites of textile or light manufacturing industry in the United States	No BCTs identified in intervention description	6 mo and follow up at month 18	PA questionnaire assessing frequency and duration of PA MET h/wk
MacKinnon et al. (2010)	Five firefighter departments in Northern Oregon and Southern Washington, United States	Plan social support/change Goal setting (behaviour) Facilitate social comparison Motivational interviewing Normative information about others' behaviour	2 yr, with follow ups each year until year 6	self-reported physical activity
Nichols et al. (2000)	Two worksites, USA	No BCTs identified in intervention description	9 months	Seven-Day Physical Activity Recall
Nisbeth et al. (2000)	Large Information technology company, Copenhagen, Denmark	Information on consequences of the behaviour to the individual	12 months	5-Point scale

		Goal setting (behaviour) Action planning Instruction on how to carry out the behaviour		Questionnaire
Opdenacker and Boen (2008)	University employees, Belgium	Goal setting (behaviour) Action planning Information on where and when to carry out the behaviour Instruction on how to carry out the behaviour Barrier identification/problem-solving Prompt review of behavioural goals Prompt self-monitoring of behaviour	3 months	IPAQ long min/week
Proper et al. (2003)	Three municipal services of Enschede, The Netherlands	Action planning	9 months	Self-report 7-day Physical Activity Recall instrument
Purath et al. (2004)	University, USA	Goal setting (behaviour) Action planning Prompt review of behavioural goals Agree behavioural contract Use of follow-up prompts	6 weeks	Paffenbarger PA questions h/weekday
van Wier et al. (2009)	Seven companies, i.e., two IT-compa- nies, two hospitals, an insurance company, the head office of a bank and a police force, The Netherlands	Goal setting (behaviour) Action planning Prompt review of behavioural goals Agree behavioural contract Use of follow-up prompts	6 months	Short Questionnaire to Asses Health enhancing physical activity (SQUASH)

				MET-minutes per week
Reijonsaari et al. (2012)	Insurance company, Finland	Prompt review of behavioural goals Prompt self-monitoring of behaviour Provision of information goal setting	12 months	IPAQ Short Version Met minutes/wk
Rowland et al. (2018)	Health organization, USA	Provision of information Plan social support/change	12 weeks	Accelerometer min/wk
Health promotion messages/information interventions				
Blissmer and McAuley (2002)	Large university, USA	Information on consequences of behaviour in general Goal setting (behaviour) Barrier identification/problem-solving Rewards contingent on successful behaviour Plan social support/social change Relapse prevention/coping planning	16 weeks	The Aerobic Centre Longitudinal Study Physical Activity Questionnaire (MET) hours/week
Cook et al. (2007)	three offices of a human resources company, Atlanta, GA, Minneapolis, MN, and Fountain Valley, CA	No BCTs identified in intervention description	3 months	Godin Leisure-Time Exercise Questionnaire
Loughlan and Mutrie (1997)	Hospital, Kilmarnock, Scotland, UK.	Information on consequences of behaviour to the individual Goal setting (outcome) Plan social support/social change Barrier identification/problem-solving Information on where and when to carry out the behaviour	6 months	amended version of the Seven-Day recall of LTPA hours/week

Marshall et al. (2003)	University, Australia.	Goal setting (behaviour) Prompt self-monitoring of behaviour Teach to use prompts/cues Plan social support/social change Stimulate anticipation of future rewards	10 weeks	Self-report
McEachan et al. (2011)	44 worksites within 5 organizations, UK	Information on consequences of behaviour in general Prompt self-monitoring of behaviour Plan social support/social change Goal setting (behaviour) Time management Teach to use prompts/cues Instruction on how to carry out the behaviour Prompt review of behavioural goals Provide feedback on performance	9 months	IPAQ short form MET min/wk
Morgan et al. (2011)	Alumunium mining company, Australia	Information on consequences of behaviour in general Prompt self-monitoring of behaviour Goal setting (behaviour) Set graded tasks Barrier identification/problem-solving Plan social support/social change Rewards contingent on effort or progress towards behaviour	14 weeks	Self-report MET minutes
Mutrie et al. (2002)	Three workplaces, Glasgow, Scotland.	Prompt self-monitoring of behaviour Information on where and when to carry out the behaviour	12 months	Self-reports of cycling or walking to and from work

		Instruction on how to carry out the behaviour		from a Seven-Day recall Questionnaire
Napolitano et al. (2003)	Several hospitals, The Northeast USA.	Information on consequences of behaviour in general Barrier identification/problem-solving Instruction on how to carry out the behaviour Prompt self-monitoring of behaviour Prompt self-monitoring of behavioural outcome Goal setting (behaviour) Plan social support/social change	3 months	Behavioural risk factor surveillance system (BRFSS) PA items
Peterson and Aldana (1999)	Large telecommunications company, USA.	Information on consequences of behaviour in general Goal setting (behaviour) Relapse prevention/coping planning	6 weeks	Seven-Day Physical Activity Recall Questionnaire
Plotnikoff et al. (2007)	Three large organisations, Alberta, Canada	Information on consequences of behaviour in general Instruction on how to carry out the behaviour	1 year	modified version of the Godin Leisure-Time Exercise Questionnaire (GLTEQ) Total MET min/week
Siegel et al. (2010)	Sixteen schools in California, United States	No BCTs identified in intervention description	2 yr	International Physical Activity Questionnaire (IPAQ) Short Form MET min/wk
Spittaels et al. (2007)	Six worksites, Northern Belgium	Information on consequences of behaviour in general Normative information about others behaviour	6 mo	Self-reports of PA. An index was

		Action planning Instruction on how to carry out the behaviour Use of follow-up prompts		computed by summing all reported PA at moderate and vigorous intensity
Sternfeld et al. (2009)	Administrative offices of a health care organization in the United States	Information on consequences of behaviour in general Goal setting (behaviour) Information on consequences of behaviour to the individual Use of follow-up prompts Prompt self-monitoring of behaviour Barrier identification/problem-solving	16 wk with a follow-up at 8 mo after intervention period	PA questionnaire adapted from the cross-cultural activity patterns questionnaire min/wk
Sloothmaker et al. (2009)	Eight worksites around Amsterdam, Netherlands	Provision of information Barrier identification/problem-solving Goal setting (behaviour) Information on where and when to carry out the behaviour Feedback on performance Prompt review of behavioural goals Prompt self-monitoring of behaviour	3 mo, with a follow-up at 8 mo after intervention period	Activity questionnaire for adolescents and adults min/wk
Blake et al. (2017)	U.K. hospital workplace	Prompt review of behavioural goals Provision of information	12 weeks	GPAQ hours/day & days/week
Dadaczynski et al. (2017)	German automobile manufacturer	Plan social support/change Facilitate social comparison provision of information goal setting	6 weeks	IPAQ short version min/week

		action planning Prompt self-monitoring of behaviour Feedback on performance		
Hager et al. (2002)	a large private university, USA	Goal setting (behaviour) Barrier identification/problem-solving Instruction on how to carry out the behaviour Environmental restructuring Relapse prevention/coping planning Prompt use of imagery	6 weeks	Seven-Day Physical Activity Recall Questionnaire
Prestwich et al. (2012)	Public sector organizations, UK	Provision of information Information on consequences of the behaviour to the individual Plan social support/change Facilitate social comparison	6 months	International Physical Activity Questionnaire METs/wk
Environmental restructuring				
Carr et al (2016)	A large private company, US	Environmental restructuring Prompt review of behavioural goals	16 weeks	Ankle worn GENEActiv % workday
French et al. (2010)	Four bus garages (two urban and two suburban) in Minneapolis, United States	Rewards contingent on effort or progress towards a behaviour Information on where and when to carry out the behaviour Model/demonstrate the behaviour Prompt practice Plan social support/social change Environment restructuring	18 months	Godin leisure time physical activity questionnaire min/day

Gazmararian et al (2013)	A large US university	Environmental restructuring Prompt review of behavioural goals Provision of information Plan social support/change Information on where and when to carry out the behaviour Prompt self-monitoring of behaviour Changes in organisational policy	9 months	7-day Physical Activity Recall instrument
Miyachi et al (2015)	Retail company, Tokyo, Japan	Environmental restructuring	6 weeks	Accelerometer METS h/day
Thorndike et al. (2014)	Massachusetts General Hospital, United States	Environmental restructuring Prompt self-monitoring of behaviour	6 weeks	Fitbit activity monitor Steps/day
Dishman et al. (2009)	Sixteen worksites of the Home Depot in the United States and Canada	Information on consequences of behaviour in general Goal setting (behaviour) Action planning Rewards contingent on successful behaviour Information on where and when to carry out the behaviour Prompt practice Environmental restructuring	12 wk	IPAQ short form MET h/wk
Sorensen et al. (2005)	Twenty-six worksites, the Greater Boston Metropolitan Area of Massachusetts, USA	Feedback on performance Information on where and when to carry out the behaviour Environmental restructuring	18 months	Self-reports of PA min/wk

Supplementary table 2: Chapter 5. Search strategy

Scopus
TITLE-ABS-KEY (((sedentar* OR sitting OR "physical inactivity") AND (leisure OR "non-occupational" OR nonoccupational OR transport OR travel OR domestic OR household OR education*)) OR ("active travel*" OR "active commut*" OR "active transport*" OR "watching TV" OR "TV watching" OR "viewing TV" OR "TV viewing" OR "television watching" OR "watching television" OR "television viewing" OR "viewing television" OR "media time" OR "screen time" OR "video game" OR "smart phone use" OR “computer use” OR “computer time”)) AND TITLE-ABS-KEY ("Randomized control trial" OR "controlled clinical trial" OR random*) AND TITLE-ABS-KEY (adult* OR elderly)
Web of science
TOPIC: (((sedentar* OR sitting OR "physical inactivity") AND (leisure OR "non-occupational" OR nonoccupational OR transport OR travel OR domestic OR household OR education*)) OR ("active travel*" OR "active commut*" OR "active transport*" OR "watching TV" OR "TV watching" OR "viewing TV" OR "TV viewing" OR "television watching" OR "watching television" OR "television viewing" OR "viewing television" OR "media time" OR "screen time" OR "video game" OR "smart phone use" OR “computer use” OR “computer time”)) AND TOPIC: ("Randomized control trial" OR "controlled clinical trial" OR random*) AND TOPIC: (adult* OR elderly)
Pubmed
1. ((sedentar*[tw] OR sitting[tw] OR "physical inactivity"[tw]) AND (leisure[tw] OR "non-occupational"[tw] OR nonoccupational[tw] OR transport[tw] OR travel[tw] OR domestic[tw] OR household[tw] OR education*[tw])) OR ("active travel*"[tw] OR "active commut*"[tw] OR "active transport*"[tw] OR "watching TV"[tw] OR "TV watching"[tw] OR "viewing TV"[tw] OR "TV viewing"[tw] OR "television watching"[tw] OR "watching television"[tw] OR "television viewing"[tw] OR "viewing television"[tw] OR "media time"[tw] OR "screen time"[tw] OR "video game"[tw] OR "smart phone use"[tw] OR “computer use” [tw] OR “computer time” [tw]) 2. "Randomized control trial"[tiab] OR "controlled clinical trial"[tiab] OR random*[tiab] 3. (adult*[tw] OR elderly[tw]) 4. animals [mh] NOT humans [mh] 5. #3 not #4 6. #1 and #2 and #5

Supplementary table 3: Chapter 5. Characteristics of included studies

Study ID/Study design	Country	Participants characteristics	Intervention	Study duration	Control group	Outcomes/ Source of information on leisure time sedentary behaviour
Aadahl et al. (2014) RCT with 2 parallel groups	Denmark	"Sedentary" adults aged 18-69 years, recruited from Health2010 study. Adults were considered sedentary if they reported ≥3.5 h/day of leisure time SB.	Intervention consisted of four face-to-face motivational counselling sessions aimed at reducing sitting time. The intervention program focused on four key messages or themes: (i) reduce daily TV viewing; (ii) substitute sitting with standing when possible at work and at home; (iii) break up prolonged sitting by standing up frequently; and (iv) 30 minutes maximum of sitting per episode. Participants set individual goals for change in SB by identifying behaviour substitutes and initiating small changes to SB.	6 months	Usual practice/lifestyle	Self-reported sitting time (h/day) at work and during leisure on an average weekday was estimated using a modified version of the Physical Activity Scale (PAS 2.1).
Chau et al. (2014) Crossover RCT with waitlist	Australia	Office workers aged ≥18 years, working ≥ 3 days/week.	Workplace intervention with environmental modification: participants were provided with a sit-stand workstation for 4 weeks after receiving brief training and advice on use of workstations.	10 weeks (6 week pre-intervention, 4 weeks intervention)	Each participant served as their own control	Total and domain-specific sitting time (min/day) on work and non-work days estimated with the Workforce Sitting Questionnaire and accelerometer. Domains included time spent sitting: (i) during transport; (ii) at work; (iii) while watching TV; (iv) while using a home computer; and (v) while doing other leisure activities on a workday and a non-workday in the last 7 days.
De Cocker et al. (2016) Cluster RCT with 3 arms	Belgium	Office workers (mostly desk based), Mean (standard deviation) age in years: tailored 40.5 (SD 8.6),	The tailored intervention group received web-based, computer-tailored, personalized feedback and tips on how to reduce or interrupt workplace sitting.	3 months	Usual lifestyle	Total and domain-specific sitting time (min/day) on work and non-work days estimated with the Workforce Sitting Questionnaire. Domains included time spent sitting: (i)

		generic 40.7 (SD 9.7), control 39.9 (SD 9).	The generic group received web-based generic advice.			during transport; (ii) at work; (iii) while watching TV; (iv) while using a home computer; and (v) while doing other leisure activities on a workday and a non-workday in the last 7 days.
Dutta et al. (2014) RCT with crossover design	USA	Office workers aged ≥18 years.	Workplace intervention utilising sit-stand desks provided for 4 weeks. Goal was to gradually replace 50% of sitting time with standing at work. Weekly email prompts were used to remind participants of the study goal.	10 weeks (4 weeks intervention, 4 weeks control separated by 2 week washout)	Usual practice (regular desk)	Non-work sedentary time (min/hr) measured with accelerometer and self-report.
French et al. (2011) Cluster RCT	USA	Households that included (i) at least one child aged ≥5 years and two HH members aged ≥12 years and ii) average weekly TV viewing ≥10 h per person.	Intervention aimed at reducing weight gain within community households. Intervention included 6 face-to-face group sessions, placement of a TV locking device on all home TVs, and 12 home-based intervention activities. Behavioural goals included reducing household and individual TV viewing. Monthly telephone support calls were utilised to support behavioural change.	1 year	Usual lifestyle	Self-reported home TV viewing and computer use (h/day).
Hu et al. (2012) RCT	China	Women aged 20-49 with prior gestational DM.	Lifestyle intervention to reduce T2DM. Major intervention elements included 6 face-to-face meetings with study dietitians in the first year, and two additional sessions and two telephone calls in second year. A PA component encouraged participants to increase PA from 15 to 30 min/day over the first 4 weeks and then maintain that for the entire trial.	2 years	Usual care, involving general education around healthy lifestyle including general oral and written information about increasing PA.	Self-reported sitting time at home (h/day).

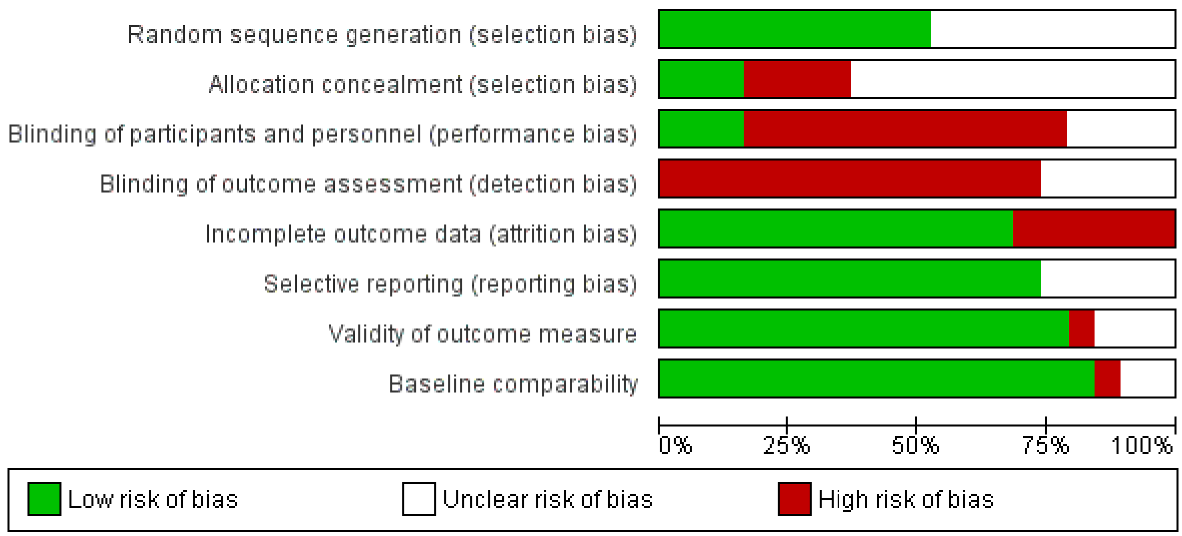
Gomersall *et al*. (2015a, 2015b) RCT, 3-arm trial	Australia	Insufficiently active adults (< 150 min/week of MVPA) aged 18–60 years of age.	Participants in the two intervention groups took part in a six-week physical activity program with prescribed exercise accumulated through both group and individual sessions (half of which was to be accumulated in supervised group classes and half in their own time).	6 months	Instructed to continue with their usual routines	Daily time use measured using the Multimedia Activity Recall for Children and Adults (MARCA), a computerized 24-h use of time recall tool. 11 activity super domains assessed including: computer use, passive transport, quiet time, TV/videogames.
Lakerveld et al. (2013) RCT	The Netherlands	Adults, 30-50 years of age, at risk of type 2 diabetes and cardiovascular diseases.	Primary care-based lifestyle intervention aimed at reducing leisure-time SB. Intervention consisted of a maximum of six individual 30-min counselling sessions, followed by 3 monthly booster sessions by phone for a period of 1 year - a combination of motivational interviewing and problem solving treatment was used.	24 months	Received health brochures.	Total and domain-specific sedentary leisure time was estimated with a subscale of the Activity Questionnaire for Adolescents & Adults (AQuAA). Domains of sedentary behavior were television viewing, computer use, reading and "other" sedentary leisure time (7-day recall).
Laska et al. (2016) RCT	USA	Young adults (students at a community college) 18-35 years of age.	Technology-integrated weight gain prevention intervention which included a semester-long academic course and a social networking and support website (available for 20 months). The intervention course focused on diet/nutrition, PA, screen time, and sleep for maintaining and/or achieving healthy weight. Students were encouraged to track their weight and up to 10 weight-related behaviours including TV/movie viewing and computer/internet use on the website.	24 months	Received basic health promotion information on a quarterly basis.	Television and leisure-time computer use assessed using weekday and weekend specific items from the CARDIA Study questionnaire. Daily hours reported in response to: "on a typical [weekday/weekend day] how much time do you spend sitting while watching TV (including videos on VCR/DVDs) and sitting while using the computer for non-work/non-school activities or playing video games.
Otten et al. (2009) RCT	USA	Overweight and obese adults (BMI 25-50), 21-65 years of age,	Home-based TV reduction intervention to examine effects on energy balance, BMI and sleep. The intervention consisted of reducing TV viewing by	6-weeks (3 week observation phase	Observation only	Objectively measured TV viewing via electronic monitors (BOB TV Time Manager; Hopscotch Technology). The

		who self-reported TV-viewing ≥3h/day.	50% (compared to baseline), enforced by an electronic lock-out system.	followed by 3-week additional intervention/observation phase)		device recorded total minutes per day of TV viewing per participant-specific code.
Pesola (2016) Cluster RCT	Finland	Sedentary parents (self-reportedly sitting more than 50% of their work-time) with children 3–8 years old in kindergarten or in the first grade of primary school.	Family-based intervention aimed at reducing and breaking up sedentary time at work and during leisure time. The intervention consisted of a lecture, face-to-face tailored counselling, two follow-up calls and five emails during the first six months, followed by six months of maintenance.	1 year	Usual lifestyle	Leisure sedentary time (min/8 hour) measured with accelerometer and self-report.
Petersen et al. (2012) RCT	Denmark	Adults (18+ years of age) with a low aerobic fitness, or who were sedentary or had low levels of physical activity in leisure time.	Intervention consisted of receiving a pedometer combined with a toolkit (logbook, goal setting book and information on health benefits of PA). Participants were informed face-to-face that taking 10,000 steps/day has health benefits and is a reasonable goal for healthy adults. In the goal-setting program, instructions were given to increase the number of steps by 20% each week until the goal was reached. Participants also received 3 emails at a three-week interval to encourage them to keep using the pedometer and adhere to the program.	3 months	Received a leaflet describing the benefits of PA and the national recommendations of a minimum of 30 min of physical activity per day.	Self-reported amount of sedentary activity (%) during leisure time during last 12 months.
Raynor et al. (2013) Two pilot RCTs	USA	Adults, 21-65 years of age, with BMI 25-40 who watched ≥16 hours of TV per week, and engaged in ≤100 minutes of MVPA per week.	8-week TV reduction interventions: STUDY 1: participants randomised to 'Increase PA' or 'Decrease TV'. Both groups received 8 x 60-min group meetings in a research setting. Those in 'Decrease TV' group were instructed to gradually reduce their TV watching to 10 h/week. STUDY 2: participants randomised to 'Increase PA' or 'Increase	8 weeks	'Increase PA' group was considered the control group for analysis. Participants were encouraged to increase MVPA to at least 40 minutes per day, 5 days per week.	TV watching: assessed objectively with a TV monitor (TV Allowances) attached to all home TVs.

			PA + Decrease TV'. Again, both groups received 8 x 60-min group meetings in a research setting. Those in 'Increase PA + Decrease TV' group were instructed to gradually reduce their TV watching time to 10 hours per week. Additionally, TV monitors were installed and programmed to lock devices based on 50% of the overall reduction needed to meet the 10 h/week goal.			
Spring et al. (2012) RCT with 4 arms	USA	Adults (21-60 years old) with elevated saturated fat and low fruit/vegetable intakes, high sedentary leisure time (>90 min/day) and low physical activity.	Diet and activity advice intervention utilising mobile technology aimed at multiple health behavior change. Participants randomised to one of 4 treatment groups. Each treatment involved 3 weeks of remote coaching supported by mobile decision support technology and financial incentives. Incentives were contingent on using the mobile device to self-monitor and attain behavioral targets. For SB, a target of sedentary leisure ≤ 90 minutes/day was set.	20 weeks	n/a	Minutes of sedentary behavior were measured cumulatively by an end-of-day 24-hour activity log in which participants accounted for every 15-minute block.
Steeves et al. (2012) RCT	USA	Sedentary (viewing ≥14 h per week of TV), overweight (BMI 33.5 ± 4.8 kg/m2) adults (age 52.0 ± 8.6 years).	Participants were randomly assigned to one of two 6-month behavioral PA programs with similar volumes of home-based exercise (≥150 min/week): 1) TV commercial stepping; or 2) walking 30 min/day. For the TV commercial stepping group, participants were instructed to stand and "briskly" step in place, or "briskly" walk continuously around the room/house for the duration of each commercial break during at least 90 min of TV programming at least 5 days/week. To help facilitate behavior change, participants received 6 monthly phone calls, attended monthly meetings	6 months	n/a	Daily time spent viewing TV recorded using an activity log and step count by pedometer.

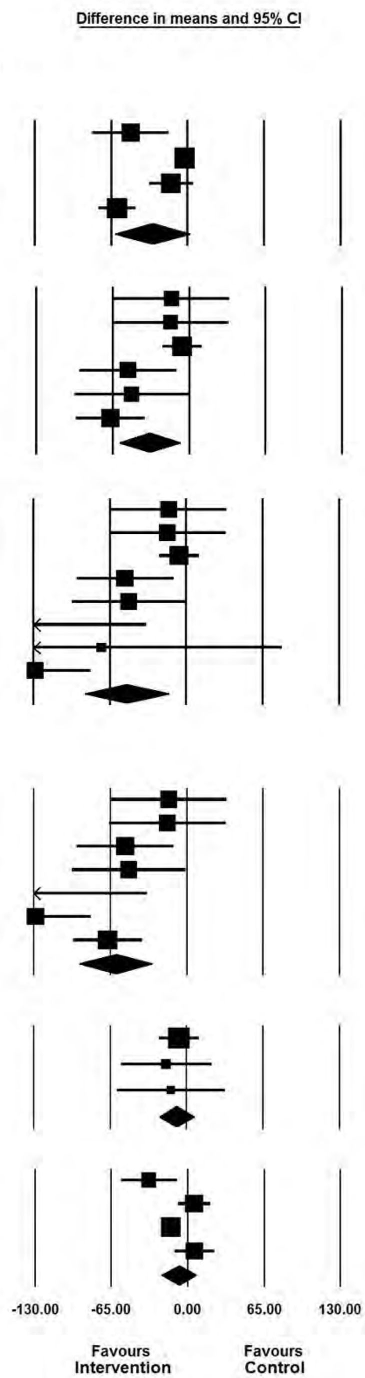
			for the first 3 months, and received monthly newsletters for the last 3 months.			
Sternfeld et al. (2009) Cluster RCT with 3 arms	USA	Employees of one large organisation Mean (standard deviation) age in years: intervention 44.8 (SD 10), control 43.5 (SD 11).	Worksite intervention to increase healthy eating and PA, incorporating a 16-week email program offering individually tailored, small-step goals; a personal homepage with tips; educational materials; and tracking and simulation tools. Participants chose to work on one of three paths (increasing physical activity; increasing intake of fruits and vegetables; or decreasing intake of fats and sugars).	8 months	Usual practise/lifestyle	Self-reported television viewing and non-work-related computer use during a typical week (min/week) assessed using a questionnaire adapted from the Cross-Cultural Activity Patterns Questionnaire.
Tomayko et al. (2017) RCT	USA	American Indian families with young children aged 2-5 years. Family homes in 4 tribal communities.	Family-based intervention assessing the efficacy of an obesity prevention toolkit delivered in two formats: in-home mentoring or by mail. In the first year, 12 'healthy behaviour' toolkit lessons were delivered by either a community-based home mentor or monthly mailings. Each lesson addressed one of four target areas: (i) eat more fruits and vegetables; (ii) consume less soda and added sugar; (iii) become more active; and (iv) watch less TV.	2 years	n/a	Adults self-reported TV/screen time use during the previous 24 hours.
Verweij et al. (2012) Cluster RCT	The Netherlands	Occupational physicians from the Netherlands Society of Occupational Medicine and employees from medium or large sized companies in the Netherlands. Mean (standard deviation) age in years: intervention 46 (SD 8), control 48 (SD 9).	Workplace intervention testing an occupational health practice guideline aimed at preventing employees' weight gain. Occupational physicians in the intervention group followed the draft guideline and provided advice to employers on how to assess and intervene on the obesogenic work environment and conducted five face-to-face behavioural change counselling sessions over 6 months.	6 months	Usual care (occupational physicians provided health risk appraisal with anthropometric measurements and subsequent health advice)	Leisure-time sedentary behaviour was assessed on week and weekend days using a questionnaire.

Rockette-Wagner et al. (2015) RCT 3 arm trial	USA	Adults (≥25 years of age) at high risk of developing diabetes.	i. Lifestyle intervention aimed at preventing diabetes in individuals at high risk. Intervention goals were to achieve a 7% weight loss and at least 150 min/week of moderate intensity activity, and included behavioural self-management strategies, such as self-monitoring. Although reduction in sedentary time was not a primary goal of the intervention, suggestions for limiting inactive lifestyle choices (eg, reducing TV watching time) were discussed briefly in the curriculum and encouraged occasionally throughout the programme ii. Metformin intervention.	3.2 years	Placebo group	Leisure sedentary behaviour was assessed via interviewer-administered Modifiable Activity Questionnaire (MAQ) and reported as average daily time spent watching television.
Abbreviations: SB: sedentary behaviour, PA: physical activity, MVPA: moderate-to-vigorous physical activity, RCT: randomised control trial, TV: television						



Supplementary figure 1: Chapter 5. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies

Study name	Difference in means	Lower limit	Upper limit	p-Value	Intervention	Control
Leisure sitting medium term (excluding workplace interventions)						
Aadahl et al. 2014	-48.60	-81.02	-16.18	0.003	76	65
Pesola et al. 2016	-2.63	-7.95	2.69	0.333	56	52
Lakerveld et al. 2014	-14.20	-32.80	4.40	0.135	253	249
Hu et al. 2012	-60.00	-75.50	-44.50	0.000	586	594
	-30.26	-61.78	1.26	0.060		
TV viewing short term (excluding TV restriction intervention)						
De cocker et al. 2016	-15.00	-64.01	34.01	0.549	22	8
De cocker et al. 2016	-16.00	-65.35	33.35	0.525	41	8
Laska et al. 2016	-6.00	-22.63	10.63	0.479	194	194
Gomersall et al. 2015	-52.00	-92.82	-11.18	0.013	37	19
Gomersall et al. 2015	-49.00	-97.26	-0.74	0.047	37	18
Chau et al. 2014	-67.00	-96.12	-37.88	0.000		
	-33.79	-59.56	-8.03	0.010		
TV viewing short term (excluding cross-over trial)						
De cocker et al. 2016	-15.00	-64.01	34.01	0.549	22	8
De cocker et al. 2016	-16.00	-65.35	33.35	0.525	41	8
Laska et al. 2016	-6.00	-22.63	10.63	0.479	194	194
Gomersall et al. 2015	-52.00	-92.82	-11.18	0.013	37	19
Gomersall et al. 2015	-49.00	-97.26	-0.74	0.047	37	18
Raynor et al. 2013	-162.00	-289.88	-34.12	0.013	12	12
Raynor et al. 2013	-72.00	-225.36	81.36	0.357	14	14
Otten et al. 2010	-128.40	-175.30	-81.50	0.000	20	16
	-50.77	-86.36	-15.18	0.005		
Modification of cut-offs for short, medium and long term follow-up						
TV viewing short term (3 months or less)						
De cocker et al. 2016	-15.00	-64.01	34.01	0.549	22	8
De cocker et al. 2016	-16.00	-65.35	33.35	0.525	41	8
Gomersall et al. 2015	-52.00	-92.82	-11.18	0.013	37	19
Gomersall et al. 2015	-49.00	-97.26	-0.74	0.047	37	18
Raynor et al. 2013	-162.00	-289.88	-34.12	0.013	12	12
Otten et al. 2010	-128.40	-175.30	-81.50	0.000	20	16
Chau et al. 2014	-67.00	-96.12	-37.88	0.000		
	-60.46	-91.19	-29.72	0.000		
TV viewing medium term (3 months to 6 months)						
Laska et al. 2016	-6.00	-22.63	10.63	0.479	194	194
Gomersall et al. 2015	-17.00	-55.26	21.26	0.384	37	17
Gomersall et al. 2015	-13.00	-58.91	32.91	0.579	36	17
	-8.27	-22.74	6.20	0.263		
TV viewing long term (more than 6 months)						
French et al. 2011	-32.77	-56.29	-9.25	0.006		
Lakerveld et al. 2013	5.80	-7.77	19.37	0.402	242	248
Rockette-Wagner et al. 2015	-14.00	-20.36	-7.64	0.000	1079	1077
Laska et al. 2016	6.00	-10.64	22.64	0.480	179	173
	-7.47	-22.16	7.22	0.319		



Supplementary figure 2: Chapter 5. Sensitivity analysis

Supplementary table 4: Chapter 5. Assessment of evidence on the effectiveness of interventions for reducing non-occupational sedentary behavior using the GRADE approach

Outcome	Criteria	Judgement	Quality of evidence
Leisure sitting time medium term	Risk of bias/Design limits	Serious limitation High risk of bias for allocation concealment and detection bias	Very Low quality
	Inconsistency	Very Serious limitation High degree of heterogeneity	
	Indirectness	serious limitation Heterogeneous interventions	
	Imprecision	serious limitation Wide confidence interval	
	Publication bias	No serious limitation	
TV viewing short term	Risk of bias/Design limits	Serious limitation High risk for detection bias	Very Low quality
	Inconsistency	Serious limitation High degree of heterogeneity	
	Indirectness	serious limitation Heterogeneous interventions	
	Imprecision	serious limitation	
	Publication bias	No serious limitation	
TV viewing medium term	Risk of bias/Design limits	Serious limitation High risk for detection bias	Low quality
	Inconsistency	Serious limitation Moderate degree of heterogeneity	
	Indirectness	No serious limitation	
	Imprecision	No serious limitation	
	Publication bias	No serious limitation	
TV viewing long term	Risk of bias/Design limits	Serious limitation High risk for detection bias	Low quality
	Inconsistency	Serious limitation High degree of heterogeneity	

	Indirectness	No Serious limitation	
	Imprecision	No serious limitation	
	Publication bias	No serious limitation	
Computer use short term	Risk of bias/Design limits	Serious limitation High risk of bias for allocation concealment, attrition bias and detection bias	Very low quality
	Inconsistency	No serious limitation	
	Indirectness	serious limitation Heterogeneous interventions	
	Imprecision	serious limitation Wide confidence interval	
	Publication bias	No serious limitation	
Computer use long term	Risk of bias/Design limits	Serious limitation High risk for detection bias	Very low quality
	Inconsistency	No Serious limitation	
	Indirectness	No Serious limitation	
	Imprecision	Serious limitation Wide confidence interval	
	Publication bias	No serious limitation	
Transport sitting time short term	Risk of bias/Design limits	Serious limitation High risk of bias for allocation concealment, attrition bias and detection bias	Very low quality
	Inconsistency	No Serious limitation	
	Indirectness	serious limitation Heterogeneous interventions	
	Imprecision	serious limitation Wide confidence interval	
	Publication bias	No serious limitation	

GRADE Working Group grades of evidence:
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

Supplementary table 5: Chapter 6. Search strategy

1. CENTRAL search strategy
#1 work* #2 sedentary #3 sitting #4 #2 or #3 #5 office #6 inactiv* #7 #5 and #6 #8 #4 or #7 #9 #1 and #8 #10 #9 AND trials
2. MEDLINE search strategy
#1 (work[tw] OR works*[tw] OR work'*[tw] OR worka*[tw] OR worke*[tw] OR workg*[tw] OR worki*[tw] OR workl*[tw] OR workp*[tw] OR occupation*[tw] OR employe*[tw]) #2 (effect*[tw] OR control[tw] OR controls*[tw] OR controla*[tw] OR controle*[tw] OR controli*[tw] OR controll*[tw] OR eval- uat*[tw] OR intervention*[tw] OR program*[tw] OR compare*[tw]) #3 (sedentary OR sitting) OR seated posture OR chair[tiab] OR desk[tiab] OR (office AND inactiv*) #4 (animals [mh] NOT humans [mh]) #5 #1 AND #2 AND #3 NOT #4
3. CINAHL search strategy
S10 S1 AND S2 AND S9 Limiters - Exclude MEDLINE records Search modes - Boolean/Phrase S9 S3 OR S4 OR S5 OR S6 OR S7 OR S8 S8 (office AND inactive*) or TX (office AND inactive*) or MW (office AND inactive*) S7 Desk or TX desk or MW desk S6 Sedentary or TX sedentary or MW sedentary S5 Seated posture or TX seated posture or MW seated posture S4 Sitting or TX sitting or MW sitting S3 Chair or TX chair or MW chair S2 TX randomised controlled trial or TX controlled clinical trial or AB placebo or TX clinical trials or AB randomly or TI trial or TX intervent* or control* or evaluation* or program* S1 work* OR (of c* OR busines*) OR occupat*

4. EMBASE search strategy
#1 sedentary #2 ’sitting’/de #3 ’seated posture’ #4 seated NEAR/1 posture #5 chair:ab,ti OR desk:ab,ti #6 chair:ab,ti #7 desk:ab,ti #8 office AND inactiv* #9 #1 OR #2 OR #4 OR #6 OR #7 OR #8 #10 ’work’/de OR work #11 work* #12 ’occupation’/de OR occupation #13 employe* #14 #10 OR #12 OR #13 #15 effect #16 control #17 evaluat* #18 intervention* #19 program #20 compare #21 #15 OR #16 OR #17 OR #18 OR #19 OR #20 #22 #9 AND #14 AND #21 #23 #22 AND [embase]/lim #24 #23 AND [humans]/lim AND [embase]/lim
5. PsycINFO (ProQuest)

S25 S13 AND S17 AND S24 S24 S18 OR S19 OR S20 OR S21 OR S22 OR S23 S23 compare S22 program S21 intervention* S20 evaluat* S19 control S18 effect S17 S14 OR S15 OR S16 S16 employe* S15 occupation S14 work S13 S1 OR S2 OR S4 OR S8 OR S11 OR S12 S12 office AND inactive* S11 S9 OR S10 S10 ab(desk) S9 ti(desk) S8 S6 OR S7 S7 ti(chair) S6 ab(chair) S5 ab(chair) OR ti(chair) S4 seated NEAR/1 posture S3 seated posture S2 sitting S1 sedentary
6. ClinicalTrials.gov
Sitting AND Workplace
7. World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) search portal
Sitting AND Workplace

Supplementary table 6: Chapter 9. Focus group questionnaire

1) What motivated you to participate in this trial?
2) What prevents you from participating in physical activity or interrupting the amount of time you spend sitting?
    a. In your environment, what facilitates engaging in physical activity or sitting less? And what limits it?
    b. What are your motivations to engage in a physical activity or conversely to not engage in a physical activity?
    c. What are your motivations in sitting less?
3) Did anything encourage you to stand up more or walk to complete your work during the study period?
    a. Did behavior of your colleagues encourage you (standing up or walking at work)?
    b. Did the goals that you set encouraged you to stand up more or walk at work?
4) Did participation in this study increased the likelihood of you recommending physical activity to your clients?

    a. How do you think your physical activity habits influence whether or not you engage in physical activity counseling with your clients?

    b. How confident are you that you can counsel your clients about physical activity even if you are physically inactive?
5) Is physical activity part of your treatment approach?

    PROBES: a. Who typically brings up the discussion about physical activity, you or your clients?

    b. What kinds of questions about physical activity do your clients ask you?

    c. What kind of questions about physical activity do you ask your clients?

    d. Have you ever felt like you were unable to answer your client's physical activity questions?

        i. PROBE: What types of questions are you unable to answer? Any others? REPHRASE: Can you recall any other questions or times?

    e. What do you do if you cannot answer?

        PROBE: Do you find the answer for them? Where? How?

    f. What would you tell your clients about why exercise is important for health?
6) Do you currently counsel your clients about their physical activity?

    PROBES: a. How often do you counsel your clients about their physical activity levels? b. What are the characteristics or types of clients that you are more likely to counsel about physical activity?

c. What do you feel your strengths are when it comes to counseling physical activity, if any?

d. What do you feel your weaknesses are when it comes to counseling physical activity, if any?

7) Was there anything about using the intervention that you particularly liked?
8) In closing, is there anything else you'd like to say about your experience of participating in this study?

Supplementary table 7: Chapter 9. Mental health professionals' perceived importance of different types of treatment for people with mental illness

Treatment strategy	Percent of clinicians who ranked the strategy as…		
	the most important	2nd most important	3rd most important
Cognitive behavioral therapy	58.8%	11.8%	11.8%
Social support	41.2%	11.8%	11.8%
Family therapy	0%	17.7%	29.4%
Vocational rehabilitation	0%	5.9%	5.9%
Medication	0%	23.5%	0%
Increasing physical activity	0%	29.4%	35.3%
Reducing sedentary behavior	0%	0%	17.7%
Social skills training	0%	0%	5.9%
Bright light therapy	0%	0%	0%
Electroconvulsive therapy	0%	0%	0%
Hospitalisation	0%	0%	0%

Supplementary table 8: Chapter 9. Mental health professionals' specific practices in recommending physical activity

What methods do you use for recommending physical activity? *	
Personal discussion	88.2%
Brochures or pamphlets	17.6%
Referral to community-based programs	35.3%
Referral to exercise professional	17.6%
Nothing specific	29.4%
Internet	11.8%
Any sporting clubs they might be interested in	5.9%
How often do you recommend they engage in physical activity?	
Every day	17.6%
Most days of the week	35.3%
Once to twice a week	11.8%
As often as they can	35.3%
What intensity do you recommend they engage in activities? *	
Low intensity	11.8%
Moderate intensity	23.5%
Vigorous intensity	5.9%
At level that makes them feel good	47%
I do not suggest intensity	29.4%
What type of physical activity do you recommend? *	
Aerobic exercise	82.4%
Weight training or resistance training	41.2%
Swimming	41.2%
Team sports	64.7%
Combat sports	35.3%
Dancing	5.9%
Group sessions at gym	5.9%
Any activity they enjoy	29.4%

*Multiple response option

*Supplementary table 9: Chapter 10. Variation matrix**

	Sedentary behaviour	Physical activity	Bedtime
Sedentary behaviour	-	0.136	0.068
Physical activity†	0.165	-	0.121
Bedtime	0.596	0.119	-

* Pre-intervention and post-intervention values are presented below and above the main diagonal, respectively

† Overall physical activity, including the time spent in light, moderate, and vigorous physical activity

Supplementary table 10: Chapter 10. Overall changes in general beliefs, perceived barriers and practices of mental health professionals from baseline to follow-up

	Pre-intervention		Post-intervention		***p****
	Mean	**SD**	**Mean**	**SD**	
Beliefs					
People with a mental illness know that physical activity is good for their physical health	3.47	0.94	3.76	0.97	0.26
People with a mental illness know that physical activity is good for their mental health	3.12	0.86	2.88	0.78	0.30
People with a mental illness do not engage in physical activity, because they don't think they can	3.29	0.92	3.53	0.62	0.22
Physical activity is valuable for patients *hospitalised* with a mental illness in the same manner as for outpatients	4.18	0.53	4.18	0.53	1.00
The physical and mental health benefits of physical activity for people with a mental illness are not long lasting	2.24	0.83	2.18	0.64	0.84
People with a mental illness who are recommended physical activity will not adhere to it	3.00	0.79	2.53	0.72	**0.03**
How do you rank increasing physical activity compared to other forms of treatment?	3.41	1.46	3.71	1.79	0.53
How do you rank reducing sedentary behaviour compared to other forms of treatment?	5.71	1.96	5.88	1.90	0.78
Perceived barriers					
Their mental health makes it impossible for them to participate in physical activity	1.88	0.86	1.65	0.86	0.10

I'm concerned physical activity might make their condition worse	1.47	0.62	1.71	0.77	0.26
I am not interested in recommending physical activity for people with a mental illness	1.41	0.51	1.29	0.59	0.43
I don't believe physical activity will help people with a mental illness	1.35	0.49	1.24	0.44	0.33
Their physical health makes it impossible for them to participate in physical activity	1.82	0.81	1.82	0.73	1.00
I'm concerned they might get injured while engaging in physical activity	1.71	0.77	1.53	0.72	0.38
People with a mental illness won't adhere to a physical activity program	2.41	1.18	1.88	0.86	**0.03**
My workload is already too excessive to include recommending physical activity to people with a mental illness	2.24	1.09	1.71	0.77	**0.02**
Recommending physical activity to people with a mental illness is not part of my job	1.47	0.51	1.47	0.72	1.00
I do not know how to recommend physical activity to people with a mental illness	2.29	1.31	2.00	1.00	0.17
Prescription of physical activity to people with mental illness is best delivered by an exercise professional such as an exercise physiologist	2.76	1.25	2.47	1.23	0.10
Practice					
Do you recommend physical activity to people with a mental illness?	3.24	0.75	3.12	0.70	0.54
Do you recommend reducing sedentary behaviour (time spent sitting/screen time) to people with a mental illness?	2.76	0.97	2.82	0.95	0.72

* *p*-value for the difference between baseline and follow-up from a one-way repeated measures univariate analysis of variance (ANOVA)

Pre-int. week	Int. week 1	Int. weeks 2-4	Post-int. week 1	Post-int. week 2
• Invitation to participate in the study • Recruitment of participants • At the beginning of the week, participants fill EMIQ questionnaire	• Participants fill the remaining questionnaires • Group counseling on physical activity and sedentary behaviour	• Reminder phone call (once a week)	• Participants wear accelerometers for 7 days	• At the beginning of the week, participants fill all questionnaires

Supplementary figure 3: Chapter 10. Study timeline

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study that aims to find out if a physical activity (PA) and sedentary behaviour (SB) intervention can be successfully delivered in mental health professionals. The study also aims to investigate changes in mental health professionals' attitudes towards and practices in recommending more PA and less SB to their clients. The study is conducted within the Active Living and Public Health Program, Institute for Health and Sport, Victoria University.

Your participation in the study is voluntary. Your responses and all collected data will be confidential, and we will not collect any personal information. You can choose not to disclose any information that may cause you discomfort, and you may withdraw from the study at any time. There are no or negligible risks for you to be involved in the study.

More detailed information about the study protocol is provided to you in the information leaflet enclosed to this document and may be obtained from project team members at any time.

CERTIFICATION BY SUBJECT

I, ____ (name)

of ____ (suburb)

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study **Effectiveness of a physical activity intervention for mental health professionals on changing their attitudes and practices in recommending physical activity as part of mental health treatment** being conducted at Victoria University by Professor Alexandra Parker.

I certify that the purpose of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

____ (program staff member name) and that I freely consent to participation involving the below mentioned procedures:

- Participation in a behaviour change physical activity intervention
- Self-reported questionnaires on demographic characteristics (gender, age, marital status), sleep duration, sedentary behaviour and physical activity, attitude towards and practices in recommending physical activity as a part of mental health treatment:
- Use of accelerometers to collect data on sleep duration, sedentary behaviour and physical activity;
- Participation in a focus group discussion to share experiences of taking part in the intervention.

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any time without any consequences.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher: Professor Alexandra Parker 03 9919 5874.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled: Effectiveness of a physical activity intervention for mental health professionals on changing their attitudes and practices in recommending physical activity as part of mental health treatment.

This project is being conducted by Professor Alexandra Parker (Institute for Health and Sport – IHES, Victoria University), Dr Zeljko Pedisic (Senior Research Fellow, IHES) and Mr Nipun Shrestha (Postgraduate Student, IHES).

Project explanation

This project is a part of the research activities of the Victoria University Public Health Network (VUPHN).

The project aims to find out if a physical activity (PA) and sedentary behaviour (SB) intervention can be successfully delivered in mental health professionals and changes on their attitude towards and practices in recommending more PA and less SB to their clients.

The research project asks you to allow your data collected during the study to be used for research purposes such as journal publications, research reports, and conference presentations. Your identity will be removed form information you provide to ensure privacy.

What will I be asked to do?

We will randomly assign each of your four participating headspace centres to either the intervention or control group. If your headspace centre is assigned to the intervention group, you will be asked to participate in a physical activity intervention of four weeks' duration. You will be asked to attend a group-based single-session for behaviour change targeting physical activity and sedentary behaviours. You will be asked to complete questionnaires at the beginning and end of the four-week study period. During the intervention, a member of the research team will additionally contact you by phone on two occasions to review your activity goals and monitor your progress. During the study period, you will also be required to wear a motion sensor on your wrist. Some of you will be invited to join a focus group interview comprising of 6 to 7 participants to share your experiences with intervention.

If your headspace centre is assigned to the control group, you will be asked to complete questionnaires at the beginning and end of study period. During the study period, you will also be required to wear a motion sensor on your wrist. You will be offered to participate in the single-session behaviour change for physical activity and sedentary behaviour at the end of the study period.

If you decide to participate in the research project, any information collected during your participation in the program will be accessible to the research team for research purposes. Your involvement may include any or all of the following information which will be collected throughout your participation using a combination of self-report and device-based measures:

- Demographics (age, gender, marital status)
- Sedentary behaviours and levels of physical activity
- Sleep quality and duration
- Attitudes towards and practices in recommending physical activity as part of routine mental health care
- Motivating and preventing factors for engaging in physical activity
- Other health-related issues

Your identity will be removed from information you provide to ensure privacy using randomly generated codes, so nobody, not even researchers in the project, will be able to match your responses with your identity.

What will I gain from participating?

You will benefit by knowing that you contributed to the potential development of physical activity intervention for mental health professionals and consequently
will strengthen the evidence for implementation of PA and SB interventions among

mental health professionals across Australia. If you are allocated to intervention group, it is possible that you may also gain health and wellbeing benefits from increasing your engagement in PA and decreasing SB.

How will the information I give be used?

Your information will be used in scientific and public health related publications, research reports and conference presentations. All data will be de-identified and summarised in these presentations, and individuals outside of the research team will not have access to any of your personal results.

What are the potential risks of participating in this project?

Physical activity interventions have been shown to have little or no harmful effects. However, if you do sustain an injury whilst engaging in physical activity as part of this project, we encourage you to contact your local GP or emergency department. If you have any pre-existing health conditions or you are concerned about your general level of health, you may wish to consult your GP to ensure that you can safely engage in physical activity. If you experience discomfort or distress as a consequence of completing questionnaires or participating in the focus group, we encourage you to make use of the psychological support offered by an independent clinical psychologist, arranged through the study.

How will this project be conducted?

This project requests to use the data collected during your participation in the 'Effectiveness of a physical activity intervention for mental health professionals on changing their attitudes and practices in recommending physical activity as part of mental health treatment' study for research purposes.

Your participation in the study will be voluntary. Your responses and all collected data will be confidential, and de-identified in the way that only you will know your personal code. You can choose not to disclose any information that may cause you discomfort, and you will have right to withdraw from the study at any time.

At your first consultation with a member of the research team, you will have an opportunity to discuss the research program with members of the research team. Then you will be asked to sign the consent form if you are willing to participate.

If you decide at any time that you would no longer like to be involved in the research project, please inform any member of the research team. You can remove yourself from the research project without any consequences.

Who is conducting the study?

Institute for Health and Sport (IHES), Victoria University; and

Victoria University Public Health Network (VUPHN)

Chief Investigator

Professor Alexandra Parker

Phone: +61 3 9919 5874

Email: alexandra.parker@vu.edu.au

Any queries about your participation in this project may be directed to the Chief Investigator.

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

Orygen

The National Centre of Excellence in Youth Mental Health

24 July 2018

Dear Victoria University Human Research Ethics Committee

Re: Letter of support for a research project examining the effectiveness of a physical activity intervention for mental health clinicians

As the Clinical Director of Orygen's four headspace centres in Sunshine, Glenroy, Werribee and Craigieburn, I support this research project that examines an intervention to increase physical activity and reduce sedentary behaviours in mental health clinicians. I understand that the project will also examine if making changes in physical activity will influence the clinician's attitudes and practices in recommending physical activity as part of mental health treatment.

Orygen will assist the project by inviting all mental health clinicians who work across our four headspace centres to contact the investigators should they wish to learn more about what participation in the project involves. We will do this by sending out an email to the clinicians. This email will be sent either by myself or by the headspace centre managers and will invite our clinicians to contact the study's Chief Investigator, Prof Alex Parker, if they wish to find out more about participating in the project. Orygen will provide access to meeting rooms for the intervention sessions and the focus group discussions to be held onsite at each headspace centre.

Should you require any further information, please do not hesitate to get in touch by email or phone.

Yours truly,

[redacted]

Dr Sophie Adams
Clinical Director
Orygen, The National Centre of Excellence in Youth Mental Health
E: Sophie.Adams@orygen.org.au M: 0422 140 9

35 Poplar Road
Parkville VIC 3052
1300 679 436

ABN 85 098 918 686
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An initiative of The University of Melbourne, Melbourne Health and The Colonial Foundation

Subject: Re: Psychological support for PhD project
Date: Wednesday, 25 July 2018 at 9:45:13 pm Australian Eastern Standard Time
From: Carolyn Deans
To: Alex Parker

Hi Alex,

That's no problem at all, happy to be included.

Carolyn

From: Alex Parker <Alex.Parker@vu.edu.au>
Date: Wednesday, 25 July 2018 at 5:59 pm
To: Carolyn Deans <Carolyn.Deans@vu.edu.au>
Subject: Psychological support for PhD project

Dear Carolyn
I hope you are well. I'm currently co-supervising a PhD student, Nipun Shrestha, who is planning an intervention study of a behaviour change intervention aimed at physical activity and sedentary behaviours in mental health clinicians. He is interested in evaluating the effectiveness of the intervention as well as clinician's attitudes towards using physical activity in mental health treatment. Nipun is a PhD member of the Healthy and Inclusive Communities research program in IHES.
We are currently finalising the ethics application and I'm writing to request your support. In the unlikely event that a participant (allied health professionals working in a youth mental health service) experiences psychological distress as a consequence of their participation in the research, would you be available to provide professional support?
If you are able to provide this support, I will include this email as an attachment to our ethics submission.
Thanks for your consideration and please let me know if you have any questions. I would usually nominate myself for this role but cannot for this study as I will be co-delivering the behaviour change intervention with my student.
Kind regards
Alex

Prof Alex Parker (MPsych, PhD)
Professor of Physical Activity and Mental Health
Research program leader of Healthy and Inclusive Communities: Physical Activity, Sport and Culture
Institute for Health and Sport (IHES)
Victoria University
Phone: +61 3 9919 5874
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Fax: +61 3 9919 9480

The Exercise in Mental Illness Questionnaire (EMIQ)

Knowledge, attitudes and behaviours regarding physical activity for people with a mental illness

Health Practitioner Version

This questionnaire asks questions regarding your knowledge, your attitudes and your behaviours regarding physical activity for people with a mental illness. We ask you to complete all questions. There is no right or wrong answer and it is important that we obtain an answer that represents your view as a health professional. For the purpose of this questionnaire, the term 'mental illness' means any mental illness including but not limited to depression, schizophrenia, bipolar disorders I and II, post-traumatic stress disorder and other mental illnesses.

Part 1. Knowledge.
This section asks about your formal training regarding physical activity and your knowledge about the benefits of physical activity

1. Have you had any formal training in recommending physical activity (e.g. University degree in a related area, Vocational training, In-service)?

   Yes / No (If no, skip to question 5)

2. If you answered yes, please provide details including course duration, on who provided this formal training (e.g. University degree, Vocational training, In-service)

   ____

3. How would you rate your knowledge of recommending physical activity for people with a mental illness? (Please circle)

1	2	3	4	5
Very poor	Poor	Average	Good	Excellent

4. How would you rate your confidence to recommend physical activity for people with mental illness? (Please circle)

1	2	3	4	5
Very poor	Poor	Average	Good	Excellent

To what extent do you agree or disagree with the following statements (for the purpose of this section, 'Physical activity' refers to activity undertaken according to population health guidelines i.e. 150-300 minutes of moderate intensity activity or 75-150 minutes of vigorous activity per week)

5. Maintaining a healthy weight can prevent you from developing chronic diseases such as cardiovascular disease or type II diabetes.

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

6. Physical activity can lower your total blood cholesterol.

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

7. Physical activity can lower your blood pressure.

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

8. People who undertake regular physical activity are less likely to develop depression than those who do not

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

9. Physical activity can reduce the risk of some forms of cancer including colorectal cancer, breast cancer (women) and prostate cancer (men).

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

10. The benefits of physical activity will still accrue if 30 minutes of daily physical activity is undertaken in shorter blocks of time such as 10 minutes

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

Part 2. Beliefs.
The next few questions ask about your beliefs regarding physical activity for people with a mental illness

11. Listed below are some treatment strategies with demonstrated evidence for effectiveness. Rate how valuable you believe each treatment strategy is compared to physical activity.

a) Medication

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

b) Social support

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

c) Electroconvulsive therapy

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

d) Bright light therapy

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

e) Family therapy

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

f) Social skills training

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

g) Cognitive behavioural therapy

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

h) Vocational rehabilitation

1	2	3	4	5
Significantly less than physical activity	Somewhat less than physical activity	Of equal value to physical activity	Somewhat better than physical activity	Significantly better than physical activity

To what extent do you agree or disagree with the following statements

12. People with a mental illness know that physical activity is good for their **physical** health

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

13. People with a mental illness know that physical activity is good for their **mental** health

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

14. People with a mental illness do not engage in physical activity because they don't think they can

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

15. Physical activity is valuable for patients ***hospitalised*** with a mental illness in the same manner as outpatients

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

16. The physical and mental health benefits of physical activity for people with a mental illness are not long lasting

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

17. People with a mental illness who are recommended physical activity will not adhere to it

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

18. Using numbers 1 – 11 with 1 as the most important, rank the importance of the following treatment strategies in the care of people with mental illness

------ Medication (e.g anti-depressants)
------ Social support
------ Electroconvulsive therapy
------ Bright light therapy
------ Family therapy
------ Social skills training

------ Cognitive behavioural therapy
------ Vocational rehabilitation
------ Increasing physical activity
------ Reducing sedentary behaviour (e.g. inactive sitting and screen time)
------ Hospitalisation

If there are other treatment strategies not listed above which you feel are important please list them here including why you believe they are important

____

____

Part 3. Behaviours.

The next few questions ask about your recommendations for physical activity (describing what they should do and how they should do it) **for people with a mental illness**

Please circle your response

19. Do you recommend reducing sedentary behaviour (time spent sitting/screen time) to people with a mental illness?

1	2	3	4
Never	Occasionally	Most of the time	Always

20. Do you recommend physical activity to people with a mental illness?

1	2	3	4
Never	Occasionally	Most of the time	Always

If you answered 'Never' above, skip to Question 27

21. Do you undertake a formal assessment of the clients' suitability for physical activity prior to prescribing a program?

    Yes / No If you answered 'Yes, please describe what assessment tools or items you use. If you answered 'No', please provide a reason for not undertaking some form of assessment.

    ____

    ____

22. When you recommend physical activity to people with a mental illness, what methods do you use? (Please tick all that apply)

    1) Personal discussion
    2) Brochures or pamphlets
    3) Referral to community-based programs
    4) Referral to an exercise professional (exercise physiologist, gymnasium, etc.)
    5) Nothing specific
    6) Other ______________________

23. When you recommend physical activity to people with a mental illness, what overall weekly duration of physical activity do you recommend?

    _______ minutes

24. When you recommend physical activity to people with a mental illness, how often do you recommend they engage in physical activity? (Please select only one response)

    1) Every day
    2) Most days of the week
    3) Once to twice a week
    4) As often as they feel they can
    5) Other __________________________

25. When you recommend physical activity to people with a mental illness, how hard (what intensity) do you recommend they engage in activities? (You can select multiple responses)

    1) Low intensity (a slight rise in heart rate and breathing, talking remains easy)
    2) Moderate intensity (a noticeable rise in heart rate and breathing but talking is still possible)
    3) Vigorous intensity (getting out of breath, talking is not possible)
    4) At a level that makes them feel good
    5) I do not suggest an intensity
    6) Other ______________________________

26. When you recommend physical activity to people with a mental illness, how long do you suggest people try to engage in activity for at any one time? (Please select only one response)

    1) 10 minutes per session
    2) 20 minutes per session
    3) 30 minutes per session
    4) 60 minutes per session
    5) As long as they can
    6) Other ______________________________

27. When you recommend physical activity to people with a mental illness, what type of physical activity do you suggest? (Please tick all that apply)

    1) Aerobic exercise (e.g. Walking, cycling)
    2) Weight training or resistance training
    3) Swimming
    4) Team sports (touch football, soccer, netball)
    5) Combat sports (Boxing, Karate etc)
    6) Relaxation activities (Tai Chi, Yoga)
    7) Other _________________________

Part 4. Barriers to recommending physical activity for people with a mental illness

To what extent do ***you*** agree with the following statements regarding the barriers to recommending physical activity to people with a mental illness?

28. Their mental health makes it impossible for them to participate in physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

29. I'm concerned physical activity might make their condition worse

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

30. I am not interested in recommending physical activity for people with a mental illness

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

31. I don't believe physical activity will help people with a mental illness

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

32. Their physical health makes it impossible for them to participate in physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

33. I'm concerned they might get injured while engaging in physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

34. People with a mental illness won't adhere to a physical activity program

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

35. My workload is already too excessive to include recommending physical activity to people with a mental illness

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

36. Recommending physical activity to people with a mental illness is not part of my job

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

37. I do not know how to recommend physical activity to people with a mental illness

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

38. Prescription of physical activity to people with mental illness is best delivered by an exercise professional such as an exercise physiologist

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

People with a mental illness report many barriers to physical activity. These are some statements expressed by people with a mental illness about barriers to engaging in physical activity. To what extent do you agree with ***their*** statements below?

39. I am too unwell to engage in physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

40. It takes too much time

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

41. There is too much stigma attached to having a mental illness

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

42. I don’t know what I should do

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

43. My friends or family won’t engage in physical activity with me

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

44. There are too many side effects from the medications

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

45. I lack the confidence to do any physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

46. I'm too fat to engage in physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

47. I am afraid I will get hurt

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

48. I have too many physical health problems

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

49. There is no safe place for me to engage in physical activity

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

50. I don’t have any equipment to do physical activity with

1	2	3	4	5
Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree

Part 5. Demographics

51. Gender (Please circle)   Male   Female   Other

52. What is your current age? ____________________ years

53. What is your current marital status? (Please circle)

1. Single
2. Widowed
3. Divorced
4. Separated not divorced
5. Married
6. De facto

54. What is your main role at a headspace centre?

1) Psychiatrist
2) Psychiatric registrar
3) General Practitioner
4) General Practice Registrar
5) Other Medical Officer
6) Mental Health Nurse – registered
7) Nurse Practitioner
8) Other Nurse
9) Psychologist – fully registered

10) Psychologist – clinically endorsed
11) Probationary Psychologist
12) Social Worker
13) Occupational Therapist
14) Counsellor/Mental Health Worker
15) Practice Manager
16) Clinical Lead
17) Manager
18) Other – please specify

____

55. How many years have you been employed in mental health profession? _________ years

56. Where did you complete your highest educational degree?

1. In Australia
2. Elsewhere

57. How is your role at headspace funded?

1. Employed by headspace (salaried staff)
2. Private provider (eg MBS/ATAPS)

58. Do you currently work in a clinical role at another service in addition to headspace?

1. Yes
2. No

59. Do you consider your headspace role as your main job?

1. Yes
2. No

References

AADAHL, M., LINNEBERG, A., MOLLER, T. C., ROSENORN, S., DUNSTAN, D. W., WITTE, D. R. & JORGENSEN, T. 2014. Motivational counseling to reduce sitting time: a community-based randomized controlled trial in adults. *Am J Prev Med,* 47**,** 576-86.

AITTASALO, M., MIILUNPALO, S. & SUNI, J. 2004. The effectiveness of physical activity counseling in a work-site setting. A randomized, controlled trial. *Patient Educ Couns,* 55**,** 193-202.

BLAKE, H., SUGGS, L. S., COMAN, E., AGUIRRE, L. & BATT, M. E. 2017. Active8! Technology-Based Intervention to Promote Physical Activity in Hospital Employees. *Am J Health Promot,* 31**,** 109-118.

BLISSMER, B. & MCAULEY, E. 2002. Testing the requirements of stages of physical activity among adults: the comparative effectiveness of stage-matched, mismatched, standard care, and control interventions. *Ann Behav Med,* 24**,** 181-9.

CAMPBELL, M. K., TESSARO, I., DEVELLIS, B., BENEDICT, S., KELSEY, K., BELTON, L. & SANHUEZA, A. 2002. Effects of a tailored health promotion program for female blue-collar workers: health works for women. *Prev Med,* 34**,** 313-23.

CARR, L. J., LEONHARD, C., TUCKER, S., FETHKE, N., BENZO, R. & GERR, F. 2016. Total Worker Health Intervention Increases Activity of Sedentary Workers. *Am J Prev Med,* 50**,** 9-17.

CHAU, J. Y., DALEY, M., DUNN, S., SRINIVASAN, A., DO, A., BAUMAN, A. E. & VAN DER PLOEG, H. P. 2014. The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav Nutr Phys Act,* 11**,** 127.

COLEMAN, K. J., RAYNOR, H. R., MUELLER, D. M., CERNY, F. J., DORN, J. M. & EPSTEIN, L. H. 1999. Providing sedentary adults with choices for meeting their walking goals. *Prev Med,* 28**,** 510-9.

COOK, R. F., BILLINGS, D. W., HERSCH, R. K., BACK, A. S. & HENDRICKSON, A. 2007. A field test of a web-based workplace health promotion program to improve dietary practices, reduce stress, and increase physical activity: randomized controlled trial. *J Med Internet Res,* 9**,** e17.

DADACZYNSKI, K., SCHIEMANN, S. & BACKHAUS, O. 2017. Promoting physical activity in worksite settings: results of a German pilot study of the online intervention Healingo fit. *BMC Public Health,* 17**,** 696.

DE COCKER, K., DE BOURDEAUDHUIJ, I., CARDON, G. & VANDELANOTTE, C. 2016. The effectiveness of a web-based computer-tailored intervention on workplace sitting: A randomized controlled trial. *J Med Internet Res,* 18**,** e96.

DISHMAN, R. K., DEJOY, D. M., WILSON, M. G. & VANDENBERG, R. J. 2009. Move to Improve: a randomized workplace trial to increase physical activity. *Am J Prev Med,* 36**,** 133-41.

DUTTA, N., KOEPP, G. A., STOVITZ, S. D., LEVINE, J. A. & PEREIRA, M. A. 2014. Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *Int J Environ Res Public Health,* 11**,** 6653-65.

FRENCH, S. A., GERLACH, A. F., MITCHELL, N. R., HANNAN, P. J. & WELSH, E. M. 2011. Household obesity prevention: Take Action--a group-randomized trial. *Obesity (Silver Spring),* 19**,** 2082-8.

FRENCH, S. A., HARNACK, L. J., HANNAN, P. J., MITCHELL, N. R., GERLACH, A. F. & TOOMEY, T. L. 2010. Worksite environment intervention to prevent obesity among metropolitan transit workers. *Prev Med,* 50**,** 180-5.

GAZMARARIAN, J. A., ELON, L., NEWSOME, K., SCHILD, L. & JACOBSON, K. L. 2013. A randomized prospective trial of a worksite intervention program to increase physical activity. *Am J Health Promot,* 28**,** 32-40.

GILSON, N. D., PUIG-RIBERA, A., MCKENNA, J., BROWN, W. J., BURTON, N. W. & COOKE, C. B. 2009. Do walking strategies to increase physical activity reduce reported sitting in workplaces: a randomized control trial. *Int J Behav Nutr Phys Act,* 6**,** 43.

GOMERSALL, S., MAHER, C., ENGLISH, C., ROWLANDS, A. & OLDS, T. 2015a. Time regained: when people stop a physical activity program, how does their time use change? A randomised controlled trial. *PLoS One,* 10**,** e0126665.

GOMERSALL, S. R., NORTON, K., MAHER, C., ENGLISH, C. & OLDS, T. S. 2015b. In search of lost time: When people undertake a new exercise program, where does the time come from? A randomized controlled trial. *J Sci Med Sport,* 18**,** 43-8.

HAGER, R. L., HARDY, A., ALDANA, S. G. & GEORGE, J. D. 2002. Evaluation of an internet, stage-based physical activity intervention. *Am J Health Educ,* 33**,** 329-337.

HU, G., TIAN, H., ZHANG, F., LIU, H., ZHANG, C., ZHANG, S., WANG, L., LIU, G., YU, Z., YANG, X., QI, L., ZHANG, C., WANG, H., LI, M., LENG, J., LI, Y., DONG, L. & TUOMILEHTO, J. 2012. Tianjin Gestational Diabetes Mellitus Prevention Program: study design, methods, and 1-year interim report on the feasibility of lifestyle intervention program. *Diabetes Res Clin Pract,* 98**,** 508-17.

LAKERVELD, J., BOT, S. D., VAN DER PLOEG, H. P. & NIJPELS, G. 2013. The effects of a lifestyle intervention on leisure-time sedentary behaviors in adults at risk: the Hoorn Prevention Study, a randomized controlled trial. *Prev Med,* 57**,** 351-6.

LASKA, M. N., LYTLE, L. A., NANNEY, M. S., MOE, S. G., LINDE, J. A. & HANNAN, P. J. 2016. Results of a 2-year randomized, controlled obesity prevention trial: Effects on diet, activity and sleep behaviors in an at-risk young adult population. *Prev Med,* 89**,** 230-6.

LOUGHLAN, C. & MUTRIE, N. 1997. An evaluation of the effectiveness of three interventions in promoting physical activity in a sedentary population. *Health Educ J,* 56**,** 154-165.

MACKINNON, D. P., ELLIOT, D. L., THOEMMES, F., KUEHL, K. S., MOE, E. L., GOLDBERG, L., BURRELL, G. L. & RANBY, K. W. 2010. Long-term effects of a worksite health promotion program for firefighters. *Am J Health Behav,* 34**,** 695-706.

MARSHALL, A. L., LESLIE, E. R., BAUMAN, A. E., MARCUS, B. H. & OWEN, N. 2003. Print versus website physical activity programs: a randomized trial. *Am J Prev Med,* 25**,** 88-94.

MCEACHAN, R. R., LAWTON, R. J., JACKSON, C., CONNER, M., MEADS, D. M. & WEST, R. M. 2011. Testing a workplace physical activity intervention: a cluster randomized controlled trial. *Int J Behav Nutr Phys Act,* 8**,** 29.

MIYACHI, M., KURITA, S., TRIPETTE, J., TAKAHARA, R., YAGI, Y. & MURAKAMI, H. 2015. Installation of a stationary high desk in the workplace: effect of a 6-week intervention on physical activity. *BMC Public Health,* 15**,** 368.

MORGAN, P. J., COLLINS, C. E., PLOTNIKOFF, R. C., COOK, A. T., BERTHON, B., MITCHELL, S. & CALLISTER, R. 2011. Efficacy of a workplace-based weight loss program for overweight male shift workers: the Workplace POWER (Preventing Obesity Without Eating like a Rabbit) randomized controlled trial. *Prev Med,* 52**,** 317-25.

MUTRIE, N., CARNEY, C., BLAMEY, A., CRAWFORD, F., AITCHISON, T. & WHITELAW, A. 2002. "Walk in to Work Out": a randomised controlled trial of a self help intervention to promote active commuting. *J Epidemiol Community Health,* 56**,** 407-12.

NAPOLITANO, M. A., FOTHERINGHAM, M., TATE, D., SCIAMANNA, C., LESLIE, E., OWEN, N., BAUMAN, A. & MARCUS, B. 2003. Evaluation of an internet-based physical activity intervention: a preliminary investigation. *Ann Behav Med,* 25**,** 92-9.

NICHOLS, J. F., WELLMAN, E., CAPAROSA, S., SALLIS, J. F., CALFAS, K. J. & ROWE, R. 2000. Impact of a worksite behavioral skills intervention. *Am J Health Promot,* 14**,** 218-21, ii.

NISBETH, O., KLAUSEN, K. & ANDERSEN, L. B. 2000. Effectiveness of counselling over 1 year on changes in lifestyle and coronary heart disease risk factors. *Patient Educ Couns,* 40**,** 121-31.

OPDENACKER, J. & BOEN, F. 2008. Effectiveness of face-to-face versus telephone support in increasing physical activity and mental health among university employees. *J Phys Act Health,* 5**,** 830-43.

OTTEN, J. J., JONES, K. E., LITTENBERG, B. & HARVEY-BERINO, J. 2009. Effects of television viewing reduction on energy intake and expenditure in overweight and obese adults: a randomized controlled trial. *Arch Intern Med,* 169**,** 2109-15.

PEDERSEN, M. T., BLANGSTED, A. K., ANDERSEN, L. L., JORGENSEN, M. B., HANSEN, E. A. & SJOGAARD, G. 2009. The effect of worksite physical activity intervention on physical capacity, health, and productivity: a 1-year randomized controlled trial. *J Occup Environ Med,* 51**,** 759-70.

PESOLA, A. 2016. *Reduced Muscle Inactivity, Sedentary: Effectiveness of a One-Year Family-Based Cluster Randomized Controlled Trial.* PhD, University of Jyväskylä.

PETERSEN, C. B., SEVERIN, M., HANSEN, A. W., CURTIS, T., GRONBAEK, M. & TOLSTRUP, J. S. 2012. A population-based randomized controlled trial of the effect of combining a pedometer with an intervention toolkit on physical activity among individuals with low levels of physical activity or fitness. *Prev Med,* 54**,** 125-30.

PETERSON, T. R. & ALDANA, S. G. 1999. Improving exercise behavior: an application of the stages of change model in a worksite setting. *Am J Health Promot,* 13**,** 229-32, iii.

PLOTNIKOFF, R. C., BRUNET, S., COURNEYA, K. S., SPENCE, J. C., BIRKETT, N. J., MARCUS, B. & WHITELEY, J. 2007. The efficacy of stage-matched and standard public health materials for promoting physical activity in the workplace: the Physical Activity Workplace Study (PAWS). *Am J Health Promot,* 21**,** 501-9.

PRESTWICH, A., CONNER, M. T., LAWTON, R. J., WARD, J. K., AYRES, K. & MCEACHAN, R. R. 2012. Randomized controlled trial of collaborative implementation intentions targeting working adults' physical activity. *Health Psychol,* 31**,** 486-95.

PROPER, K. I., HILDEBRANDT, V. H., VAN DER BEEK, A. J., TWISK, J. W. & VAN MECHELEN, W. 2003. Effect of individual counseling on physical activity fitness and health: a randomized controlled trial in a workplace setting. *Am J Prev Med,* 24**,** 218-26.

PURATH, J., MILLER, A. M., MCCABE, G. & WILBUR, J. 2004. A brief intervention to increase physical activity in sedentary working women. *Can J Nurs Res,* 36**,** 76-91.

RAYNOR, H. A., STEEVES, E. A., BASSETT, D. R., JR., THOMPSON, D. L., GORIN, A. A. & BOND, D. S. 2013. Reducing TV watching during adult obesity treatment: two pilot randomized controlled trials. *Behav Ther,* 44**,** 674-85.

REIJONSAARI, K., VEHTARI, A., KAHILAKOSKI, O. P., VAN MECHELEN, W., ARO, T. & TAIMELA, S. 2012. The effectiveness of physical activity monitoring and distance counseling in an occupational setting - results from a randomized controlled trial (CoAct). *BMC Public Health,* 12**,** 344.

ROCKETTE-WAGNER, B., EDELSTEIN, S., VENDITTI, E. M., REDDY, D., BRAY, G. A., CARRION-PETERSEN, M. L., DABELEA, D., DELAHANTY, L. M., FLOREZ, H., FRANKS, P. W., MONTEZ, M. G., RUBIN, R., KRISKA, A. M. & DIABETES PREVENTION PROGRAM RESEARCH, G. 2015. The impact of lifestyle intervention on sedentary time in individuals at high risk of diabetes. *Diabetologia,* 58**,** 1198-202.

ROWLAND, S. A., BERG, K. E., KUPZYK, K. A., PULLEN, C. H., COHEN, M. Z., SCHULZ, P. S. & YATES, B. C. 2018. Feasibility and Effect of a Peer Modeling Workplace Physical Activity Intervention for Women. *Workplace Health Saf,* 66**,** 428-436.

SIEGEL, J. M., PRELIP, M. L., ERAUSQUIN, J. T. & KIM, S. A. 2010. A worksite obesity intervention: results from a group-randomized trial. *Am J Public Health,* 100**,** 327-33.

SLOOTMAKER, S. M., CHINAPAW, M. J., SCHUIT, A. J., SEIDELL, J. C. & VAN MECHELEN, W. 2009. Feasibility and effectiveness of online physical activity advice based on a personal activity monitor: randomized controlled trial. *J Med Internet Res,* 11**,** e27.

SORENSEN, G., BARBEAU, E., STODDARD, A. M., HUNT, M. K., KAPHINGST, K. & WALLACE, L. 2005. Promoting behavior change among working-class, multiethnic workers: results of the healthy directions--small business study. *Am J Public Health,* 95**,** 1389-95.

SPITTAELS, H., DE BOURDEAUDHUIJ, I., BRUG, J. & VANDELANOTTE, C. 2007. Effectiveness of an online computer-tailored physical activity intervention in a real-life setting. *Health Educ Res,* 22**,** 385-96.

SPRING, B., SCHNEIDER, K., MCFADDEN, H. G., VAUGHN, J., KOZAK, A. T., SMITH, M., MOLLER, A. C., EPSTEIN, L. H., DEMOTT, A., HEDEKER, D., SIDDIQUE, J. & LLOYD-JONES, D. M. 2012. Multiple behavior changes in diet and activity: a randomized controlled trial using mobile technology. *Arch Intern Med,* 172**,** 789-96.

STEEVES, J. A., BASSETT, D. R., FITZHUGH, E. C., RAYNOR, H. A. & THOMPSON, D. L. 2012. Can sedentary behavior be made more active? A randomized pilot study of TV commercial stepping versus walking. *Int J Behav Nutr Phys Act,* 9**,** 95.

STERNFELD, B., BLOCK, C., QUESENBERRY, C. P., JR., BLOCK, T. J., HUSSON, G., NORRIS, J. C., NELSON, M. & BLOCK, G. 2009. Improving diet and physical activity with ALIVE: a worksite randomized trial. *Am J Prev Med,* 36**,** 475-83.

THORNDIKE, A. N., MILLS, S., SONNENBERG, L., PALAKSHAPPA, D., GAO, T., PAU, C. T. & REGAN, S. 2014. Activity monitor intervention to promote physical activity of physicians-in-training: randomized controlled trial. *PLoS One,* 9**,** e100251.

TOMAYKO, E. J., PRINCE, R. J., CRONIN, K. A. & ADAMS, A. K. 2017. The Healthy Children, Strong Families intervention promotes improvements in nutrition, activity, and body weight in American Indian families with young children - ERRATUM. *Public Health Nutr,* 20**,** 380.

VAN WIER, M. F., ARIENS, G. A., DEKKERS, J. C., HENDRIKSEN, I. J., SMID, T. & VAN MECHELEN, W. 2009. Phone and e-mail counselling are effective for weight management in an overweight working population: a randomized controlled trial. *BMC Public Health,* 9**,** 6.

VERWEIJ, L. M., PROPER, K. I., WEEL, A. N., HULSHOF, C. T. & VAN MECHELEN, W. 2012. The application of an occupational health guideline reduces sedentary behaviour and increases fruit intake at work: results from an RCT. *Occup Environ Med,* 69**,** 500-7.
VON THIELE SCHWARZ, U., LINDFORS, P. & LUNDBERG, U. 2008. Health-related effects of worksite interventions involving physical exercise and reduced workhours. *Scand J Work Environ Health,* 34**,** 179-88.

MAKE YOUR DAY ACTIVE

for health and fun

24 strategies to move more and sit less at work, in transport, at home, and in leisure time

Prepared by:
Nipun Shrestha, Alexandra Parker, Stuart Biddle, Danijel Jurakic, and Zeljko Pedisic

VICTORIA UNIVERSITY
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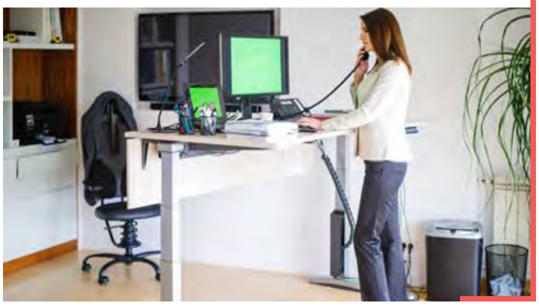
AT WORK

TAKE SHORT BREAKS FROM SITTING

It is recommended to take a short break from sitting at least every half an hour. Set the printer, bin, and other facilities away from your work station. Use a smaller cup or water bottle so that you will need to go for a refill more often.

USE A SIT-STAND DESK

Did you know that by using sit-stand desks, office workers reduce their sitting time on average by 100 minutes per workday? Handy guidelines for using sit-stand workstations can be found **here**. You can purchase a foldable cardboard standing desk for as little as $30. Consider trying how it works for you before buying a more fancy (and expensive) height-adjustable sit-stand desk!



STRETCH

Prolonged periods of sitting may cause muscle fatigue. Taking stretching breaks relieves muscle fatigue and makes you feel refreshed. Set an alarm to stretch every hour, take a few moments once you're back from lunch, or stretch in the hallway after a bathroom break. Check out these resources for easy ways to relieve muscle fatigue (**1**, **2**, **3**)

GET UP TO TALK TO YOUR COLLEAGUES

Getting up and talking to your colleagues instead of emailing them is another option to stand up more often. You might even find it's nicer and more efficient to talk in person!

USE COMPUTER REMINDERS TO STAND UP

The human body isn't made to sit in one position for endless hours, gripping a mouse or typing on the keyboard. Several apps are available that gently remind you to take a break on a regular basis. Some of them can be found here (**for Windows**/**for Macbook**). You can set how long each kind of break lasts and the length of the period between the breaks.

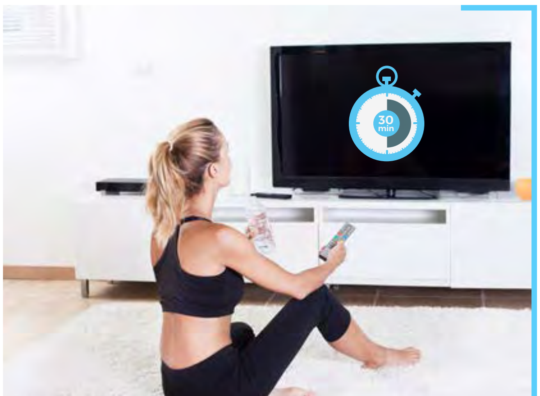
SCHEDULE WALKING MEETINGS

If the weather is nice, think about scheduling some outdoor walking meetings with your colleagues. Not only will this give you the opportunity to get some fresh air, but you'll be able to stretch your legs, help boost your circulation, and beat the afternoon slump. If the weather is not that nice, maybe you can meet while wondering around your office building. Handy guidelines for conducting a walking meeting (not including the guidance for discovering hidden routes) can be found **here**.

ORGANISE A GROUP EXERCISE SESSION

Want to do some good for your colleagues? Organise an exercise session once in a while and invite your office buddies to participate. Team building through exercise, why not?!

AT HOME



SET A SLEEP TIMER ON YOUR TV

Set the TV to turn off automatically after 30 minutes, as a reminder to take regular activity breaks. You can keep on watching TV while stretching or resume watching after the active break.

TAKE EVERY OPPORTUNITY TO MOVE

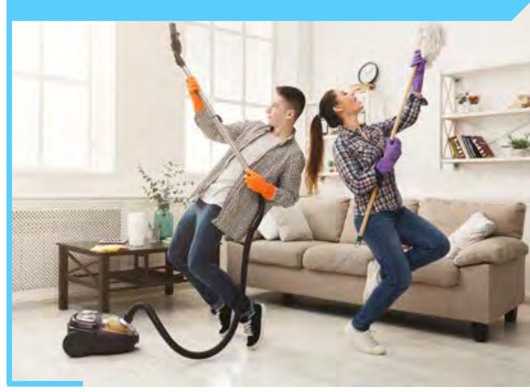
For example, while talking on your mobile phone, head outside for a short walk. Also, when possible, avoid online shopping and grocery delivery. Walking while shopping is a healthy physical activity.

MAKE YOUR TV TIME MORE ACTIVE

Exercise while watching a TV show or a movie (e.g. ride a stationary bike, use a home stepper, lift weights or do stretching exercises between episodes or during commercial breaks). A word of warning: make sure you have enough space so you don't break your TV screen!

TURN YOUR HOUSEWORK INTO A FUN PHYSICAL ACTIVITY

Dance to your favorite music while vacuuming, wiping floors, and hanging clothes. Make housework a competition and race against your housemates or family members. Try squatting instead of bending when reaching low to clean or pick things up off the floor. You could even wear wrist weights while dusting!



IN TRANSPORT

USE STAIRS INSTEAD OF LIFTS AND ESCALATORS

If you feel fit enough, try climbing the stairs briskly. Short bouts of vigorous physical activity have a number of proven health benefits.

CYCLE TO WORK

If the travel distance to work is too long, try combining cycling with public transport. If you are not allowed to board with your bike on a train, consider buying a foldable bike. When folded they are small enough to be carried nearly anywhere. Electrically-assisted bicycles are another option to easily cover longer distances. Research shows that electrically-assisted cycling can help you maintain or improve your physical fitness.

INCREASE WALKING

Get off the public transport 1-2 stops earlier, park the car further away from your workplace, or walk a part of the journey before you hop on the bus or train.

IN LEISURE

EXERCISE BY FOLLOWING WORKOUT VIDEOS

You can start by exercising 10 minutes a day. Perform an exercise like sit-ups or squats for 30 seconds at a moderate pace and then rest for 30 seconds. Slowly, day by day, start increasing the number of times you repeat each exercise, the time you spend doing it, and the number of different exercises, while decreasing the time spent resting between the sets. Some workout videos that may help you start with this can be found here (**1**, **2**, **3**)

TRY NEW PHYSICAL ACTIVITIES

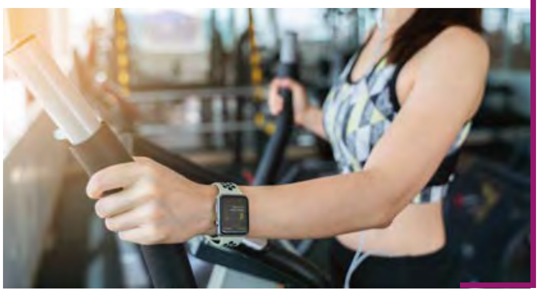
Explore the options! In the next month, try at least one new activity that you've never done before. You might get surprised how fun and engaging some physical activities are.

USE PHYSICAL ACTIVITY AS A REWARD

Many physical activities can be enjoyable and used to reward yourself. For example, if you enjoy jogging, after a long or stressful day at work, go for a quiet evening run.

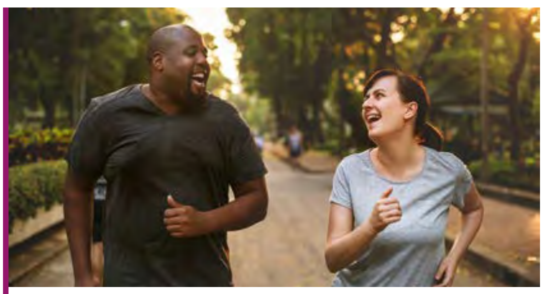
KEEP TRACK OF YOUR ACTIVITY

Use a pedometer or a mobile phone app to keep track of your activity. A good quality pedometer can be purchased for less than $20. Several mobile phone aps that can help you track your activity can be downloaded for free. Some examples can be found here (**Android**/**Iphone**).



FIND PLACES FOR PHYSICAL ACTIVITY IN YOUR AREA

Map local opportunities for exercise, physical activity, and active leisure. This may include parks, swimming pools, gyms, walking/running/cycling trails, and sports clubs. Try out these few handy resources to explore the local opportunities: **Park**/ **Trail**/**Other routes**

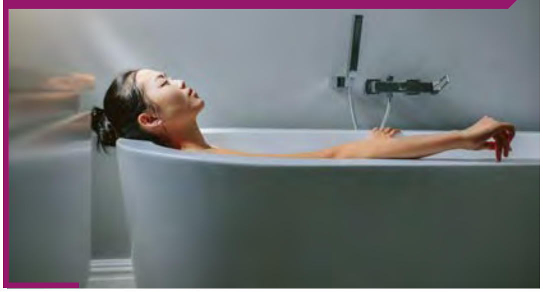


FIND AN "EXERCISE BUDDY"

Encouragement from your significant others may play a vital role in keeping you motivated to engage in regular exercise. Suggest to a family member, a friend, or a college to help each other meet your exercise goals. You will all benefit from supporting one another.

REWARD YOURSELF FOR BEING ACTIVE

Reward yourself when you reach your daily or weekly physical activity goal. You could do that by treating yourself to a massage, a facial, spa, or a bubble bath. Or maybe cook your favourite meal, read a book, or have fun playing an old board game.



USE FITNESS APPS

Install a fitness app on your mobile phone to guide your exercise sessions. There are several workout and exercise-focused apps available for iPhone and Android covering a wide range of activities: cardio, circuit training, strength, yoga, running and more. Find out more about apps **here**.

SET A FAMILY FITNESS CHALLENGE

Setting up a simple and fun family fitness challenge is the perfect way to get everyone in the household motivated to do something good for their health. Aim for a total steps or energy expenditure goal during the challenge and track your pace to reach your target goal by the last day. Slacking on one day? No problem, just pick up the pace the next day! As long as the sum of your steps or the total energy expenditure for the challenge meets the target goal, you've succeeded. Handy guidelines for creating fitness challenges can be found **here**. You can also set up the steps challenge **here**. Guidelines on recommended number of steps for different age groups can be found **here**.

JOIN AN EXERCISE GROUP

Join a walking, cycling, running, or some other dedicated exercise group. Group exercise can be a fun social experience and an opportunity to meet new people. Here are a few useful resources for walking/cycling groups: **walking groups**/**bicycle networks**.

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Shrestha N, Kukkonen-Harjula KT, Verbeek JH, Ijaz S, Hermans V, Pedisic Z. Workplace interventions for reducing sitting at work. Cochrane Database of Systematic Reviews 2018, Issue 12. Art. No.: CD010912. DOI: 10.1002/14651858.CD010912.pub5.

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TABLE OF CONTENTS

[Intervention Review]

Workplace interventions for reducing sitting at work

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ABSTRACT

Background

A large number of people are employed in sedentary occupations. Physical inactivity and excessive sitting at workplaces have been linked to increased risk of cardiovascular disease, obesity, and all-cause mortality.

Objectives

To evaluate the effectiveness of workplace interventions to reduce sitting at work compared to no intervention or alternative interventions.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Embase, CINAHL, OSH UPDATE, PsycINFO, ClinicalTrials.gov, and the World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) search portal up to 9 August 2017. We also screened reference lists of articles and contacted authors to find more studies.

Selection criteria

We included randomised controlled trials (RCTs), cross-over RCTs, cluster-randomised controlled trials (cluster-RCTs), and quasi-RCTs of interventions to reduce sitting at work. For changes of workplace arrangements, we also included controlled before-and-after studies. The primary outcome was time spent sitting at work per day, either self-reported or measured using devices such as an accelerometer-inclinometer and duration and number of sitting bouts lasting 30 minutes or more. We considered energy expenditure, total time spent sitting (including sitting at and outside work), time spent standing at work, work productivity and adverse events as secondary outcomes.

Data collection and analysis

Two review authors independently screened titles, abstracts and full-text articles for study eligibility. Two review authors independently extracted data and assessed risk of bias. We contacted authors for additional data where required.

Main results

We found 34 studies — including two cross-over RCTs, 17 RCTs, seven cluster-RCTs, and eight controlled before-and-after studies — with a total of 3,397 participants, all from high-income countries. The studies evaluated physical workplace changes (16 studies), workplace policy changes (four studies), information and counselling (11 studies), and multi-component interventions (four studies). One study included

both physical workplace changes and information and counselling components. We did not find any studies that specifically investigated the effects of standing meetings or walking meetings on sitting time.

Physical workplace changes

Interventions using sit-stand desks, either alone or in combination with information and counselling, reduced sitting time at work on average by 100 minutes per workday at short-term follow-up (up to three months) compared to sit-desks (95% confidence interval (CI) −116 to −84, 10 studies, low-quality evidence). The pooled effect of two studies showed sit-stand desks reduced sitting time at medium-term follow-up (3 to 12 months) by an average of 57 minutes per day (95% CI −99 to −15) compared to sit-desks. Total sitting time (including sitting at and outside work) also decreased with sit-stand desks compared to sit-desks (mean difference (MD) −82 minutes/day, 95% CI −124 to −39, two studies) as did the duration of sitting bouts lasting 30 minutes or more (MD −53 minutes/day, 95% CI −79 to −26, two studies, very low-quality evidence).

We found no significant difference between the effects of standing desks and sit-stand desks on reducing sitting at work. Active workstations, such as treadmill desks or cycling desks, had unclear or inconsistent effects on sitting time.

Workplace policy changes

We found no significant effects for implementing walking strategies on workplace sitting time at short-term (MD −15 minutes per day, 95% CI −50 to 19, low-quality evidence, one study) and medium-term (MD −17 minutes/day, 95% CI −61 to 28, one study) follow-up. Short breaks (one to two minutes every half hour) reduced time spent sitting at work on average by 40 minutes per day (95% CI −66 to −15, one study, low-quality evidence) compared to long breaks (two 15-minute breaks per workday) at short-term follow-up.

Information and counselling

Providing information, feedback, counselling, or all of these resulted in no significant change in time spent sitting at work at short-term follow-up (MD −19 minutes per day, 95% CI −57 to 19, two studies, low-quality evidence). However, the reduction was significant at medium-term follow-up (MD −28 minutes per day, 95% CI −51 to −5, two studies, low-quality evidence).

Computer prompts combined with information resulted in no significant change in sitting time at work at short-term follow-up (MD −14 minutes per day, 95% CI −39 to 10, three studies, low-quality evidence), but at medium-term follow-up they produced a significant reduction (MD −55 minutes per day, 95% CI −96 to −14, one study). Furthermore, computer prompting resulted in a significant decrease in the average number (MD −1.1, 95% CI −1.9 to −0.3, one study) and duration (MD -74 minutes per day, 95% CI −124 to −24, one study) of sitting bouts lasting 30 minutes or more.

Computer prompts with instruction to stand reduced sitting at work on average by 14 minutes per day (95% CI 10 to 19, one study) more than computer prompts with instruction to walk at least 100 steps at short-term follow-up.

We found no significant reduction in workplace sitting time at medium-term follow-up following mindfulness training (MD −23 minutes per day, 95% CI −63 to 17, one study, low-quality evidence). Similarly a single study reported no change in sitting time at work following provision of highly personalised or contextualised information and less personalised or contextualised information. One study found no significant effects of activity trackers on sitting time at work.

Multi-component interventions

Combining multiple interventions had significant but heterogeneous effects on sitting time at work (573 participants, three studies, very low-quality evidence) and on time spent in prolonged sitting bouts (two studies, very low-quality evidence) at short-term follow-up.

Authors' conclusions

At present there is low-quality evidence that the use of sit-stand desks reduce workplace sitting at short-term and medium-term follow-ups. However, there is no evidence on their effects on sitting over longer follow-up periods. Effects of other types of interventions, including workplace policy changes, provision of information and counselling, and multi-component interventions, are mostly inconsistent. The quality of evidence is low to very low for most interventions, mainly because of limitations in study protocols and small sample sizes. There is a need for larger cluster-RCTs with longer-term follow-ups to determine the effectiveness of different types of interventions to reduce sitting time at work.

PLAIN LANGUAGE SUMMARY

Workplace interventions (methods) for reducing time spent sitting at work

Why is the amount of time spent sitting at work important?

Time spent sitting and being physically inactive at work has increased in recent decades. Long periods of sitting may increase the risk of obesity, heart disease, and premature death. It is unclear whether interventions that aim to reduce sitting at workplaces are effective.

The purpose of this review

We wanted to find out the effects of interventions aimed at reducing sitting time at work. We searched the literature in various databases up to 9 August 2017.

What trials did the review find?

We found 34 studies conducted with a total of 3,397 employees from high-income countries. Sixteen studies evaluated physical changes in the workplace design and environment, four studies evaluated changes in workplace policies, 10 studies evaluated information and counselling interventions, and four studies evaluated multi-category interventions.

Effect of sit-stand desks

The use of sit-stand desks seems to reduce workplace sitting on average by 84 to 116 minutes per day. When combined with the provision of information and counselling, the use of sit-stand desks seems to result in similar reductions in sitting at work. Sit-stand desks also seem to reduce total sitting time (including sitting at work and outside work) and the duration of workplace sitting bouts that last 30 minutes or longer. One study compared standing desks and sit-stand desks but due to the small number of employees included, it does not provide enough evidence to determine which type of desk is more effective at reducing sitting time.

Effect of active workstations

Treadmill desks combined with counselling seem to reduce sitting time at work, while the available evidence is insufficient to conclude whether cycling desks combined with the provision of information reduce sitting at work more than the provision of information alone.

Effect of walking during breaks or length of breaks

The available evidence is insufficient to draw conclusions about the effectiveness of walking during breaks in reducing sitting time. Taking short breaks (one to two minutes every half hour) seems to reduce time spent sitting at work by 15 to 66 minutes per day more than taking long breaks (two 15-minute breaks per workday).

Effect of information and counselling

Providing information, feedback, counselling, or all of these reduces sitting time at medium-term follow-up (3 to 12 months after the intervention) on average by 5 to 51 minutes per day. The available evidence is insufficient to draw conclusions about the effects at short-term follow-up (up to three months after the intervention). The use of computer prompts combined with providing information reduces sitting time in the medium-term on average by 14 to 96 minutes per day. The available evidence is insufficient to draw conclusions about the effects in the short-term.

One study found that prompts to stand reduce sitting time more than prompts to step, on average by 10 to 19 minutes per day.

The available evidence is insufficient to conclude whether providing highly personalised or contextualised information is more or less effective than providing less personalised or contextualised information in reducing siting time at work. The available evidence is also insufficient to draw conclusions about the effect of mindfulness training and the use of activity trackers on sitting at work.

Effect of combining multiple interventions

Combining multiple interventions seems to be effective in reducing sitting time and time spent in prolonged sitting bouts in the short-term and the medium-term. However, this evidence comes from only a small number of studies and the effects were very different across the studies.

Conclusions

The quality of evidence is low to very low for most interventions, mainly because of limitations in study protocols and small sample sizes. At present there is low-quality evidence that sit-stand desks may reduce sitting at work in the first year of their use. However, the effects are likely to reduce with time. There is generally insufficient evidence to draw conclusions about such effects for other types of interventions and for the effectiveness of reducing workplace sitting over periods longer than one year. More research is needed to assess the effectiveness of different types of interventions for reducing sitting at workplaces, particularly over longer periods.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Alternative desks and workstations compared to sit-desks for reducing sitting at work

Alternative desks and workstations compared to sit-desks for reducing sitting at work

Patient or population: employees who sit at work
Setting: workplace
Intervention: alternative desks and workstations
Comparison: sit-desks

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with sit-desk	Risk with changes in desk			
Comparison: sit-stand desk with or without information and counselling versus sit-desk					
Mean difference in time spent sitting at work, short-term follow-up (up to 3 months)	The mean difference in time spent sitting at work (short-term follow-up) was 364 minutes	MD 100 minutes lower (116 lower to 84 lower)	323 (10 studies: 4 RCTs, 2 cross-over RCTs, 4 CBAs)	⊕⊕⊝⊝ LOW [1,2]	Subgroup analysis showed no difference in effect between sit-stand desks used alone or in combination with information and counselling. Restricting the analysis to RCTs only did not show any difference in effect either.
Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up	The mean difference in time in sitting bouts lasting 30 minutes or more (short-term follow-up) was 167 minutes	MD 53 minutes lower (79 lower to 26 lower)	74 (2 CBAs)	⊕⊝⊝⊝ VERY LOW [2,3]	
Comparison: treadmill desk combined with counselling versus sit-desk					
Mean difference in time spent sitting at work, short-term follow-up (up to 3 months)	The mean difference in time spent sitting at work (short-term follow-up) was 342 minutes	MD 29 minutes lower (55 lower to 2 lower)	31 (1 RCT)	⊕⊕⊝⊝ LOW [2,4]	
Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up — not reported	-	-	-	-	

Comparison: cycling desk + information and counselling versus sit-desk + information and counselling					
Mean difference in time spent in inactive sitting at work, medium-term follow-up (from 3 to 12 months)	The mean difference in time spent in inactive sitting at work (medium-term follow-up) was 413 minutes	MD 12 minutes lower (24 lower to 1 higher)	54 (1 RCT)	⊕⊕⊝⊝ LOW [2, 5]	
*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval; **RR:** Risk ratio; **OR:** Odds ratio; **RCT:** randomised controlled trial **CBA:** controlled before-and-after study; **MD:** mean difference					
GRADE Working Group grades of evidence **High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect **Moderate certainty:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low certainty:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect **Very low certainty:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect					

[1] Of the six RCTs, five were at high risk of bias. The non-randomised controlled before-and-after study/studies were also at high risk of bias; downgraded one level
[2] Imprecision with wide confidence intervals, small sample size; downgraded one level
[3] Unconcealed allocation, unblinded outcome assessment and attrition bias; downgraded two levels
[4] Unblinded outcome assessment; downgraded one level
[5] Unblinded outcome assessment and attrition bias; downgraded one level

Summary of findings 2. Workplace policy changes compared to no intervention or alternate intervention for reducing sitting at work

Workplace policy changes compared to no intervention for reducing sitting at work

Patient or population: employees who sit at work
Setting: workplace
Intervention: policy changes
Comparison: no intervention

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no intervention	Risk with Policy changes			
Comparision: walking strategies versus no intervention					
Mean difference in time spent sitting at work, short-term follow-up	The mean difference in time spent sitting at work (short-term follow-up) was 344 minutes	MD 15 minutes lower (50 lower to 19 higher)	179 (1 RCT)	⊕⊕⊝⊝ LOW [1, 2]	

Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up — not reported	-	-	-	-	
Comparision: short break versus long break					
Mean difference in time spent sitting at work, short-term follow-up	The mean difference in time spent sitting at work (short term follow-up) was 131 minutes	MD 40 minutes lower (66 lower to 15 lower)	49 (1 RCT)	⊕⊕⊝⊝ LOW [2] [3]	
Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up — not reported	-	-	-	-	

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **RR:** Risk ratio; **OR:** Odds ratio; **RCT:** randomised controlled trial; **MD:** mean difference

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] Risk of bias high due to unblinded outcome assessment and lack of allocation concealment; downgraded with one level
[2] Imprecision with wide confidence intervals; downgraded with one level
[3] Unconcealed allocation and attrition bias

Summary of findings 3. Information, feedback, and/or counselling compared to information only or no intervention for reducing sitting at work

Information and counselling compared to information only or no intervention for reducing sitting at work

Patient or population: employees who sit at work
Setting: workplace
Intervention: information and counselling
Comparison: information only or no intervention

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with information only or no intervention	Risk with Information and counselling			

Information, feedback and counselling versus no intervention				
Mean difference in time spent sitting at work, short-term follow-up — information and feedback versus no intervention	The mean difference in time spent sitting at work (short-term follow-up) was 550 minutes	MD 19 minutes lower (57 lower to 19 higher)	63 (2 RCTs)	⊕⊕⊝⊝ LOW[1,2]
Mean difference in time spent sitting at work, medium-term follow-up — counselling versus no intervention	The mean difference in time spent sitting at work (medium-term follow-up) was 462 minutes	MD 28 minutes lower (51 lower to 5 lower)	747 (2 RCTs)	⊕⊕⊝⊝ LOW[1,3]
Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up - not reported	-	-	-	-
Prompts combined with information versus information alone				
Mean difference in time spent sitting at work, short-term follow-up	The mean difference in time spent sitting at work (short-term follow-up) was 350 minutes	MD 14 minutes lower (39 lower to 10 higher)	103 (3 RCTs)	⊕⊕⊝⊝ LOW[1,2]
Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up	The mean difference in time in sitting bouts lasting 30 minutes or more (short-term follow-up) was 286 minutes	MD 74 minutes lower (124 lower to 24 lower)	28 (1 RCT)	⊕⊕⊝⊝ LOW[1,4]
Mindfulness training versus no intervention				
Mean difference in time spent sitting at work, medium-term follow-up	The mean difference in time spent sitting at work (medium-term follow-up) was 316 minutes	MD 23 minutes lower (63 lower to 17 higher)	257 (1 RCT)	⊕⊕⊝⊝ LOW[1,6]
Mean difference in time in sitting bouts lasting 30 minutes or more, medium-term follow-up — not reported	-	-	-	-

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: Confidence interval; **RR:** Risk ratio; **OR:** Odds ratio; **RCT:** randomised controlled trial; **MD:** mean difference

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] Imprecision with wide confidence intervals, small sample size; downgraded with one level
[2] Unblinded outcome assessment and attrition bas
[3] Risk of bias, allocation not concealed, lack of blinding, high attrition rate; downgraded with one level
[4] Lack of blinding of participants and selective reporting
[5] Lack of blinding of participants and attrition bias
[6] Risk of bias high due to unconcealed allocation and unblinded outcome assessment; downgraded with one level
[7] Lack of blinding of participants

Summary of findings 4. Multi-component intervention compared to no intervention for reducing sitting at work

Multi-component intervention compared to no intervention for reducing sitting at work

Patient or population: employees who sit at work
Setting: workplace
Intervention: multi-component intervention
Comparison: no intervention

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with no intervention	Risk with Multi-component intervention			
Mean difference in time spent sitting at work, short-term follow-up	See comment	see comment	573 (3 RCTs)	⊕⊝⊝⊝ VERY LOW [1,2,3]	Not pooled
Mean difference in time in sitting bouts lasting 30 minutes or more, short-term follow-up	See comment	See comment	518 (2 RCTs)	⊕⊝⊝⊝ VERY LOW [1,2,3]	Not pooled

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **RR:** Risk ratio; **OR:** Odds ratio; **RCT:** randomised controlled trial

GRADE Working Group grades of evidence
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

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[1] Unconcealed allocation and unblinded outcome assessment
[2] Imprecision with wide confidence interval, small sample size
[3] Not pooled due to high heterogeneity
[3] Small sample size

BACKGROUND

Description of the condition

Sedentary behaviour, especially sitting, has attracted great interest from media, government agencies and researchers in recent years. Energy expenditure in various tasks can be expressed in metabolic equivalents (METs). One MET is equivalent to resting energy expenditure, i.e. the energy cost of resting quietly, defined as an oxygen uptake of 3.5 mL kg^{-1} min^{-1}(Ainsworth 2000). Sitting at work and conducting work tasks whilst seated usually involves energy expenditure of 1.5 METs or less. Reduction in time spent sitting usually results in increased levels of physical activity of light to moderate intensity, such as standing or walking (Mansoubi 2014).

The nature of office work has changed since the year 2000 in such a way that workers do not have to move often from their work stations (VicHealth 2012). Advancement in technology (e.g. robotics, computers) has led to a decrease in physical strain at workplaces (Craig 2002). Consequently, workers in some settings have become less physically active at their workplace compared to their leisure time (Franklin 2011; McCrady 2009; Parry 2013; Thorp 2012; van Uffelen 2010). Since the 1960s, in the USA and the UK for example, population levels of occupational physical activity have declined by more than 30% (Ng 2012). A large decline in occupational physical activity has been also found in low- and middle-income countries, such as Brazil and China (Ng 2012). This decline in occupational physical activity can largely be attributed to an increase in time spent sitting at the workplace. It has been found that office-based employees spent 66% of their total working time sitting, with 5% of all sitting events and 25% of total sitting time spent in bouts longer than 55 minutes (Ryan 2011).

Studies have shown that excessive time spent sitting at work may increase the risk of cardiovascular disease, obesity, diabetes, and all-cause mortality, even if one is engaged in recommended levels of physical activity during their leisure time (Chau 2014a; Craft 2012; Dunstan 2011). Estimates show a 5% increase in the risk of obesity and 7% increase in the risk of diabetes associated with every two-hour per day increase in sitting time at work (Hu 2003). It has also been estimated that those who sit for eight to 11 hours per day are at a 15% increased risk of death in the next three years than those who sit for less than four hours per day, whilst the risk increases to 40% for those who sit for more than 11 hours per day (Van der Ploeg 2012). In Bey 2003, it is hypothesised that replacing sitting with physical activity of light (from 1.5 METs to 3 METs) to moderate (3 METs to 6 METs; Ainsworth 2011) intensity improves glucose and lipid metabolism. Another study, Duvivier 2013, has also suggested that benefits may be greater when sitting is replaced with activity of light to moderate intensity, such as standing and walking, than when it is replaced with vigorous cycling of equal energy expenditure. This may indicate that, in interventions to reduce sedentary behaviour, changing posture may be equally or even more important than increasing energy expenditure.

Description of the intervention

It is estimated that 60% of the world's population is part of the workforce and spends on average 60% of their waking hours at work (WHO/WEF 2008). Thus, it is possible to influence health behaviour of a large proportion of the adult population worldwide through workplace interventions.

Workplaces have the advantage of having the potential for creating in-built social support, that is, active collaboration of employees in making sustainable changes to attain a healthy lifestyle, which may reduce the degree of individual effort and motivation needed to make behavioural changes. Therefore, the changes in lifestyle achieved at work are thought to be sustainable in the long term (Plotnikoff 2012).

Workers can be encouraged to be more physically active through changes in the workplace environment and design. A conventional sitting desk can be replaced or supplemented with: a sit-stand desk; a so-called 'hot desk' that is height-adjustable and allows its user to alternate posture between sitting and standing (Alkhajah 2012; Gilson ND 2012; Straker 2013); a vertical workstation that allows the use of a personal computer while walking on a treadmill at a self-selected velocity (Levine 2007); a stepping/pedalling desk exercise machine placed under the desk that allows the user to step or pedal while being seated (McAlpine 2007); an inflated balloon chair; or a therapy ball (Beers 2008; USPTO 2000). Replacing conventional office chairs with inflated balloon chairs makes the act of sitting more physically demanding by increasing the need to use the abdominal, back, leg and thigh muscles to remain upright and maintain balance.

Time spent in sedentary behaviour can theoretically also be reduced by changing the layout of workplaces, for example by placing printers further away from desks. Office work can also be made more physically demanding by forming walking or other exercise groups like dance or gym groups during work time (Ogilvie 2007; Thogersen-Ntoumani 2013), and by encouraging employees to walk around office buildings during breaks or to take a walk to communicate with fellow employees instead of using the telephone or email. The practices and policies of workplaces can be changed by incorporating periodic breaks within the organisational schedule including short bouts of physical activity (e.g. five to 15-minute activity bouts) or by conducting walking or standing meetings (Commissaris 2007). Meeting rooms can be equipped with sit-stand desks so that employees can choose to stand during meetings, if they wish (Atkinson 2014). These changes in workplace practice and policy have the potential of providing an opportunity to a large number of people, who mostly sit at work, to reduce their sitting time.

Workers can also be made aware of the importance of changing their sitting behaviour by the provision of information, such as by motivational prompts to sit less at the workstation, via e-health interventions that encourage and remind workers to sit less or interrupt prolonged periods of sitting (Cooley 2014; Evans 2012; Pedersen 2013), or by distributing leaflets with messages like "Sit less, move more" that highlight the risks associated with sitting. An e-health intervention consists of information that is delivered electronically like emails, point-of-choice prompts, or any message periodically displayed on the computer screen. Informational interventions can also be delivered by trained counsellors in an interactive manner, where, as part of counselling sessions, they find out about worker's interests and provide the worker different options on how to reduce sedentary behaviour (Opdenacker 2008).

There are some potential drawbacks to these interventions. The performance and productivity of workers at sitting jobs might be decreased when walking at the workplace is encouraged and the employees more frequently leave their desks. Workers using a treadmill desk need to be careful not to trip or fall, and thus divide their attention between work and safety, which might compromise their productivity (Tudor-Locke 2013). In addition, fine motor skills like mouse handling accuracy, math problem solving skills, and perceived work performance seem to decrease with treadmill and cycling desks (Commissaris 2014; John 2009). This decrease in efficiency might be due to learning effects, that is, becoming acquainted with new modes of work.

How the intervention might work

According to ecological models, successful strategies for reducing sedentary behaviour include:

- providing access to infrastructures for reducing sedentary behaviour;
- increasing awareness and understanding of the importance of and methods for reducing sedentary behaviour; or
- using social networks and organisational support to inform and encourage changes in policies and norms related to sedentary behaviour (Sallis 2006).

Based on this definition, we envisage three different ways (in isolation or conjunction with each other) in which interventions could work to decrease sitting at workplaces.

Physical changes in the workplace design and environment

If employees are using a conventional desk or chair in the workplace, provision of new types of work desks or chairs can make them aware of the possibilities such new equipment offers to decrease sitting, and they may be tempted to try them. This would hypothetically replace sitting with some other activity, while allowing the usual tasks to be carried out with the same efficiency. Changing the layout of the workplace by, for example, placing printers away from desks would force employees to stand up and walk to obtain their printouts.

Policies to change the organisation of work

Organisational policies could support the formation of walking or exercise groups at the workplace or conducting walking meetings. Formation of walking or exercise groups or conducting walking meetings, might help individuals to reduce sitting and might also help them encourage each other to adapt new behaviours. The provision of purposive short breaks (with the aim of reducing sitting) might help workers engage in such activities more frequently. The breaks might also encourage employees to take a walk to communicate with colleagues instead of using the telephone or email. Standing meeting rooms would provide an opportunity for office employees to reduce their sitting time.

Provision of information and counselling

Sedentary workers could be made aware of the importance of reducing their time spent in sedentary behaviour. They could be informed about health risks and the benefits of reducing time spent sitting and replacing it with time spent in a more physically demanding behaviour. In Wilks 2006, it was found that employees who had received information regarding the health risks of sitting were more likely to use a sit-stand desk more frequently than those who had not. Even if people are aware of the adverse effects of excessive sitting, and have access to facilities and programs to decrease sitting, they might still find difficulties in adapting to new behaviour. It requires conscious effort for a person to interrupt their normal sitting behaviour and engage in physical activity while at work. To facilitate behaviour change, people could be provided with point-of-choice prompts or counselling, which might enable individuals to evaluate their behavioural choices and motivate them to adopt healthy ones. Points-of-choice prompts can be delivered through various means such as signs, emails, text messages, or telephone calls, to motivate change of behaviour. A prompting software can be installed on an employee's personal computer, so that a one-minute reminder to take a break appears on their screen every 30 minutes (Evans 2012).

Why it is important to do this review

Interventions to decrease sitting at work are becoming increasingly popular, but it is unclear whether they are effective in the long term or not (Healy 2013). Therefore, there is a need to evaluate whether sitting at work can be reduced by interventions, and to compare the effectiveness of various types of such interventions.

Although some studies have shown that sit-stand desks and walking strategies have been useful in reducing sitting, no significant difference in the duration of individual bouts of sitting was found in Straker 2013. Another study did not find a significant effect of strategies to increase walking on sitting behaviour (Gilson 2009), while in Evans 2012, it was found that point-of-choice prompting software along with education was superior to education alone. Such inconsistency in the findings from individual studies means it is unclear whether workplace interventions for reducing sitting are effective, and whether different types of interventions differ in their effectiveness.

Possibly because of the variation in results across studies, recommendations for reducing sitting at work vary. In recent years, several countries, such as the UK and Australia (Australian Government 2014; Department of Health 2011), have incorporated sedentary behaviour recommendations as part of their physical activity guidelines. These guidelines, however, only propose potential strategies for reducing sitting time without quantifying the recommended total duration of sitting time. In 2015, an international group of experts recommended that desk-based employees should aim towards accumulating two hours of standing and light activity (light walking) per day during working hours, eventually progressing to a total accumulation of four hours per day. To achieve this, they recommended breaking up sitting time with standing by using sit–stand desks or by taking short active standing breaks (Buckley 2015). While all these guidelines stress the evidence of the adverse effects of sitting on health, there is little evidence that different interventions aiming to reduce sitting can help individuals meet any of these recommendations. Furthermore, since this topic is of increasing interest, it is likely that the availability of evidence will increase in the near future. A Cochrane systematic review will ensure timely updating of this information for decision makers.

OBJECTIVES

To evaluate the effectiveness of workplace interventions for reducing sitting at work compared to no intervention or alternative interventions.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials (RCTs), cross-over RCTs, cluster-RCTs, and quasi-RCTs. Quasi-RCTs are trials that allocate participants to the intervention or control group using a method of randomisation that is not actually random. At workplaces, interventions operate at group level and may therefore be difficult to deliver to individuals (Ijaz 2014). Since it is more difficult to randomise units when the intervention is implemented at a higher aggregate level, we also included controlled before-and-after studies (CBAs) that used a concurrent control group for the interventions that aimed to change workplace arrangements.

Types of participants

We included all studies conducted with participants aged 18 years or more, whose occupations involved spending the majority of their working time sitting at a desk, such as administrative workers, customer service operators, help-desk professionals, call-centre representatives, and receptionists.

We excluded studies that addressed transportation work. People working in the transportation industry (such as taxi drivers, truck drivers, bus drivers, and airline pilots) and who operate heavy equipment (such as crane operators and bulldozer operators) are also exposed to prolonged sitting, but current technology provides very limited options for implementing interventions to decrease sitting in such occupations. Reducing sitting in people who work in the transportation industry and operate heavy machinery would require specific interventions that could be the scope of another review.

Types of interventions

Intervention

Physical changes in the workplace design and environment

- Changes in the layout of the workplace, such as placing printers away from office desks.
- Changes in desks enabling more physical activity, such as the use of sit-stand desks, vertical workstations on treadmills, desk cycle/cycling desks, or stepping devices.
- Changes in chairs enabling more physical activity, such as inflated balloon chairs or therapy balls.

Policies to change the organisation of work

- Walking meetings and walking or other exercise groups during work time.
- Breaks (periodic, frequent, or purposive) to sit less, stand up, and take an exercise break.
- Sitting diaries.

Provision of information and counselling

- Signs or prompts at the workplace (e.g. posters) or at the workstation (computer).
- E-health intervention.
- Distribution of leaflets.
- Counselling (face to face, by email, or by telephone).

Multi-component interventions

- Interventions that included elements from all the three above-mentioned categories.

Comparison

We compared the interventions described above with no intervention or with other interventions.

Types of outcome measures

Primary outcomes

We included studies that evaluated sitting at work measured either as:

- self-reported time spent sitting at work by questionnaires; or
- device-based measures of sitting assessed by means of an accelerometer-inclinometer, which assesses intensity of physical activity and body posture (Kanoun 2009; Kim 2015); or
- self-reported or device-based measures of time spent in prolonged sitting bouts (e.g. 30 minutes or more) and number of such bouts.

Secondary outcomes

- Estimated energy expenditure in metabolic equivalent (MET) hours per workday as a proxy measure to detect changes in sitting time.
- Self-reported or device-measured total time spent sitting, including sitting at and outside work.
- Self-reported or device-measured time spent standing and stepping at work.
- Work productivity.
- Adverse events including any reported musculoskeletal symptoms due to prolonged standing as a possible side-effect of using a sit-stand desk.

Search methods for identification of studies

Electronic searches

We searched for all eligible published and unpublished trials in any language. We were prepared to translate non-English language abstracts for potential inclusion. Our search strategy was based on types of study population, types of study design, work-related aspects, and outcomes related to sitting, and it consisted of keywords generated with the help of a thesaurus, such as 'seated posture'.

We searched the following electronic databases from inception to 9 August 2017 for identifying potential studies:

- Cochrane Central Register of Controlled Trials (CENTRAL; Appendix 1);
- MEDLINE (searched through Ovid; Appendix 2);
- Cumulative Index to Nursing & Allied Health Literature (CINAHL; Appendix 3);
- Occupational Safety and Health Database (OSH UPDATE; Appendix 4);
- Excerpta Medica dataBASE (Embase; Appendix 5);
- PsycINFO (searched through Ovid; Appendix 6);
- ClinicalTrials.gov (http://clinicaltrials.gov/; Appendix 7); and

- World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) search portal (http://apps.who.int/trialsearch/; Appendix 8).

Searching other resources

We checked reference lists of all included studies and systematic reviews for additional trials. We contacted experts in the field and authors of included studies to identify additional unpublished or ongoing studies.

Data collection and analysis

Selection of studies

Two review authors (NS, KKH) independently screened titles and abstracts of the documents found in our systematic search, to identify potential studies for inclusion. The same authors marked citations as 'retrieve' (eligible or potentially eligible/unclear) or 'do not retrieve'. We retrieved full-text study reports or publications for all citations considered potentially relevant. Two authors (NS, KKH) independently assessed the retrieved full-texts to identify eligible studies for inclusion. We recorded reasons for exclusion of ineligible studies. We resolved disagreements through discussion or, if required, we consulted a third author (SI). We identified and excluded duplicates and collated multiple reports of the same study so that each study rather than each report was the unit of interest in the review. We recorded the selection process in sufficient detail to create a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram (Moher 2009).

Data extraction and management

We used a data collection template to extract study characteristics and outcome data. We extracted the following information.

- Methods: study location, date of publication, type of study design, study setting.
- Participants: number randomised or recruited, mean age or age range, gender, inclusion and exclusion criteria of the trial, occupation, number of withdrawals, similarity of study groups in age, gender, occupation, and sitting time at baseline.
- Interventions: description of intervention methods and randomised groups, duration of active intervention, duration of follow-up, and description of comparisons, interventions and co-interventions.
- Outcomes: description of primary and secondary outcomes and their assessment methods.
- Notes: source of funding for the trial and potential conflicts of interest of trial authors.

Two review authors (NS and either VH or SI) independently extracted outcome data from the included studies. We noted in the Characteristics of included studies table when trial authors did not report outcome data in a usable way. We resolved disagreements by consensus or by involving a third author (either SI or VH). One review author (NS) transferred data into Cochrane's statistical software, Review Manager 5 (Review Manager 2014). We double-checked that we had entered the data correctly. For this purpose we tabulated extracted information about studies in a spreadsheet before entry into Review Manager. A review author (JV) spot-checked a random 20% of extracted data for accuracy against the trial report.

Assessment of risk of bias in included studies

Two review authors (NS and either VH or SI) independently assessed risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). We resolved disagreements by discussion or by involving another author (ZP). We assessed the included studies' risk of bias according to the following domains.

- Random sequence generation
- Allocation concealment
- Blinding of participants and personnel
- Blinding of outcome assessment
- Incomplete outcome data
- Selective outcome reporting
- Validity of outcome measure
- Baseline comparability/imbalance for age, gender and occupation of study groups

We graded each potential source of bias as high, low, or unclear and provided a quote from the study report together with a justification for our judgment in the 'Risk of bias' tables. We summarised the risk of bias judgements across different studies for each of the domains. Where information on risk of bias related to unpublished data or correspondence with a trialist, we noted it as such in the 'Risk of bias' tables.

We judged studies as being at low risk for selective outcome reporting, if the publications of the trial followed what had been planned and had been registered in international databases (trial registries), such as ClinicalTrials.gov, Australia and New Zealand Clinical Trials Registry (anzctr.org.au/), or Netherlands Trial Registry (trialregister.nl). We judged the studies that were not registered in trial registries as being at low risk for selective outcome reporting if they had reported all the outcomes mentioned in their methods section.

We judged a study to be at low risk of bias overall when the study included a sufficiently detailed description of its random sequence generation, allocation concealment, blinding of outcome assessment, complete outcome data, no selective outcome reporting, and valid outcome measures, that is, all the domains had a low risk of bias. We judged a study to have a high risk of bias when it reported a feature that would be judged as having a high risk of bias in any one of the eight domains. We did not assess blinding of participants or study personnel for risk of bias, as it is very difficult to blind either of them in studies that are trying to modify sedentary behaviour.

Measures of treatment effect

We entered the outcome data for each study into the data tables in Review Manager to calculate the pooled treatment effects. We used risk ratios (RRs) for dichotomous outcomes and mean differences (MDs) for continuous outcomes. Where only effect estimates and their 95% confidence intervals (CIs) or standard errors were reported in studies, we entered these data into Review Manager using the generic inverse variance method.

Unit of analysis issues

For cluster-RCTs that did not present results accounting for clustering effect, we calculated these assuming a large intra-cluster correlation coefficient of 0.10. We based this assumption on a realistic estimate by analogy on studies about implementation research (Campbell 2001). We transformed all measurement units for sitting at work into minutes per eight-hour workday where needed and possible, and assumed the data referred to a five-day work week, if this was not reported.

Dealing with missing data

We contacted researchers or study sponsors to verify key study characteristics and obtain missing information or full-text reports. When we did not find a full study report even after contacting authors listed in the respective abstract, we categorised the references as Studies awaiting classification.

For missing data not obtained from authors, such as standard deviations, we calculated these following the advice in the *Cochrane Handbook* section 16.1.2 (Higgins 2011). We tested the inclusion of studies with missing data and any imputations in sensitivity analyses.

Assessment of heterogeneity

We assessed clinical homogeneity of the results of included studies based on similarity of populations, interventions, outcomes, and follow-up times. We considered populations to be similar when the participants were 18 years or older and their occupations involved sitting for a major part of their working time. We considered interventions to be similar when their working mechanisms were similar, for example, replacing sit-desks with sit-stand desks (see Types of interventions). We regarded follow-up times of three months or less as short-term, between three months and one year as medium-term, and more than one year as long-term.

We quantified the degree of heterogeneity using the I^2 statistic, where an I^2 value of 25% to 50% indicates a low degree of heterogeneity, 50% to 75% a moderate degree of heterogeneity, and more than 75% a high degree of heterogeneity. If we identified moderate to high heterogeneity, we reported it and explored possible causes by pre-specified subgroup analyses.

Assessment of reporting biases

When ten or more studies were included in a meta-analysis, we tested for the effect of small studies using a funnel plot.

Data synthesis

We analysed the effects of interventions in the categories defined in Types of interventions: physical changes in the workplace design and environment (changes in desks; changes in chairs); policies to change the organisation of work (supporting social environment and policies for breaks); or provision of information and counselling. We pooled effect size estimates from individual studies using Review Manager 5 (Review Manager 2014). We considered studies to be heterogeneous, and therefore used a random-effects model to calculate pooled effect sizes.

We calculated the prediction interval for the outcome sitting time at work for sit-stand desks compared to sit-desks. Prediction intervals give an estimate of the effect of a new study based on the heterogeneity of effects of studies included in the meta-analysis (Higgins 2009; IntHout 2016).

'Summary of findings' table

We reported time spent sitting at work and time spent in sitting bouts of 30 minutes or more at short-term follow-up in the 'Summary of findings' table. Where study authors did not report effects in the short-term follow-up for the outcomes mentioned above, we presented results at medium-term follow-up. We only reported the most relevant comparisons. We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) considerations (study limitations, consistency of effect, imprecision, indirectness, and publication bias) to assess the quality of the body of evidence that contributed data to the meta-analyses for these outcomes (Higgins 2011). We justified all decisions to downgrade or upgrade the quality of evidence using footnotes and we made comments to aid readers' understanding of the review where necessary.

Subgroup analysis and investigation of heterogeneity

If sufficient data become available in future updates of this review we will conduct the following subgroup analyses for the primary outcome of time spent sitting at work.

- Age: we will compare studies conducted in participants aged 18 to 40 years with studies where all participants were aged 41 years or older, as the probability of maintaining good health and fitness diminishes with older age (AIHW 2008). Older employees might also expect a larger health benefit due to a reduction in sitting (Manini 2015).
- Types of outcome measure: we will carry out a subgroup analysis by type of outcome measure, that is, self-reported (e.g. questionnaire, log book) versus accelerometer/inclinometer versus Ecological Momentary Assessment.
- Types of intervention: we will carry out a subgroup analysis for different interventions that have been pooled under a broader category of intervention.

Similarly, we will assess the robustness of our results by excluding studies we judge to have a high risk of bias from all meta-analyses.

RESULTS

Description of studies

See: Figure 1, Characteristics of included studies, Characteristics of excluded studies, Characteristics of studies awaiting classification, and Characteristics of ongoing studies.

Figure 1. PRISMA study flow diagram

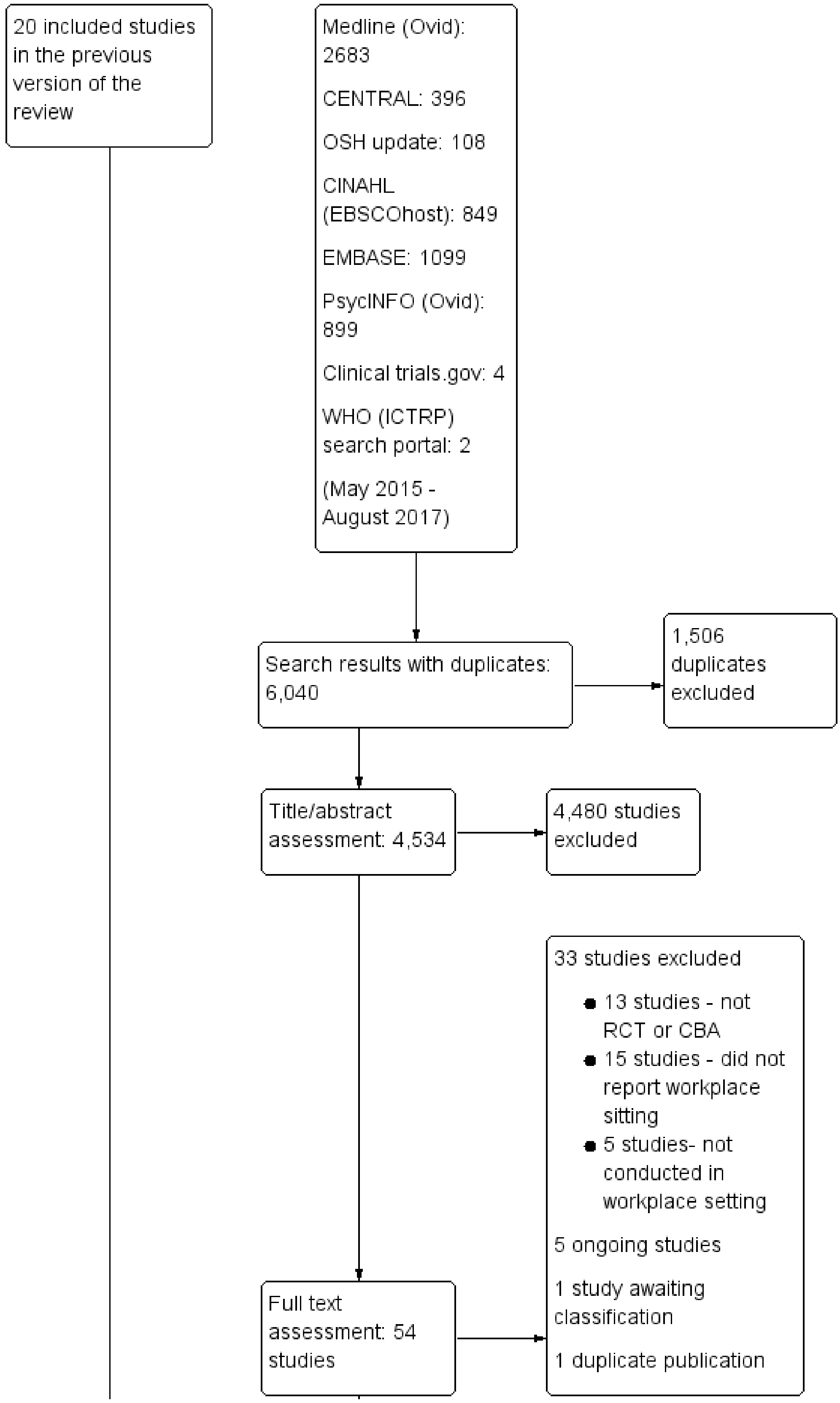
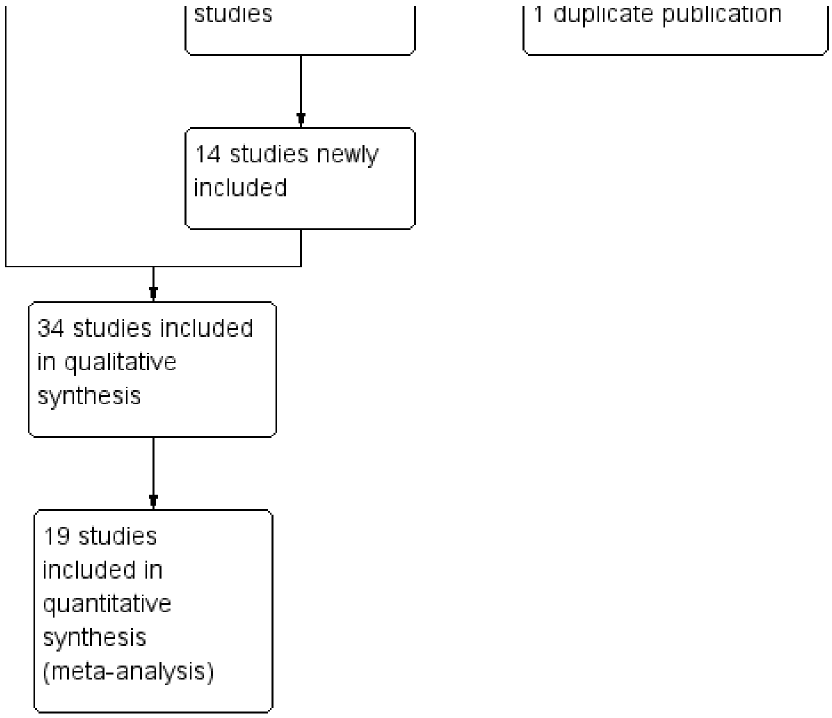


Figure 1. (Continued)



Results of the search

We conducted systematic searches in selected electronic databases and grey literature sources. We identified altogether 12,368 references in the initial search (December 2013) and the first search update (June 2015), and retrieved a total of 92 references for full-text scrutiny. Of these, we excluded 72 articles and included 20 studies in the previous published version of this review. For this update, we searched the electronic databases from June 2015 until 9 August 2017. The updated search identified a total of 6,040 references, as outlined in Figure 1: 396 from CENTRAL (Appendix 1; 9 August 2017); 2683 from MEDLINE (searched through Ovid, Appendix 2; 9 August 2017); 849 from CINAHL (Appendix 3; 9 August 2017); 108 from OSH UPDATE (Appendix 4; 9 August 2017); 1099 from Embase (Appendix 5; 9 August 2017); 899 from PsycINFO (Appendix 6; 9 August 2017); 4 from ClinicalTrials.gov (Appendix 7; 9 August 2017); and 2 from the WHO trials search portal (Appendix 8; 9 August 2017). Removal of duplicates reduced the total number of references to 4,534. Based on their titles and abstracts, we selected 54 of these references for full-text reading. Out of these, we excluded 33 studies. Five studies are ongoing, one study was a duplicate and one study was not available in full text so we classified it as a study awaiting classification. This resulted in 14 studies being included in this review update in addition to the 20 studies already included in the previous version of the review.

Included studies

Study design

Out of the 34 included studies, 17 are RCTs, two are cross-over RCTs, seven are cluster-RCTs, and eight are controlled before-and-after studies with concurrent controls. See Characteristics of included studies for further details. Although the authors described their studies as quasi-RCTs, we categorised Alkhajah 2012, and Neuhaus 2014a, as controlled before-and-after studies because the risk of baseline differences for studies with only two clusters is very high. Only one cluster trial reported unadjusted results (De Cocker 2016). Therefore we adjusted their results for the design effect following the methods stated in Section 16.3 of the *Cochrane Handbook for Systematic Reviews of Interventions* for the calculations (Higgins 2011).

We considered randomised and non-randomised studies as similar if there were no considerable differences in their effect estimates (Alkhajah 2012; Chau 2014; Chau 2016; Dutta 2014; Graves 2015; Healy 2013; Li 2017; MacEwen 2017; Neuhaus 2014a; Tobin 2016), but explored any potential differences in a subgroup analysis.

For meta-analyses that included two arms of the same study, we halved the number of participants in the control group (Coffeng 2014; De Cocker 2016; Neuhaus 2014a). For Coffeng 2014, we used the unadjusted results at twelve months follow-up. In other comparisons we used the adjusted values with the generic inverse variance method. One included study (Neuhaus 2014a) reported only MDs and standard errors and the authors could not provide raw data, so we could not adjust the number of participants. In this case we modelled the means and standard deviations from the intervention and the control group in Review Manager as closely to the real data as possible to achieve the same MD and standard error. Then we halved the number of participants in the control group and entered the resulting standard errors into Review Manager.

Participants

The included studies were conducted with a total of 3,397 employees. The sample sizes of included trials ranged from 16 in the smallest study (Chau 2016), to 523 in the largest one (Verweij 2012), with a median of 44. Studies included workers from the public and private sectors, with nine studies including researchers and other academic staff, two studies including health workers, and 23 including employees in private companies.

Gender

Participants in 20 studies were predominantly women (Carr 2015; Danquah 2017; De Cocker 2016; Donath 2015; Dutta 2014; Evans 2012; Gao 2015; Gilson 2009; Graves 2015; Healy 2016; Kress 2014; Li 2017; MacEwen 2017; Mailey 2016; Pickens 2016; Priebe 2015; Schuna 2014; Swartz 2014; Tobin 2016; Urda 2016). In the remaining 14 studies the proportions of women and men did not differ significantly.

Country

The studies were conducted in Australia, the USA, Canada, and several high-income countries in Europe.

Interventions

1. Physical changes in the workplace design and environment

Sixteen studies evaluated the effectiveness of individual workspace modifications on workplace sitting time (Alkhajah 2012; Carr 2015; Chau 2014; Chau 2016; Dutta 2014; Gao 2015; Graves 2015; Healy 2013; Kress 2014; Pickens 2016; Li 2017; MacEwen 2017; Neuhaus 2014a; Schuna 2014; Sandy 2016; Tobin 2016)

Sit-stand desk

Twelve studies assessed the effectiveness of interventions using sit-stand desks. The interventions using a sit-stand desk were assessed independently (Alkhajah 2012; Chau 2014; Dutta 2014; Gao 2015; MacEwen 2017; Neuhaus 2014a), and in combination with information and counselling (Chau 2016; Graves 2015; Healy 2013; Li 2017; Neuhaus 2014a; Tobin 2016).

One study compared the effectiveness of multiple types of interventions, including: 1) sit-stand desk; 2) ergonomic training; 3) sit-stand desk combined with ergonomic training; and 4) standard sit-desk (Sandy 2016).

Standing desk

Two studies compared the effectiveness of a standing desk intervention and a sit-stand desk intervention (Kress 2014; Pickens 2016).

Active workstation

Two studies evaluated the effectiveness of interventions using active workstations (i.e. desks that cause significant increase in energy expenditure compared to conventional sit-desks). One study assessed the effectiveness of a treadmill desk (Schuna 2014), while another assessed the effectiveness of a cycle desk (Carr 2015).

2. Policy to change the organisation of work

Two studies evaluated the effectiveness of walking strategies (Gilson 2009; Puig-Ribera 2015). The first evaluated the effectiveness of route and incidental walking on office employees' sitting time at work (Gilson 2009). The route-based walking intervention was intended to increase the amount of brisk, sustained walking during work breaks. The incidental walking intervention aimed to increase walking and talking to colleagues, instead of sending emails or making telephone calls, and standing and walking during meetings, instead of sitting at desks. The other study evaluated the effectiveness of incidental movement and short (5 to 10 minutes) and longer (10+ minute) walks on office employees' sitting time at work (Puig-Ribera 2015).

One study evaluated the effectiveness of planned daily breaks from sitting (Mailey 2016). They compared taking short breaks (one to two minutes every half hour) to taking long breaks (two 15-minute breaks per workday).

3. Provision of information and counselling

Information and feedback

One study evaluated the effectiveness of personalised computer-tailored feedback and generic feedback intervention in reducing sitting time in office employees (De Cocker 2016). Another compared the effectiveness of delivering emails containing psychosocial materials and other available resources that were based on constructs of Social Cognitive Theory relating to decreasing sedentary behaviours at work, to delivering emails concerning general health topics (Gordon 2013). In Priebe 2015, the effectiveness of providing highly personalised or contextualised information was compared with the effectiveness of providing less personalised or contextualised information.

Counselling

In Verweij 2012, the effectiveness of counselling by occupational physicians (highly trained specialists who provide health services to employees and employers (AFOEM 2014)) was compared with usual care in decreasing sitting time in office employees. Another study evaluated the effectiveness of group motivational interviewing (i.e. a counselling style that stimulates behavioural change by focusing on exploring and resolving ambivalence in a group) by occupational physicians on office employees' sitting time (Coffeng 2014).

Computer prompts

Four studies evaluated the effectiveness of computer prompts combined with information, compared to information alone, for decreasing sitting time in office employees (Donath 2015; Evans 2012; Pedersen 2013; Urda 2016). Computer prompts offer an opportunity to employees to choose and engage in a short 'burst' of physical activity such as standing or walking. One study, Swartz 2014, assessed the effect of hourly prompts (computer-based and wrist worn) to stand up or to step on reducing sitting time in office employees.

One study, Brakenridge 2016, assessed the effectiveness of activity tracker combined with organisational support compared to organisational support only.

One study, van Berkel 2014, evaluated the effectiveness of mindfulness training in decreasing sitting time in office employees. The mindfulness intervention consisted of homework exercises and information through emails.

4. Multi-component interventions

Four studies evaluated the effectiveness of combining multiple interventions on sitting at work (Coffeng 2014; Danquah 2017; Ellegast 2012; Healy 2016).

In Coffeng 2014, the effectiveness of combining multiple environmental interventions with Group Motivational Interviewing (GMI) was assessed. The multi-component environmental intervention consisted of: 1) the Vitality in Practice (VIP) Coffee

Corner Zone, where a workplace coffee corner was modified by adding a bar with bar chairs, a large plant, and a giant wall poster (a poster visualizing a relaxing environment, e.g. wood, water, and mountains); 2) the VIP Open Office Zone, where an office was modified by introducing exercise balls and curtains to divide desks in order to reduce background noise; 3) the VIP Meeting Zone, where conference rooms were modified by placing a standing table and a giant wall poster; and 4) the VIP Hall Zone, where table tennis tables were placed and lounge chairs were introduced in the hall for informal meetings. In addition, footsteps were placed on the floor in the entrance hall to promote stair walking.

In Ellegast 2012, the effectiveness of multiple environmental interventions in combination with a walking strategy were assessed. The intervention consisted of measures aiming to change workplace environment (e.g. sit-stand tables) and behaviour (e.g. using pedometers to provide activity feedback, face-to-face motivation for lunch walks, and an incentive system for bicycle commuting or sports activities).

The study by Danquah and colleagues evaluated the effectiveness of a multi-component intervention comprising of organisational strategies (support from management), environmental strategies (installation of standing meeting tables), and individual strategies (a lecture and email or text messages) (Danquah 2017).

The fourth study evaluated the effectiveness of a multi-component intervention comprising of organisational strategies (consultation and support from the management), environmental strategies (sit-stand desk), and individual strategies (coaching and goal setting) (Healy 2016).

Type of control group

No intervention

Twenty-three included studies used a 'no intervention' control group (Alkhajah 2012; Chau 2014; Chau 2016; Coffeng 2014; Danquah 2017; De Cocker 2016; Dutta 2014; Ellegast 2012; Gao 2015; Gilson 2009; Graves 2015; Healy 2013; Healy 2016; Li 2017; MacEwen 2017; Neuhaus 2014a; Puig-Ribera 2015; Sandy 2016; Schuna 2014; Tobin 2016; Urda 2016; van Berkel 2014; Verweij 2012).

Other controls

In Carr 2015, a cycle desk in combination with information and counselling was compared with information and counselling only, resulting in the net effect of a cycle desk. In Kress 2014, and Pickens 2016, the effectiveness of standing desks was compared with the effectiveness of sit-stand desks. Three studies compared computer prompts combined with information with information only, resulting in the net effect of computer prompts (Donath 2015; Evans 2012; Pedersen 2013). In Gordon 2013, the effectiveness of delivering emails concerning general health topics was compared with delivering emails containing psychosocial materials and other available resources based on constructs of the Social Cognitive Theory relating to decreasing sedentary behaviours at work. In Swartz 2014, computer-based and wrist-worn prompts, combined with instruction to stand, were compared with the same prompts combined with instruction to walk at least 100 steps. In Priebe 2015, highly personalised information was compared with less personalised information. One study evaluated the effectiveness of short breaks compared to long breaks (Mailey 2016). Another study compared the effectiveness of activity trackers combined with organisational support with organisational support only (Brakenridge 2016).

Outcomes

Total time spent sitting at work

Total time spent sitting at work was used as an outcome variable in 25 studies (Alkhajah 2012; Brakenridge 2016; Chau 2014; Chau 2016; Danquah 2017; De Cocker 2016; Donath 2015; Dutta 2014; Ellegast 2012; Evans 2012; Gilson 2009; Gordon 2013; Graves 2015; Healy 2013; Healy 2016; Kress 2014; Li 2017; MacEwen 2017; Neuhaus 2014a; Pedersen 2013; Puig-Ribera 2015; Sandy 2016; Swartz 2014; Tobin 2016; Urda 2016).

Eight studies reported time spent in occupational sedentary behaviour, which we considered to be equivalent to time spent sitting at work (Carr 2015; Coffeng 2014; Gao 2015; Mailey 2016; Pickens 2016; Schuna 2014; Verweij 2012; van Berkel 2014).

Number of prolonged sitting bouts at work

Three studies reported number of prolonged sitting bouts at work (Evans 2012; Danquah 2017; Swartz 2014).

Total duration of prolonged sitting bouts at work

Six studies reported time spent in prolonged periods of sitting at work (Brakenridge 2016; Danquah 2017; Evans 2012; Healy 2013; Neuhaus 2014a; Priebe 2015).

Total time spent sitting, including sitting at and outside work

Eight studies reported total time spent sitting, including sitting at and outside work (Alkhajah 2012; Brakenridge 2016; De Cocker 2016; Dutta 2014; Ellegast 2012; Healy 2016; MacEwen 2017; Verweij 2012).

Time spent standing and stepping at work

Sixteen studies reported time spent standing at work (Alkhajah 2012; Brakenridge 2016; Chau 2014; Chau 2016; Danquah 2017; De Cocker 2016; Donath 2015; Gao 2015; Graves 2015; Healy 2013; Healy 2016; Li 2017; MacEwen 2017; Neuhaus 2014a; Swartz 2014; Tobin 2016).

Eleven studies reported time spent stepping at work (Alkhajah 2012; Brakenridge 2016; Chau 2014; Chau 2016; Graves 2015; Healy 2013; Healy 2016; Li 2017; Neuhaus 2014a; Swartz 2014; Tobin 2016).

Energy expenditure

Only one study reported estimated energy expenditure based on information about sitting time at work (Pedersen 2013). They used 1.5 METs to represent energy expenditure of sitting and 2.3 METs to represent energy expenditure of quiet standing.

Work productivity

Three studies assessed work performance on a scale from 1 to 10 (Alkhajah 2012; Healy 2013; Neuhaus 2014a). One study, Carr 2015, also reported they had assessed work productivity, but the authors did not report the results.

Two studies assessed work engagement on a scale from 0 to 6 (Coffeng 2014; van Berkel 2014), using the Utrecht Work Engagement Scale, a questionnaire that measures three aspects of engagement: vigour (six items); dedication (five items); and absorption (six items).

One study, Puig-Ribera 2015, reported the percentage of lost work productivity in terms of Work Limitation Questionnaire Index (WLQ Index) Score. WLQ Index Score is a weighted sum of the scores from the WLQ scales. The Work Limitation Questionnaire consists of 25 items which require employees to rate their level of difficulty to perform 25 specific job demands in the last two weeks. The individual items form four scales: Time management; Physical demands; Mental or Interpersonal, and Output demands scale.

Adverse events

Three studies reported musculoskeletal symptoms by anatomical regions (Alkhajah 2012; Healy 2013; Neuhaus 2014a). Two studies reported musculoskeletal discomfort or pain at three sites: lower back, upper back, and neck and shoulders (Gao 2015; Graves 2015). The first study, Gao 2015, used a scale ranging from 1 (very comfortable) to 5 (very uncomfortable); and in Graves 2015, a scale ranging from 0 (no discomfort) to 10 (extremely uncomfortable) was used. Another study, Carr 2015, also reported having measured musculoskeletal discomfort but they presented no respective data in their article. One study, Danquah 2017, reported musculoskeletal symptoms at all sites on the scale from 0 to 6.

One study measured adverse events as 'one sick day in the last three months' (Alkhajah 2012), whilst two studies used 'more than one sick day in the last month of intervention' (Healy 2013; Neuhaus 2014a).

In Neuhaus 2014a, adverse events were defined as overall body pain.

Follow-up times

In six studies the longest follow-up was one month or less (Evans 2012; Healy 2013; Li 2017; Priebe 2015; Swartz 2014; Urda 2016), and in 19 studies the longest follow-up was between one and three months (Alkhajah 2012; Brakenridge 2016; Chau 2014; Chau 2016; Danquah 2017; De Cocker 2016; Donath 2015; Dutta 2014; Ellegast 2012; Gilson 2009; Gordon 2013; Graves 2015; Kress 2014; MacEwen 2017; Mailey 2016; Neuhaus 2014a; Pickens 2016; Schuna 2014; Tobin 2016). We categorised all these as short-term follow-up.

The remaining nine studies followed participants between three and 12 months (Carr 2015; Coffeng 2014; Gao 2015; Healy 2016; Pedersen 2013; Puig-Ribera 2015; Sandy 2016; van Berkel 2014; Verweij 2012), which we categorised as medium-term follow-up.

No studies had a follow-up longer than 12 months, which we defined as long-term follow-up.

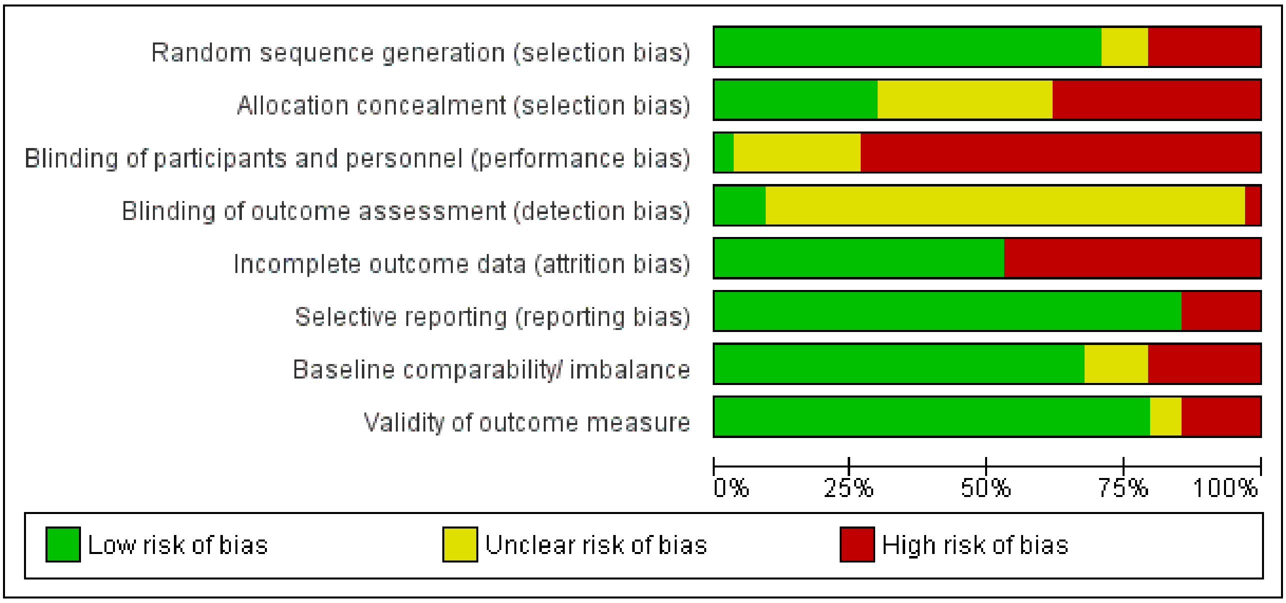
Excluded studies

Of the 54 papers we assessed as full-text, 33 did not meet our inclusion criteria and we summarily excluded them. Thirteen studies were not RCTs or controlled before-and-after studies with concurrent controls. Five studies were not conducted in a workplace setting and another 15 studies did not report sitting time at work. See the Characteristics of excluded studies table for further details.

Risk of bias in included studies

Risk of bias varied considerably across the studies (Figure 2).

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.



Allocation

Seven studies, Alkhajah 2012, Chau 2016, Gao 2015, Healy 2013, Kress 2014, Neuhaus 2014a, Pickens 2016, did not randomise participants and we judged these studies to be at high risk of bias for the domain of random sequence generation. Except for De Cocker 2016, Puig-Ribera 2015, and Tobin 2016, all the studies described the method of randomisation they had used, so we judged them as having a low risk of bias for the domain of sequence generation. Although these studies mentioned in their publication they conducted randomised trials (De Cocker 2016; Puig-Ribera 2015; Tobin 2016), they did not describe the method of randomisation and so we judged them to have an unclear risk of bias. One study, Donath 2015, used the minimisation method which is considered equivalent to randomisation (Chapter 8 of the *Cochrane Handbook for Systematic Reviews of Interventions*, Higgins 2011).

Only 10 studies reported concealing intervention versus control group allocation, so we judged these studies to be at low risk of bias (Brakenridge 2016; Carr 2015; Danquah 2017; Ellegast 2012; Evans 2012; Healy 2016; Li 2017; Mailey 2016; Schuna 2014; Swartz 2014). Eleven studies provided no information on allocation concealment, thus we judged these studies to be at unclear risk of bias (Coffeng 2014; De Cocker 2016; Donath 2015; Gilson 2009; Gordon 2013; MacEwen 2017; Priebe 2015; Puig-Ribera 2015; Sandy 2016; Tobin 2016; Urda 2016). Allocation was not concealed in the remaining studies (Alkhajah 2012; Chau 2014; Chau 2016; Dutta 2014; Gao 2015; Graves 2015; Healy 2013; Kress 2014; Neuhaus 2014a; Pedersen 2013; Pickens 2016; van Berkel 2014; Verweij 2012) and thus we judged them to be at high risk of bias.

Blinding

In all but a single study (Verweij 2012), the blinding of participants to the interventions they were receiving was not done due to the nature and aims of interventions being self-evident, so we judged that these 33 studies had a high risk of bias in the performance bias domain. The single study, Verweij 2012, reported asking randomised occupational physicians not to reveal their allocation to participating employees who were their patients.

With regard to outcome assessment, only three studies reported blinding of outcome assessor to group allocation and thus we judged them to have a low risk of bias (Danquah 2017; Evans 2012; Li 2017). One study, Healy 2013, reported that outcome assessors were not blinded to group allocation and we judged their study to have a high risk of bias. The remaining studies did not report on blinding of outcome assessors and thus we judged them to have an unclear risk of detection bias.

Incomplete outcome data

We judged 16 studies to have a high risk of bias due to incomplete outcome data (Chau 2016; De Cocker 2016; Donath 2015; Dutta 2014; Gao 2015; Gilson 2009; Kress 2014; Li 2017; MacEwen 2017; Mailey 2016; Neuhaus 2014a; Pickens 2016; Priebe 2015; Puig-Ribera 2015; Swartz 2014; Verweij 2012). One study, Dutta 2014, did not report 14% of working hours; the remaining studies lost more than 10% of participants during the follow-up period. We judged all the remaining 18 studies to have a low risk of bias for incomplete outcome data because of the following reasons. Three studies, Gordon 2013, Graves 2015, and van Berkel 2014, conducted an intention-to-treat analysis. One study, Coffeng 2014, conducted multilevel analysis to account for missing data. Another, Chau 2014, reported that imputing values for missing covariate data did not influence the estimated adjusted effects of the intervention on the outcomes. Three studies, Brakenridge 2016, Danquah 2017, and Healy 2016, reported assessing sensitivity of results by multiple imputation using chained equations. Another three studies, Evans 2012, Healy 2013, and Tobin 2016, lost the same proportion of participants from both the intervention groups and the control groups, so we assumed that the missing data was unlikely to have had a significant impact on outcomes (*Cochrane Handbook for Systematic Reviews of Interventions,* section 8.13.2*,* Higgins 2011).

Selective reporting

We judged five studies to have a high risk of bias due to discordance between outcomes in available protocols and the ones reported in study results (De Cocker 2016; Evans 2012; Li 2017; Neuhaus 2014a; Schuna 2014). We judged the remaining 17 studies to have a low risk of bias as they reported results for all the outcome measures mentioned either in the protocol or in the methods section of studies where a protocol was not available (Alkhajah 2012; Chau 2014; Coffeng 2014; Donath 2015; Dutta 2014; Gao 2015; Gilson 2009; Gordon 2013; Healy 2013; Pedersen 2013; Puig-Ribera 2015; Schuna 2014; Swartz 2014; van Berkel 2014; Verweij 2012).

Other potential sources of bias

This domain had the following two parts of assessment, as decided a priori:

- validity of outcome measure;
- baseline comparability or imbalance for age, gender and occupation of study groups.

Eight studies assessed sitting time at work using questionnaires (Coffeng 2014; Gao 2015; Pedersen 2013; Pickens 2016; Priebe 2015; Sandy 2016; Verweij 2012; van Berkel 2014). Questionnaires are cost-effective and readily accessible to the majority of the population, but participants receiving the intervention might be aware of the goals and the purpose of the intervention and may, therefore, misreport outcomes (Healy 2011). In six studies (Coffeng 2014; Gao 2015; Priebe 2015; Sandy 2016; Verweij 2012; van Berkel 2014), the questionnaire used has not been tested for validity in assessing time spent sitting at work. Two studies, Pedersen 2013, and Pickens 2016 used the Occupational Sitting and Physical Activity Questionnaire (OSPAQ) which has moderate validity for assessing time spent sitting at work (Chau 2012). Another two studies, Gilson 2009, and Puig-Ribera 2015, assessed sitting time using a paper-based diary (log book). The validity and reliability of assessing sitting time using log-books has not been established. However, they are less dependent on long-term recall and therefore might provide a more accurate measurement of sitting time at work. In any case log data are subject to reporting bias, as it is not possible to determine whether the log has been filled in at the required intervals or if it was, for example, completed in whole on the final day of assessment (Clark 2009). In Graves 2015, sitting time at work was assessed with Ecological Momentary Assessment diaries. This is a valid, reliable, and feasible approach to assess physical activity and sedentary behaviour. The benefit of Ecological Momentary Assessment is its ability to collect data in real-time and real-world circumstances; hence there is no recall bias (Marszalek 2014).

Twenty-three studies assessed sitting time at work with an accelerometer-inclinometer (Alkhajah 2012; Brakenridge 2016; Carr 2015; Chau 2014; Chau 2016; Danquah 2017; De Cocker 2016; Donath 2015; Dutta 2014; Ellegast 2012; Evans 2012; Gordon 2013; Healy 2013; Healy 2016; Kress 2014; Li 2017; MacEwen 2017; Mailey 2016; Neuhaus 2014a; Schuna 2014; Swartz 2014; Tobin 2016; Urda 2016. Such device-based measurements also have some limitations, as outcomes may be affected by methodological decisions made before and after the data collection (e.g. type of accelerometer, cut-off points, and non-wear time definitions)

(Janssen 2015; Pedišić 2015). Self-reported sedentary time has shown to have low to moderate correlation with accelerometer-derived sedentary time, with improved validity when specific domains of sedentary time are recalled (e.g. time spent watching television, computer use, sitting at work; Healy 2011). We therefore judged six studies to have a high risk of bias based on validity of outcome measure (Coffeng 2014; Gao 2015; Priebe 2015; Sandy 2016; Verweij 2012; van Berkel 2014).

We judged two studies to have a high risk of other bias. In Alkhajah 2012, participants in the intervention group were academics involved in sedentary behaviour research, whilst participants in the control group had never been involved in sedentary behaviour or physical activity research. In Gao 2015, Gordon 2013, MacEwen 2017, Mailey 2016, and Pickens 2016, a significant difference was reported between the intervention group and the control group in baseline characteristics and thus we judged these studies to have a high risk of bias. Four studies did not report characteristics of participants at baseline and thus we judged them to have an unclear risk of bias (Priebe 2015; Puig-Ribera 2015; Sandy 2016; Urda 2016). We judged all other studies to have a low risk of other bias, as neither baselines nor outcome validity was questionable.

Overall Risk of Bias

Overall, we judged only four studies to have a low risk of bias (Carr 2015; Danquah 2017; Ellegast 2012; Healy 2016). The remaining studies were judged to have a high risk of bias overall based on: inadequate randomisation (Alkhajah 2012; Chau 2016; Gao 2015; Healy 2013; Kress 2014; Neuhaus 2014a; Pickens 2016); allocation concealment (Alkhajah 2012; Chau 2014; Chau 2016; Dutta 2014; Gao 2015; Graves 2015; Healy 2013; Kress 2014; Neuhaus 2014a; Pedersen 2013; Pickens 2016; van Berkel 2014; Verweij 2012); blinding of outcome assessment (Healy 2013); incomplete outcome data (Chau 2016; De Cocker 2016; Donath 2015; Dutta 2014; Gao 2015; Gilson 2009; Kress 2014; Li 2017; MacEwen 2017; Mailey 2016; Neuhaus 2014a; Pickens 2016; Priebe 2015; Puig-Ribera 2015; Swartz 2014; Verweij 2012); selective reporting (De Cocker 2016; Evans 2012; Li 2017; Neuhaus 2014a; Schuna 2014); and other bias (Alkhajah 2012; Brakenridge 2016; Coffeng 2014; Gao 2015; Gordon 2013; MacEwen 2017; Mailey 2016; Pickens 2016; Sandy 2016; van Berkel 2014; Verweij 2012). See Figure 3 for a summary of our judgements about each risk of bias item for each included study.

Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

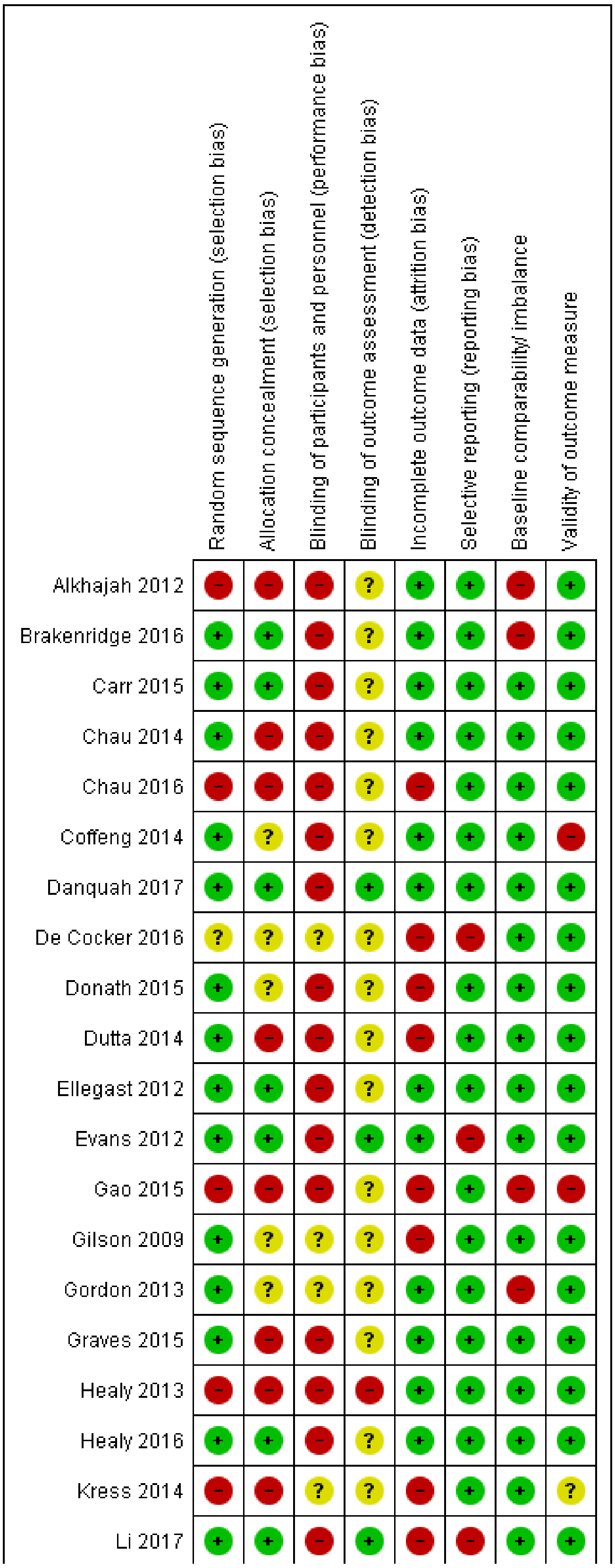
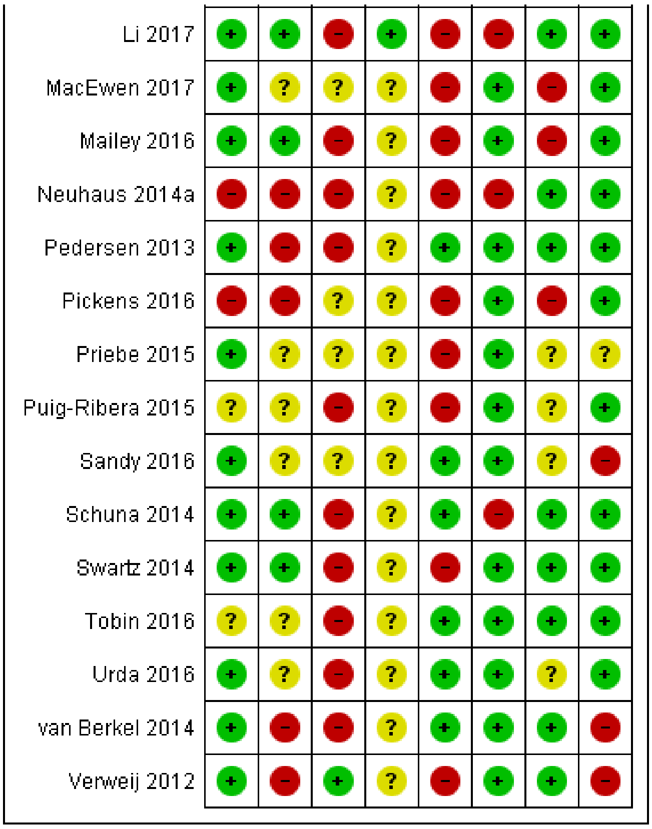


Figure 3. (Continued)



Effects of interventions

See: **Summary of findings for the main comparison** Alternative desks and workstations compared to sit-desks for reducing sitting at work; **Summary of findings 2** Workplace policy changes compared to no intervention or alternate intervention for reducing sitting at work; **Summary of findings 3** Information, feedback, and/or counselling compared to information only or no intervention for reducing sitting at work; **Summary of findings 4** Multi-component intervention compared to no intervention for reducing sitting at work

We present results using only outcomes for which data were available.

Physical changes in the workplace design and environment

Sit-stand desk with or without information and counselling versus sit-desk

Outcome: sitting time

Time spent sitting at work: follow-up at short term

Ten studies compared the effects of using a sit-stand desk with or without information and counselling to the effects of using a sit-desk (Chau 2014; Chau 2016; Dutta 2014; Gao 2015; Graves 2015; Healy 2013; Li 2017; MacEwen 2017; Neuhaus 2014a; Tobin 2016). The pooled analysis showed that the sit-stand desk with or without information and counselling intervention reduced sitting time at work by on average 100 minutes per eight-hour workday (95% CI −116 to −84, I^2 = 37%; Analysis 1.1). In a subgroup analysis, there was no difference in effectiveness between sit-stand desks with information and counselling and sit-stand desks only in reducing sitting time at work.

In a subgroup analysis including only RCTs, (four studies, Graves 2015; Li 2017; MacEwen 2017; Tobin 2016), a sit-stand desk with information and counselling reduced sitting time at work on average by 105 minutes (95% CI −128 to −82, I^2 = 0%; Analysis 1.2). Data presented by one study, Sandy 2016, did not allow for calculation of time spent in sitting time at work and therefore we did not include the study in the quantitative synthesis.

The prediction interval for sitting time ranged from −146 to −54 minutes a day, indicating that in 95% of cases the true effect of a new unique intervention will fall within these values.

Time spent sitting at work: follow-up at medium-term

At medium-term follow-up, two controlled before-and-after studies (Chau 2016; Gao 2015), that provided workers with sit-stand desks, reduced sitting time at work on average by 57 minutes per eight-hour workday (95% CI −99 to −15, I^2 = 0%) compared to sit-desks (Analysis 1.3).

Total duration of sitting bouts lasting 30 minutes or more: follow-up at short-term

Two controlled before-and-after studies containing three study arms measured the intervention effect on the total duration of sitting bouts lasting 30 minutes or more (Healy 2013; Neuhaus 2014a).

In Neuhaus 2014a, they compared the effects of using a sit-stand desk only with a sit-stand desk combined with counselling and with a sit-desk. In Healy 2013, they compared a sit-stand desk combined with counselling with a sit-desk. The pooled effect estimate combining sit-stand desk and sit-stand desk combined with counselling showed a reduction of 53 minutes, on average, per eight-hour workday (95% CI −79 to −26) in the total duration of sitting bouts lasting 30 minutes or more in the intervention group, with moderate heterogeneity (I^2 = 45%; Analysis 1.4). Analysis of the subgroup of interventions combining sit-stand desks with counselling resulted in a mean reduction of 63 minutes per eight-hour workday (95% CI −93 to −34), with moderate heterogeneity (I^2 = 31%; Analysis 1.4).

Total time spent sitting, including sitting at and outside work: follow-up at short-term

The pooled analysis of two studies (Alkhajah 2012; MacEwen 2017), which compared the effects of sit-stand desks and sit-desks on total sitting time, including sitting at work and outside work, at short-term follow-up showed a reduction of 82 minutes, on average, per day (95% CI −124 to −39, I^2 = 0%; Analysis 1.5).

Outcome: standing and stepping time

Time spent standing at work: follow-up at short-term

Nine studies reported time spent standing at work at short-term follow-up (Alkhajah 2012; Chau 2014; Chau 2016; Graves 2015; Healy 2013; Li 2017; MacEwen 2017; Neuhaus 2014a; Tobin 2016). The pooled analysis showed that sit-stand desks with or without information and counselling increased standing time at work on average by 89 minutes per eight-hour workday (95% CI 76 to 102, I^2 = 58%; Analysis 1.6). However, in a subgroup analysis, sit-stand desks combined with information and counselling were more effective in increasing standing time at work than sit-stand desks only (test for subgroup differences: Chi^2 = 4.31, df = 1 (P = 0.04), I^2 = 76.8%). Sit-stand desks only increased standing time at work on average by 76 minutes per eight-hour workday (95% CI 58 to 94), but there was substantial heterogeneity (I^2 = 78%) in effect sizes. Sit-stand desks combined with information and counselling increased standing time at work on average by 103 minutes per eight-hour workday (95% CI 85 to 122, I^2 = 0%; Analysis 1.6.2).

In a sensitivity analysis, including only RCTs (four studies, Graves 2015; Li 2017; MacEwen 2017; Tobin 2016), a sit-stand desk combined with information and counselling increased standing at work on average by 99 minutes per eight-hour workday (95% CI 75 to 122, I^2 = 0%; Analysis 1.7).

Time spent stepping at work: follow-up at short-term

In the pooled analysis of eight studies (Alkhajah 2012; Chau 2014; Chau 2016; Graves 2015; Healy 2013; Li 2017; Neuhaus 2014a; Tobin 2016), we found no significant difference between the effects of sit-stand desks and sit-desks on time spent stepping at work at short-term follow-up (MD −1 minute per eight hour workday, 95% CI −4 to 3, I^2 = 0%; Analysis 1.8).

Time spent standing at work: follow-up at medium-term

At medium-term follow-up, two controlled before-and-after studies (Chau 2016; Gao 2015), found that providing workers with sit-stand desks increased standing time at work on average by 53 minutes per eight-hour workday (95% CI 17 to 90, I^2 = 0%) compared to sit-desks (Analysis 1.9).

Outcome: work performance

Self-reported work performance: follow-up at short-term

In three studies (Alkhajah 2012; Healy 2013; Neuhaus 2014a), interventions with sit-stand desks produced a non-significant pooled effect on work performance (on a scale from 1 to 10; MD 0.35 score points; 95% CI −0.1 to 0.8; Analysis 1.10). In these studies, work performance was assessed with a 10-item scale ranging from 1 to 10 relating to the past week, with higher values on the scale indicating better performance.

Number of sick days: follow-up at short-term

One study found no significant change in the proportion of employees having more than one sick day in the sit-stand desk group compared to sit-desk in the three months following the installation of sit-stand desks (risk ratio (RR) 2.2, 95% CI 0.9 to 5.2; Analysis 1.11; Alkhajah 2012).

Two studies assessed the proportion of people with more than one sick day in the last month at three months follow-up (Healy 2013; Neuhaus 2014a). We found no significant pooled effect of the introduction of sit-stand desks on the risk of having more than one sick day in the last month (RR 0.8, 95% CI 0.5 to 1.2). Accordingly, we found no significant effects for interventions that included information and counselling along with a sit-stand desk (RR 0.7, 95% CI 0.4 to 1.2) and for those that included sit-stand desks only (RR 0.9, 95% CI 0.4 to 2.1; Analysis 1.12).

Outcome: adverse events

Overall body pain

In one controlled before-and-after study, Neuhaus 2014a, one out of 13 participants in the sit-stand desk group withdrew from the trial because of overall body pain.

Musculoskeletal symptoms: follow-up at short-term

Three studies, Alkhajah 2012, Healy 2013, and Neuhaus 2014a, reported musculoskeletal symptoms, assessed using questions with a binary response scale (yes/no), by anatomic regions. We did not combine their results in a meta-analysis because of substantial heterogeneity in the results (I^2 = 98%).

Two studies found a lower prevalence of musculoskeletal symptoms among participants using sit-stand desks compared to those using sit-desks at three months follow-up (Alkhajah 2012; Neuhaus 2014a). In the study by Neuhaus 2014a, the magnitude of the effect was significantly larger (MD −16.5, 95% CI −17.8 to −15.3) than in the study by Alkhajah 2012 (MD −6, 95% CI −6.9 to −5.1).

In Healy 2013, a significant but relatively small increase was found in the percentage of participants with musculoskeletal symptoms in the sit-stand desk combined with counselling group (MD 4, 95% CI 2.6 to 5.5), while in Neuhaus 2014a, a slight decrease was found in the percentage of participants with musculoskeletal symptoms (MD −11.5, 95% CI −12.6 to −10.5) in the sit-stand desk combined with counselling group compared to the sit-desk group at three-month follow-up.

In Graves 2015, a non-significant change was found in the ratings of musculoskeletal discomfort by participants using sit-stand desks compared to participants using sit-desk at short-term follow-up (MD −0.5, 95% CI −1 to 0; Analysis 1.13). Participants rated musculoskeletal discomfort or pain at three sites (lower back, upper back, and neck and shoulders) on a Likert scale ranging from 0 (no discomfort) to 10 (extremely uncomfortable).

Musculoskeletal symptoms: follow-up at medium-term

One study, Gao 2015, assessed perceived musculoskeletal comfort for different body parts (neck and shoulders, upper limbs, back, and lower limbs) rated at the end of a normal workday on a scale from 1 (very comfortable) to 5 (very uncomfortable). The study found a significant but relatively small change in musculoskeletal symptoms with a sit-stand desk compared to a sit-desk at six-month follow-up (MD −0.5, 95% CI −0.9 to −0.2; Analysis 1.14).

Standing desk versus sit-stand desk

Outcome: sitting time

Time spent sitting at work

One controlled before-and-after study, Kress 2014, found that using a standing desk reduced sitting time at work in their sample on average by 10 minutes per eight-hour workday (95% CI −62 to 43) at short-term follow-up (Analysis 2.1) and by 19 minutes per eight-hour workday (95% CI −64 to 26) at medium-term follow-up, but these effects were not statistically significant (Analysis 2.2). Data presented by another study, Pickens 2016, did not allow for calculation of time spent sitting at work and the study was therefore not included in the quantitative synthesis.

Active workstation versus sit-desk

Outcome: sitting time

Time spent sitting at work: follow-up at short-term

Treadmill desk combined with counselling versus sit-desk

One RCT, Schuna 2014, found that a treadmill desk combined with counselling reduced sitting time at work by 29 minutes on average per eight-hour workday (95% CI −55 to −2) compared to no intervention at short-term follow-up (Analysis 3.1).

Time spent in inactive sitting at work: follow-up at medium-term

Cycling desks + information and counselling versus information and counselling only

One RCT, Carr 2015, found a non-significant decrease in inactive sitting at work (MD −12 minutes per day, 95% CI −24 to 1) with a cycling desk combined with information and counselling compared to information and counselling only at medium-term follow-up (Analysis 3.2).

Outcome: work productivity

One RCT, Carr 2015, found no significant change in musculoskeletal discomfort over the past seven days and work productivity with a cycling desk combined with information and counselling compared to information and counselling only at medium-term follow-up. The study did not report any quantitative data for these outcomes.

Policies to change organisation of work

Walking strategies versus no intervention

Outcome: sitting time

Time spent sitting at work: follow-up at short-term

A three-armed RCT, Gilson 2009, found a non-significant decrease in mean sitting time at work per day (MD −15 minutes per day, 95% CI −50 to 19) in route and incidental walking groups compared to a control group (Analysis 4.1).

Time spent sitting at work: follow-up at medium-term

A cluster-RCT, Puig-Ribera 2015, found a non-significant decrease in sitting time at work (MD −17 minutes per day, 95% Cl −61 to 28) following a web-based intervention encouraging incidental walking and short walks during the working day compared to a control group at 21-week follow-up (Analysis 4.2).

Outcome: work productivity

Percentage of lost work productivity: follow-up at medium-term

One cluster-RCT, Puig-Ribera 2015, found walking strategies resulted in an average decrease in Work Limitation Questionnaire Index Score of −2.6% (95% CI −4 to −1.3) when compared to no intervention (Analysis 4.3).

Short break versus long break

Time spent sitting at work: follow-up at short-term

One RCT, Mailey 2016, reported that short breaks reduced time spent sitting at work by 40 minutes per eight-hour workday (95% CI −66 to −15) when compared to long breaks at short-term follow-up (Analysis 5.1).

Information and counselling

Information, counselling, and feedback versus no intervention

Outcome: sitting time

Time spent sitting at work: follow-up at short-term

Two RCTs compared the effects of information and feedback to no intervention on time spent sitting a work at short-term follow-up (De Cocker 2016; Gordon 2013). The pooled effect size for information, feedback, reminder, or all of the above was not significantly different from no intervention (MD −19 minutes per eight-hour workday, 95% CI −57 to 19, I^2 = 0%; Analysis 6.1).

Time spent sitting at work: follow-up at medium-term

The pooled analysis of two RCTs comparing counselling to no intervention, Coffeng 2014, and Verweij 2012, showed that counselling reduced sitting time at work on average by 28 minutes per eight-hour workday (95% CI −51 to −5; I^2 =0%; Analysis 6.2).

Total time spent sitting, including sitting at and outside work: follow-up at short-term

One RCT, De Cocker 2016 found a non-significant decrease in total time spent sitting with information and feedback compared to no intervention at short-term follow-up (MD −16 minutes per day, 95% CI −97 to 64; Analysis 6.3).

Total time spent sitting, including sitting at and outside work: follow-up at medium-term

One RCT, Verweij 2012, found a non-significant decrease in total sitting time with guideline-based counselling by an occupational physician compared to usual care by an occupational physician (MD −20 minutes per day, 95% CI −85 to 45; Analysis 6.4).

Outcome: standing time at work

Time spent standing at work: follow-up at short-term

One RCT, De Cocker 2016, found a non-significant effect of information and feedback compared to no intervention on time spent standing at work at short-term follow-up (MD 10 minutes per eight-hour workday, 95% CI −17 to 38; Analysis 6.5).

Outcome: work engagement

One RCT, Coffeng 2014, found a non-significant difference in work engagement (MD 0.1 score points, 95% CI −0.1 to 0.3; on a scale of 0 to 6) at medium-term follow-up (Analysis 6.6).

Prompts combined with information versus information alone

Outcome: sitting time

Time spent sitting at work: follow-up at short-term

Three RCTs compared the effects of computer prompts combined with information to information only on time spent sitting at work (Evans 2012; Donath 2015; Urda 2016). The pooled effect size for the computer prompts combined with information compared to information alone was not significant (−14 minutes per eight-hour workday, 95% CI −39 to 10; I^2 =0%) (Analysis 7.1).

Time spent sitting at work: follow-up at medium-term

One RCT, Pedersen 2013, reported a mean decrease in sitting time at work of 55 minutes per eight-hour workday (95% CI −96 to −14) when computer prompting combined with information was compared to information alone (Analysis 7.2).

Number of sitting bouts lasting 30 minutes or more: follow-up at short-term

One RCT, Evans 2012, found a significant but small decrease of on average 1.1 sitting bouts lasting 30 minutes or more per day (95% CI −1.9 to −0.3) when computer prompting combined with information was compared to information alone (Analysis 7.3).

Total duration of sitting bouts lasting 30 minutes or more: follow-up at short-term

One RCT, Evans 2012, also found a reduction of on average 74 minutes per day in the total duration of sitting bouts lasting 30 minutes or more (95% CI −124 to −24) when computer prompts combined with information was compared to information alone (Analysis 7.4).

Outcome: standing time at work

Time spent standing at work: follow-up at short-term

One RCT, Donath 2015, found a non-significant increase in time spent standing at work with computer prompts combined with information compared to information alone at short-term follow-up (MD 32 minutes per eight-hour workday, 95% CI −7 to 72; Analysis 7.5).

Outcome: energy expenditure at workplace

Calories: follow-up at medium-term

One RCT, Pedersen 2013, found a non-significant difference between the effects of an intervention using computer prompts combined with information compared to information alone on estimated energy expenditure at the workplace based on reported activities (MD −278 kilocalories per workday, 95% CI −556 to 0.01; Analysis 7.6).

Computer prompts with instruction to walk 100 steps versus computer prompts with instruction to stand

Outcome: sitting time

Time spent sitting at work: follow-up at short-term

One RCT, Swartz 2014, found that employees who received computer prompts to step, sat on average 14 minutes per eight-hour workday more (95% CI 10 to 19) than employees who received computer prompts to stand (Analysis 8.1).

Number of sitting bouts lasting 30 minutes or more: follow-up at short-term

In the same study, Swartz 2014, the number of sitting events lasting 30 minutes or more was on average 0.4 (95% CI 0.3 to 0.5) higher among the employees in the step group than among the employees in the stand group (Analysis 8.2).

Outcome: standing and stepping time

Time spent standing and stepping at work: follow-up at short-term

One RCT, Swartz 2014, found that employees who received computer prompts to step stood on average 12 minutes less (95% CI −15 to −8; Analysis 8.3) and stepped on average 7 minutes more (95% CI 5 to 8; Analysis 8.4) compared to employees who received computer prompts to stand.

Highly personalised information versus less personalised information

Total duration of sitting bouts lasting 30 minutes or more: follow-up at short-term

One RCT, Priebe 2015, found a non-significant increase in the total duration of sitting bouts lasting 30 minutes or more at short-term follow-up (MD 14 minutes per eight-hour workday, 95% CI −37 to 65; Analysis 9.1).

Mindfulness training versus no intervention

Outcome: sitting time

Time spent sitting at work: follow-up at medium-term

One RCT, van Berkel 2014, found a non-significant reduction in sitting time at work with mindfulness training compared to no intervention at medium-term follow-up (MD −23 minutes per day, 95% CI −63 to 17; Analysis 10.1).

Outcome: work engagement

One study, van Berkel 2014, reported no significant difference in work engagement (on a scale of 0 to 6) at medium-term follow-up (0.2 score points; 95% CI −0.1 to 0.5; Analysis 10.2). The authors assessed work engagement using the Utrecht Work Engagement Scale, which is a self-reported questionnaire that measures three aspects of engagement: vigour, dedication and absorption.

Activity tracker combined with organisational support versus organisational support only

Time spent sitting at work: follow-up at short-term

One RCT, Brakenridge 2016, found a non-significant difference in the effectiveness of an activity tracker combined with organisational support and organisational support only in reducing time spent sitting at work at short-term follow-up (MD −6.60 minutes per eight-hour workday, 95% CI −35 to 22; Analysis 11.1).

Time spent sitting at work: follow-up at medium-term

One RCT, Brakenridge 2016, found a non-significant difference in the effectiveness of an activity tracker combined with organisational support and organisational support only in reducing time spent sitting at work at medium-term follow-up (MD −4.40 minutes per eight-hour workday, 95% CI −33 to 42; Analysis 11.2).

Total duration of sitting bouts lasting 30 minutes or more: follow-up at short-term

One RCT, Brakenridge 2016, found a non-significant increase in the duration of sitting bouts lasting 30 minutes or more at short-term follow-up with an activity tracker combined with organisational support compared to organisational support only (MD 11 minutes per eight-hour workday, 95% CI −28 to 50; Analysis 11.3).

Total duration of sitting bouts lasting 30 minutes or more: follow-up at medium-term

One RCT, Brakenridge 2016, found a non-significant difference in the effectiveness of an activity tracker combined with organisational support and organisational support only in reducing duration of sitting bouts lasting 30 minutes or more at medium-term follow-up (MD −1 minute per eight-hour workday, 95% CI −51 to 48; Analysis 11.4).

Total time spent sitting, including sitting at and outside work: follow-up at short-term

One RCT, Brakenridge 2016, found a non-significant difference in the effectiveness of an activity tracker combined with organisational support and organisational support only in reducing total time spent sitting, including sitting at and outside work, at short-term follow-up (MD 2 minutes per eight-hour workday, 95% CI −42 to 46; Analysis 11.5).

Total time spent sitting, including sitting at and outside work: follow-up at medium-term

One RCT, Brakenridge 2016, found a non-significant decrease in total time spent sitting, including sitting at and outside work, at medium-term follow-up with an activity tracker combined with organisational support compared to organisational support only (MD −8 minutes per eight-hour workday, 95% CI −57 to 40; Analysis 11.6).

Outcome: standing and stepping time

Time spent standing and stepping at work: follow-up at short-term

One RCT, Brakenridge 2016, found a non-significant change in time spent standing (MD 3 minutes per eight-hour workday, 95% CI −20 to 26 minutes per eight-hour workday; Analysis 11.7) and stepping at work (MD 4 minutes per eight-hour workday, 95% CI −6 to 14 minutes per eight-hour workday; Analysis 11.8) with an activity tracker combined with organisational support compared to organisational support only at short-term follow-up.

Time spent standing and stepping at work: follow-up at medium-term

One RCT, Brakenridge 2016, found a non-significant change in time spent standing (MD −12 minutes per eight-hour workday, 95% CI −45 to 20 minutes per eight-hour workday; Analysis 11.9) and stepping at work (MD 8 minutes per eight-hour workday, 95% CI −4 to 19 minutes per eight-hour workday; Analysis 11.10) with an activity tracker combined with organisational support compared to organisational support only at medium-term follow-up.

Multi-component intervention versus no intervention

Outcome: sitting time

Time spent sitting at work: follow-up at short-term

Three RCTs reported effects on time spent sitting at work at short-term follow-up (Ellegast 2012; Danquah 2017; Healy 2016). The pooled analysis of two studies (Ellegast 2012; Healy 2016), showed a significant reduction of on average 101 minutes per eight-hour workday (95% CI −117.27 to −84, I^2 =0%; Analysis 12.1) in time spent sitting at work at short-term follow-up. However, the third study, Danquah 2017, reported a much smaller reduction in sitting of on average 48 minutes per eight-hour workday (95% CI −62 to −34). Therefore, we did not pool this study with the other two studies comparing the effect of multi-component intervention versus no intervention, due to substantial heterogeneity (I^2 = 92%).

Time spent sitting at work: follow-up at medium-term

The pooled analysis of two RCTs (Coffeng 2014; Healy 2016), showed a significant decrease of on average 46 minutes per eight-hour workday in workplace sitting (95% CI −63 to −29, I^2 = 0%) following multi-component intervention compared to no intervention at medium-term follow-up (Analysis 12.2).

Number of sitting bouts lasting 30 minutes or more: follow-up at short-term

One RCT, Danquah 2017, found a small decrease in the number of sitting bouts lasting 30 minutes or more with multi-component intervention compared to no intervention at short-term follow-up (MD −0.4 bouts per day, 95% CI −0.7 to −0.12; Analysis 12.3).

Total duration of sitting bouts lasting 30 minutes or more: follow-up at short-term

One RCT, Healy 2016, found a decrease of 73 minutes, on average, per eight-hour workday (95% CI −94 to −51) in the total duration of sitting bouts lasting 30 minutes or more following multi-component intervention compared to no intervention at short-term follow-up. However, in the study by Danquah 2017, a much smaller decrease was found in the total duration of sitting bouts lasting 30 minutes or more of on average 16 minutes per eight-hour workday (95% CI −31 to −1) following multi-component intervention. Therefore, we did not pool the results of these two studies due to substantial heterogeneity (Analysis 12.4, I^2 = 95%).

Total duration of sitting bouts lasting 30 minutes or more: follow-up at medium-term

One RCT, Healy 2016, reported a non-significant decrease of on average 18 minutes per eight-hour workday (95% CI −46 to 10) in the total duration of sitting bouts lasting 30 minutes or more at medium-term follow-up (Analysis 12.5).

Total time spent sitting, including sitting at and outside work: follow-up at short-term

Two RCTs reported total time spent sitting, including sitting at and outside work, at short-term follow-up (Ellegast 2012; Healy 2016). The pooled analysis showed a significant reduction of on average 73 minutes per day (95% CI −92 to −54) in total time spent sitting, including sitting at and outside work with multi-component intervention compared to no intervention (Analysis 12.6).

Total time spent sitting, including sitting at and outside work: follow-up at medium-term

One RCT, Healy 2016, reported a reduction of on average 36 minutes per day (95% CI −62 to −11) in total time spent sitting, including sitting at and outside work, at medium-term follow-up (Analysis 12.7).

Outcome: standing and stepping time

Time spent standing and stepping at work: follow-up at short-term

Two RCTs reported effects on time spent standing at work at short-term follow-up (Danquah 2017; Healy 2016). In Healy 2016, an increase was reported of on average 95 minutes per eight-hour workday (95% CI 79 to 112) in time spent standing at work with multi-component intervention compared to no intervention (Analysis 12.8). Danquah 2017, however, reported a significantly smaller increase of 43 minutes, on average, per eight-hour workday (95% CI 30 to 56; Analysis 12.8). We did not pool the results of these two studies due to high heterogeneity (I^2 = 96%).

One RCT, Healy 2016, found no significant change in time spent stepping at work (MD 1 minute per eight-hour workday, 95% CI −4 to 5; Analysis 12.9) following multi-component intervention compared to no intervention at short-term follow-up.

Time spent standing and stepping at work: follow-up at medium-term

One RCT, Healy 2016, reported an average increase of 43 minutes per eight-hour workday (95% CI 26 to 60; Analysis 12.10) in standing time, whilst they found no significant change in stepping time at work (MD 0 minutes per eight-hour workday, 95% CI −5 to 4; Analysis 12.11) at medium-term follow-up.

Outcome: work engagement

Work engagement: follow-up at medium-term

One study, Coffeng 2014, reported no change in work engagement scale score (MD 0 points, 95% CI −0.1 to 0.1, on a scale from 0 to 6) following multi-component intervention compared to no intervention at medium-term follow-up (Analysis 12.12).

Outcome: adverse events

Musculoskeletal symptoms: follow-up at short-term

One study, Danquah 2017, reported no change in musculoskeletal symptom score (MD −0.2 points, 95% CI −0.32 to −0.02, on a scale from 0 to 6) following multi-component intervention compared to no intervention at short-term follow-up (Analysis 12.13).

DISCUSSION

Summary of main results

We identified 34 studies which evaluated interventions for reducing sitting at work. These studies investigated physical workplace changes in workplace design and environment, workplace policy changes, information and counselling, and multi-component interventions for reducing sitting at work.

Physical workplace changes

According to ten studies, providing workers with sit-stand desks either alone or in combination with information and counselling reduces workplace sitting at short-term by on average 100 minutes per eight-hour workday (95% CI −116 to −84, low-quality evidence) compared to sit-desks. This finding shows that sit-stand desk interventions may contribute to achieving the two to four hours of standing at work promoted by a group of experts, in the short term (Buckley 2015). The prediction interval for sitting time at work resulting from interventions comparing sit-stand desks to sit-desks ranges from −146 to −54, indicating that in 95% of cases the effect a new unique intervention will fall within these values. It is important to know which activity replaced sitting with the implementation of intervention. The sit-stand desk intervention seems to replace sitting primarily with standing at short-term follow-up (MD 89 minutes, 95% CI 76 to 102). The effectiveness of sit-stand desk seems to decrease with the length of follow up, with two studies showing an average reduction of 57 minutes per day (95% CI −99 to −15) at medium-term follow-up. In two studies that had a follow-up at short-term, providing workers with sit-stand desks reduced the total amount of time spent in bouts of prolonged sitting by 53 minutes a day (95% CI −79 to −26, very low-quality evidence). Similarly, total sitting time (including sitting at and outside work) also decreased at short-term follow-up on average by 82 minutes per day (95% CI −124 to −39, two studies). A single study found a non-significant difference between standing desks and sit-stand desks in their effects on reducing the total amount of time spent in bouts of prolonged sitting. The effects of active workstations, such as treadmill desks or cycling desks, on sitting time were unclear or inconsistent.

Policies to change organisation of work

One study showed that implementing walking strategies had no significant effect on workplace sitting time at short-term (MD −15 minutes per day, 95% CI −50 to 19, low-quality evidence) and medium-term follow-up (MD −17 minutes per day, 95% CI −61 to 28). Furthermore, a single study found that short breaks (one to two minutes every half hour) reduced time spent sitting at work on average by 40 minutes per day (95% CI 66 to 15, low-quality evidence) more than long breaks (two 15-minute breaks per workday) at short-term follow-up.

Information and counselling

The pooled effect size from two studies which evaluated provision of information and feedback found a non-significant reduction in time spent sitting at work at short-term follow-up (MD −19 minutes per day, 95% CI −57 to 19, low-quality evidence). A pooled analysis of two studies comparing counselling to no intervention, showed a significant reduction in time spent sitting at work at medium-term follow-up (MD −28 minutes per day, 95% CI −51 to −5, low-quality evidence). Computer prompting led to a nonsignificant reduction in sitting time at work in the short term (MD −14 minutes per day, 95% CI −39 to 10, 3 studies, low-quality evidence). However, their effect at medium-term follow-up was significant (MD −55 minutes per day, 95% CI −96 to −15, one study). Furthermore, computer prompting resulted in a significant decrease in the average number (−1.1, 95% CI −1.9 to −0.3, one study). and duration (MD -74 minutes per day, 95% CI −124 to −24) of sitting bouts lasting 30 minutes or more. A single study found that, in the short term, employees receiving computer prompts to step sat on average 14 minutes more per eight-hour workday (95% CI 10 to 19) than employees receiving computer prompts to stand. One study found no significant added benefit of providing highly personalised information compared to less personalised information in terms of reducing sitting time at work. A single study did not find a significant change in workplace sitting time at medium-term follow-up with mindfulness training (MD −16 minutes, 95% CI −45 to 12, low-quality evidence). Similarly, a single study found no significant effects of activity trackers on reducing sitting at work in short and medium terms.

Interventions from multiple categories

Multi-component interventions consisting of physical workplace changes, workplace policy changes, and informational components resulted in significant reductions of time spent sitting at work (three studies, very low-quality evidence) and time spent in prolonged sitting bouts (two studies, very low-quality evidence) in the short term. However, there was significant heterogeneity in effect sizes between different studies. At medium-term follow-up, the pooled effects of two studies showed a reduction of 46 minutes, on average, per eight-hour workday (95% CI −63 to −29) with multi-component intervention.

Overall completeness and applicability of evidence

In total, we included 34 studies assessing various kinds of interventions for reducing time spent sitting at work. Most studies assessed the effectiveness of sit-stand desks, and the results of our review largely concern this particular intervention. There are no RCTs or controlled before-and-after studies that have specifically assessed the effects of standing meetings or walking meetings to reduce sitting at work.

The included studies are all from Australia, Europe, Canada, and the USA. We not find any studies from other countries or continents. None of the included studies had been conducted in low- and middle-income countries. This potentially limits the generalisability of the findings of this review beyond the settings in which the included studies have been conducted. This is partly because work environments and normal practices vary greatly across the globe, and the acceptability and feasibility of workplace interventions pertaining to sitting at work may differ accordingly. Since obesity and other lifestyle-related diseases are common in high-income countries, it is not surprising that most studies were from such countries. However, since these diseases are now becoming increasingly prevalent in other countries, for example, in some parts of Asia (Tan 2011; Wang 2011), it would be important to test the effectiveness of these interventions among office employees in a more diverse range of countries.

Almost all studies included in this Cochrane Review have used only short-term follow-up. There are no studies with a follow-up period longer than one year. It is important to demonstrate that behaviour change from sitting to a more active behaviour is sustainable in the long term. The cost of interventions, such as implementation of sit-stand desks, may be considerable; but if the effects can be sustained in the long-term, potential benefits are more likely to outweigh the costs.

The population of participants in the included studies consists of office workers of academic institutions, a government agency, a police organisation, and private organisations. We believe that the overall population is largely representative of office workers who spend a large part of their working time sitting and who are in need of interventions to reduce their workplace sitting time.

Although individually focused interventions, such as sit-stand desks, seem to be very popular, they are considerably more expensive than standard desks and so their use may not be feasible in many workplaces with limited financial resources. In some settings, standing meetings may be an alternative, low-cost option for reducing sitting time at work (Atkinson 2014). Motivational posters or prompting to stand up or engage in light- to moderate-intensity physical activity, or placing printers or dust-bins away from desks, could also be feasible low-cost interventions for larger groups of employees. There is some evidence of health benefits available for breaking up sitting time with intermittent brief bouts of light-intensity or moderate-intensity physical activity (Bailey 2015; Larsen 2014) but, as for now, no definite conclusions can be drawn about applicability of such findings to workplaces. There is a need for evaluating the effectiveness of low-cost interventions that would enable workers to break up sitting time by engaging in brief bouts of physical activity. Only some of the included studies assessed outcomes like standing or stepping to identify where the sitting time was reallocated. It would be important to assess this in future studies, as reallocation of time spent sitting at work to walking or other physical activities would potentially be a more healthy substitute than reallocation to standing.

Quality of the evidence

Even though 26 of 34 studies included in this Cochrane Review are RCTs or cluster-RCTs, we considered the majority of them to be at high risk of bias and therefore the quality of evidence they yield is low to very low. With complex interventions in the occupational health setting, the random allocation and its concealment is known to be more difficult than in clinical trials. Nevertheless, 10 of the included studies managed to achieve it. Unless sample size is large enough, random allocation does not distribute the potential confounders equally across groups; therefore, randomisation is not very effective in studies as small as those included in our review. Further, the self-evident nature of the interventions makes it very difficult to blind personnel and participants.

Risk of bias for device-based measures of sitting time by accelerometer-inclinometer differs from self-reported sitting time. Participants may be aware of the goals of intervention and overestimate or underestimate sitting time, if it is assessed by self-reports. Using accelerometer-inclinometers may make it less likely for participants to interfere with outcome measurement. Consequently the use of device-measured sedentary behaviour has been recommended for intervention trials (Pedišić 2015).

Two studies are not RCTs as stated a priori in their publication, because they randomised only two groups (Alkhajah 2012; Neuhaus 2014a). The trial authors described them as quasi-RCTs. The risk of baseline differences is much higher for such studies with only two clusters, so we categorised these two studies as controlled before-and-after studies, rather than RCTs. We addressed the baseline imbalances for both studies in our 'Risk of bias' assessment.

Although studies performed poorly on the allocation concealment and blinding of participants and personnel domains, most studies assessed the outcomes in a way that we judged to have a low risk of bias. Taking all this into consideration, we rated the overall quality of the evidence as low to very low.

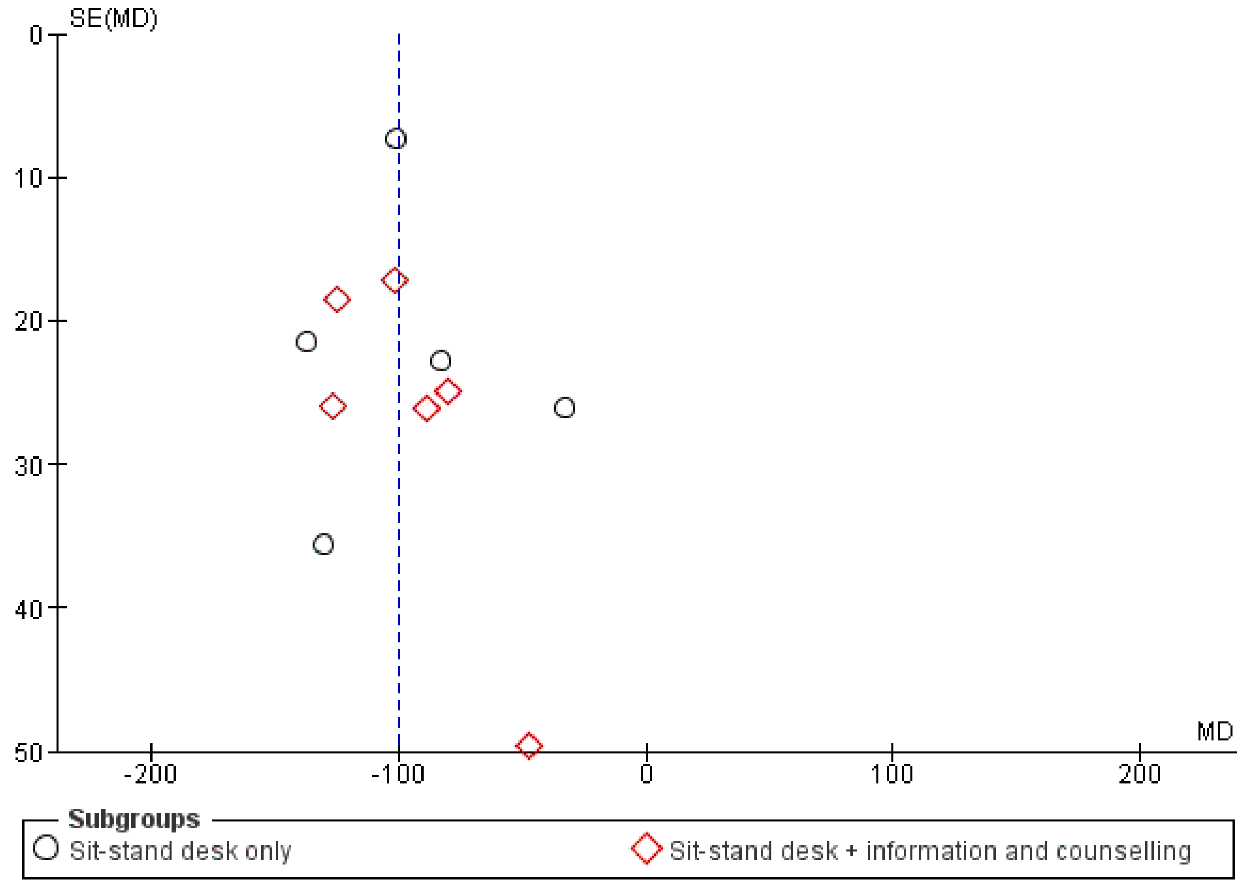
Potential biases in the review process

We did not exclude articles published in languages other than English. In this way, we avoided language bias in our review.

We could not assess the robustness of our results, as there were not enough studies with a low risk of bias to perform a meaningful sensitivity analysis.

To avoid publication bias, we searched sources of grey literature and unpublished studies and data. We noted no obvious asymmetry (which would indicate publication bias) in the funnel plots of studies comparing sit-stand desks with or without information and counselling with sit-desks for time spent sitting at work as an outcome (Figure 4). For other comparisons and outcomes, there were too few studies per outcome (less than 10 studies) to assess publication bias using funnel plots. However, the fact that most included studies were small and all reported positive outcomes is indicative that there may be publication bias in this area. If more studies are included in a future update of this review, we will assess the extent of publication bias by means of funnel plots and Egger's test (Egger 1997).

Figure 4. Funnel plot of comparison: 1 Sit-stand desk with or without information and counselling versus sit-desk, outcome: 1.1 Mean difference in time spent sitting at work: short-term follow-up.



Agreements and disagreements with other studies or reviews

Recently, several systematic reviews have been published on interventions for reducing sedentary behaviour (Commissaris 2016; Gardner 2015a; Martin 2015; Prince 2014). Two of these assessed the effectiveness of interventions for reducing sedentary behaviour in adults at the workplace as well as in other settings; they included 51 studies (Martin 2015), and 65 studies (Prince 2014). Both reviews concluded that sedentary behaviour interventions in adults may be effective for reducing sedentary behaviour. A recent systematic review by Commissaris 2016, containing 40 studies, assessed the effectiveness of workplace interventions to change employees' sedentary behaviour or physical activity, or both. This systematic review found strong evidence for a decrease in sedentary behaviour with the use of alternative desks, and this differs considerably from our finding of very-low to low-quality evidence for alternative desks.

Another recent systematic review with 26 included studies, Gardner 2015a, looked into the behaviour change strategies adopted by sedentary behaviour interventions using the Behaviour Change Wheel. It found that using more techniques made the interventions more promising in terms of their effectiveness. The most frequently observed behaviour change techniques were: setting behavioural goals, providing social support, and environmental interventions. In Gardner 2015a, they found two workplace interventions to be promising: education and environmental interventions. Only the finding about the latter type of interventions is in line with the findings of our review.

The differences in energy expenditure between sitting and standing seem to be minor. In Mansoubi 2015, it was found that sitting typing tasks resulted in energy expenditure of 1.45 METs (standard deviation (SD) 0.32), whereas the energy cost of standing equated to 1.59 METs (SD 0.37). By contrast, there was a considerable difference between energy costs of sitting and physical activity; for example, walking MET values increased incrementally with speed from 2.17 METs (SD 0.5) at 0.2 miles/hour to 3.22 METs (SD 0.69) at 1.6 miles/hour. It is therefore clear that the use of more dynamic workstations has the potential to considerably increase energy costs. For example, energy expenditure of using a desk-bike type workstation at light intensity reaches 2.4 METs (Botter 2015). Mansoubi 2015, in line with this, questions if the health benefits of reduced sedentary behaviour are primarily driven by increases in energy expenditure that accompany the transition to light activity (e.g. cycling), differences in postural allocation (e.g. standing), or a combination of both (e.g. walking and cycling). This should be further investigated, to inform future interventions.

Although obesity in employees might incur a significant loss for the workplace (Shrestha 2016), aiming to reduce obesity or overweight by standing up at work may, however, not be pragmatic. One study found only a marginally higher additional metabolic cost for quiet standing compared to sitting (Júdice 2015b). In theory, if an average man and woman spent 50% of an eight-hour workday standing, they would spend approximately an additional 20 kilocalories (kcal) and 12 kcal, respectively. Our findings show that after three months, a sit-stand desk combined with counselling increased time spent standing on average by 89 minutes (95% CI 76 to 102), so the additional energy expenditure that can be expected from standing in such interventions is negligible. In accordance with our finding, the authors of a longitudinal study suggested that increasing occupational standing time may not be sufficient to prevent the development of overweight, obesity, impaired glucose tolerance, and type 2 diabetes (Chaput 2015).

One study has suggested that higher amounts of time spent standing may be associated with reduced risk of all-cause and cardiovascular-disease mortality (Katzmarzyk 2014). Given that mortality rates decline at higher levels of standing, regardless of insignificant increase in energy expenditure, it may be that standing is generally a healthier behaviour than sitting. However, promoting sustained standing over longer periods of time also does not seem a reasonable solution; for example, Andersen 2007, reported increased musculoskeletal symptoms associated with prolonged standing. Coenen and colleagues have mentioned that an intervention with increased standing and reduced sitting was less effective for people with low back pain than those without low back pain (Coenen 2015). It is not yet known at which amount of standing we may expect adverse health effects, but it is possible that promoting four hours of standing per day during work hours could have negative consequences for some population groups. For instance, elderly workers complain when performing standing work, even if it constitutes less than 50% of their working time (Graf 2015). Pedišić and colleagues have suggested that exploring the effectiveness of interventions promoting an optimal balance between physical activity, quiet standing, sedentary behaviour, and sleep may be an important avenue for future research (Pedišić 2017).

AUTHORS' CONCLUSIONS

Implications for practice

Regarding interventions in the category 'physical changes in workplace design and environment', there is low-quality evidence that a sit-stand desk reduces workplace sitting time at short-term and medium-term follow-up. The expected reduction in sitting time with this type of intervention is a little less than two hours per day in short term, which is nearly sufficient on its own to meet expert recommendations on reducing occupational sedentary behaviour. However, the sustainability of these effects over longer periods still remains to be examined. Sit-stand desks do not have significant effects on work performance, whilst their effects on musculoskeletal symptoms are unclear. The effects of active workstations are inconsistent; treadmill desks seem to reduce inactive sitting time, but we found no significant effects for a cycle desk intervention.

Regarding interventions in the category 'policies to change the organisation of work', studies found that implementing walking strategies had no significant effects on workplace sitting. A single study found taking short breaks to be more effective than taking long breaks for reducing time spent sitting at work. However, it should be noted that the total durations of short breaks (approximately eight breaks of one to two minutes) and long breaks (two breaks of 15 minutes) in this study were not equal; hence the finding about the difference in their effectiveness is vague.

Regarding interventions in the category 'provision of information and counselling', a single study found no significant effects for mindfulness training, while the provision of information, feedback or counselling (or both) and computer prompting showed inconsistent effects on workplace sitting.

Multi-component interventions consisting of physical workplace changes, workplace policy changes, and informational components resulted in significant reductions of time spent sitting at work, but significant heterogeneity in their effects across studies prevent estimation of a pooled effect size.

Implications for research

Regarding physical changes of the workplace design and environment, we need studies on sit-stand desks with larger sample sizes and longer duration of follow-up and more studies testing the effectiveness of active workstations. To prevent possible contamination, we recommend randomising employees using a cluster-randomised design with at least two intervention sites and two control sites but preferably many more, to minimise confounding by workplace-specific variables (EPOC). Even when employees are not explicitly told which group they are in, true blinding is not possible as intervention activities will be noticeable at work sites (McEachan 2011). We recommend conducting trials aimed at reducing sitting at work in low- and middle-income countries, where the burden of non-communicable diseases is also increasing.

Regarding policies to change the organisation of work, there is a need to conduct trials evaluating low-cost interventions (e.g. standing meetings or walking meetings, posters or prompts for standing, printers or dust-bins placed away from the workstation), as they might be the only feasible options in settings with limited financial resources. To develop more effective interventions, it might be important to first better understand the ideas that workers and employers have about health effects of excessive sitting and means to reduce it. There is qualitative research on this topic available that should be summarised in a systematic review.

Future studies should consider measuring the time spent sitting using wearable devices, because of their superior measurement properties compared to self-reports. Thigh-mounted accelerometer-inclinometers may be useful for this purpose, because the thigh changes its angle when shifting from sitting to standing (Janssen 2015). We do not recommend only employing self-reported measures as their validity may not be adequate for intervention trials (Aadahl 2003; Lagersted-Olsen 2014). Moreover, participants receiving the intervention are aware of the goals set and the intention of the intervention, and are therefore susceptible to recall bias when reporting their sitting time (Rzewnicki 2003; Shephard 2003). Furthermore, if the intervention is found to reduce sitting, future studies should try to examine what behaviour replaces sitting (e.g. standing, light-intensity physical activity, or moderate- to vigorous-intensity physical activity). Mansoubi and colleagues argued that reducing sitting time at work might result in more sitting during leisure (Mansoubi 2016). However, a recent systematic review found that interventions aimed at reducing sitting at work also reduced sitting during leisure time (Shrestha 2018). Hence, it is important that workplace intervention studies assess time spent sitting not only in the work domain but also, if possible, in non-occupational domains.

We recommend including outcome measures that will be of interest to employers, such as valid and reliable measures of productivity, job stress, absenteeism, and cardio-metabolic health. Future studies should also consider including cost-effectiveness analyses to help stakeholders and decision makers determine whether the cost of interventions to reduce sitting at work is justified by improvements in health and work-related outcomes.

Where applicable, the effect should be statistically adjusted for the clustering effect. The overall sample size and the number of clusters should be taken into account when recruiting participants, in order to calculate the required sample size for achieving adequate statistical power.

The ongoing studies that we identified study effectiveness of sit-stand desks, treadmill desks, cycle desks, walking strategies, computer prompts, provision of information, and counselling. There are still no workplace RCTs evaluating other types of interventions, such as sitting diaries, stepping devices and assessing specifically standing meetings or walking meetings.

One ongoing study has been designed according to our recommendations (O'Connell 2015). This study is a cluster-RCTs and will have at least two intervention and two control sites. This study has planned to assess the effectiveness of sit-stand or height adjustable desks and measure sitting at work with an accelerometer-inclinometer.

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REFERENCES

References to studies included in this review

Alkhajah 2012 *{published data only}*

* Alkhajah TA, Reeves MM, Eakin EG, Winkler EA, Owen N, Healy GN. Sit-stand workstations: a pilot intervention to reduce office sitting time. *American Journal of Preventive Medicine* 2012;**43**(3):298-303.

Healy G, Alkhajah T, Winkler E, Owen N, Eakin E. Reducing sitting time in office workers: efficacy and acceptability of sit-stand workstations. *Journal of Science and Medicine in Sport* 2012;**15**:S196.

Brakenridge 2016 *{published data only}*

ACTRN12614000252617. Comparison of organisational support vs. organisational plus technology support for reducing prolonged sitting in office workers. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=365886 (accessed 12 September 2017).

* Brakenridge CL, Fjeldsoe BS, Young DC, Winkler EA, Dunstan DW, Straker LM. Evaluating the effectiveness of organisational-level strategies with or without an activity tracker to reduce office workers' sitting time: a cluster-randomised trial. *International Journal of Behavioural Nutrition and Physical Activity* 2016;**13**(1):115.

Brakenridge CL, Fjeldsoe BS, Young DC, Winkler EA, Dunstan DW, Straker LM. Organizational level strategies with or without an activity tracker to reduce office workers' sitting time: rationale and study design of a pilot cluster-randomized trial. *JMIR research protocols* 2016;**5**(2):e73.

Carr 2015 *{published data only}*

Carr LJ, Leonhard C, Tucker S, Fethke N, Benzo R, Gerr F. Total worker health intervention increases activity of sedentary workers. *American Journal of Preventive Medicine* 2015;**49**:[Epub ahead of print].

NCT02071420. Efficacy of a combined ergonomic health promotion intervention on employee health. https://clinicaltrials.gov/ct2/show/NCT02071420 (accessed 28 November 2015).

Chau 2014 *{published data only}*

ACTRN12612000072819. The Stand@Work Pilot Study. A randomised controlled trial to see if using sit-stand workstations reduces sitting time in office workers. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12612000072819 (accessed 3 June 2015).

* Chau JY, Daley M, Dunn S, Srinivasan A, Do A, Bauman AE, et al. The effectiveness of sit-stand workstations for changing office workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *International Journal of Behavioral Nutrition and Physical Activity* 2014;**11**:127.

Chau JY, Daley M, Srinivasan A, Dunn S, Bauman AE, van der Ploeg HP. Desk-based workers' perspectives on using sit-stand workstations: a qualitative analysis of the Stand@Work study. *BMC Public Health* 2014;**14**:752.

Chau 2016 *{published data only}*

Chau JY, Sukala W, Fedel K, Do A, Engelen L, Kingham M, et al. More standing and just as productive: effects of a sit-stand desk intervention on callcenter workers' sitting, standing, and productivity at work in the Opt to Standpilot study. *Preventive Medicine Reports* 2016;**3**:68-74.

Coffeng 2014 *{published data only}*

* Coffeng JK, Boot CR, Duijts SF, Twisk JW, van Mechelen W, Hendriksen IJ. Effectiveness of a worksite social & physical environment intervention on need for recovery, physical activity and relaxation; results of a randomized controlled trial. *PLoS ONE* 2014;**9**(12):e114860.

Coffeng JK, Hendriksen IJ, Duijts SF, Proper KI, Mechelen WV, Boot CRL. The development of the Be Active & Relax "Vitality in Practice" (VIP) project and design of an RCT to reduce the need for recovery in office employees. *BMC Public Health* 2012;**12**:592.

Coffeng JK, Hendriksen IJ, van Mechelen W, Boot CR. Process evaluation of a worksite social and physical environmental intervention. *Journal of Occupational and Environmental Medicine* 2013;**55**(12):1409-20.

Coffeng JK, Hendriksen IJM, Duijts SFA, Twisk JWR, Van Mechelen W, Boot CRL. Effectiveness of a combined social and physical environmental intervention on presenteeism, absenteeism, work performance and work engagement in office employees. Journal of Occupational Environment Medicine in press; Vol. 56, issue 3:258-65.

NTR2553. The cost-effectiveness of an intervention to increase physical activity and relaxation amongst office workers. http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=2553 (accessed 3 June 2014).

Danquah 2017 *{published data only}*

* Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll AK, et al. Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. *International Journal of Epidemiology* 2017;**46**(1):128–40.

Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup JS. Effects on musculoskeletal pain from "Take a stand!" – A cluster-randomized controlled trial reducing sitting time among office workers. *Scandinavian Journal of Work, Environment and Health.* 2017;**43**(4):350-7.

NCT01996176. Take a Stand! - an intervention to reduce occupational sitting time. https://clinicaltrials.gov/ct2/show/NCT01996176 (accessed 12 September 2017).

De Cocker 2016 *{published data only}*

* De Cocker K, De Bourdeaudhuij I, Cardon G, Vandelanotte C. The effectiveness of a web-based computer-tailored intervention on workplace sitting: a randomized controlled trial. *Journal of Medical Internet Research* 2016;**18**(5):e96.

De Cocker Katrien, De Bourdeaudhuij I, Cardon G, Vandelanotte C. What are the working mechanisms of a web-based workplace sitting intervention targeting psychosocial factors and action planning?. *BMC Public Health* 2017;**1**:382.

NCT02672215. RCT Computer-tailored intervention on workplace sitting (StartToStand). https://clinicaltrials.gov/ct2/show/NCT02672215 (accessed 12 September 2017).

Donath 2015 *{published data only}*

Donath L, Faude O, Schefer Y, Roth R, Zahner L. Repetitive daily point of choice prompts and occupational sit-stand transfers, concentration and neuromuscular performance in office workers: an RCT. *International Journal of Environmental Research and Public Health* 2015;**12**(4):4340-53.

Dutta 2014 *{published data only}*

* Dutta N, Koepp GA, Stovitz SD, Levine JA, Pereira MA. Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. *International Journal of Environmental Research and Public Health* 2014;**11**(7):6653-65.

Dutta N, Walton T, Pereira MA. Experience of switching from a traditional sitting workstation to a sit-stand workstation in sedentary office workers. *Work* 2014;**52**(1):83-9.

Ellegast 2012 *{published and unpublished data}*

Ellegast R, Weber B, Mahlberg R. Method inventory for assessment of physical activity at VDU workplaces. Work. 2012; Vol. 41, issue suppl 1:2355-9.

* Mahlberg R. Entwicklung und Erprobung eines arbeitsmedizinischen Methodeninventars zur Effektivitätsanalyse von Präventionsmassnahmen zur Vermeidung von Muskel-Skelett Erkrankungen an bewegungsarmen Arbeitsplätzen. Hohen Medizinischen Fakultät der Ruhr-Universität Bochum. PhD dissertation 2011.

Evans 2012 *{published data only}*

* Evans RE, Fawole HO, Sheriff SA, Dall PM, Grant PM, Ryan CG. Point-of-choice prompts to reduce sitting time at work: a randomised trial. *American Journal of Preventive Medicine* 2012 Sep;**43**(3):293-7.

NCT01628861. Point-of-choice prompts to reduce prolonged sitting time at work. http://clinicaltrials.gov/ct2/show/NCT01628861 (accessed 15 March 2014).

Gao 2015 *{published data only}*

Gao Y, Nevala N, Cronin NJ, Finni T. Effects of environmental intervention on sedentary time, musculoskeletal comfort and work ability in office workers. *European Journal of Sport Science* 2015;**(Epub ahead of print)**:1-8.

ISRCTN43848163. Can an adjustable workstation reduce occupational sedentary time?. http://www.isrctn.com/ISRCTN43848163 (accessed 3 June 2015).

Gilson 2009 *{published data only}*

Gilson ND, Puig-Ribera A, McKenna J, Brown WJ, Burton NW, Cooke CB. Do walking strategies to increase physical activity reduce reported sitting in workplaces: a randomised control trial. *International Journal of Behavioral Nutrition and Physical Activity* 2009;**6**:43.

Gordon 2013 *{published data only}*

Gordon A. A theory-based pilot study to decrease sitting time in the workplace. A theory-based pilot study to decrease sitting time in the workplace (Msc Thesis). Arizona: Arizona State University, 2013.

Graves 2015 *{published data only}*

Graves LEF, Murphy RC, Shepherd SO, Cabot J, Hopkins ND. Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. *BMC Public Health* 2015;**15**(1):1145.

NCT02496507. A mixed-methods evaluation of sit-stand workstations in an office setting. https://clinicaltrials.gov/ct2/show/NCT02496507 (accessed 1 December 2015).

Healy 2013 *{published data only}*

* Healy GN, Eakin EG, Lamontagne AD, Owen N, Winkler EA, Wiesner G, et al. Reducing sitting time in office workers: short-term efficacy of a multi component intervention. *Preventive Medicine* 2013;**57**(1):43-8.

Neuhaus M, Healy G, Eakin E, FJeldsoe B, Lamontagne A, Owen N, et al. Efficacy of an integrated approach to reduce sitting time in office workers. *Journal of Science and Medicine in Sport* 2012;**15**:S197.

Stephens SK, Winkler EA, Trost SG, Dunstan DW, Eakin EG, Chastin SF, et al. Intervening to reduce workplace sitting time: how and when do changes to sitting time occur?. *British Journal of Sports Medicine* 2014;**48**(13):1037-42.

Healy 2016 *{published data only}*

ACTRN12611000742976. In office workers, does environmental modification combined with behavioural counselling, compared to no change, lead to reductions in workplace sitting time. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12611000742976 (accessed 12 September 2017).

Dunstan DW, Wiesner G, Eakin EG, Neuhaus M, Owen N, LaMontagne AD, et al. Reducing office workers' sitting time: rationale and study design for the Stand Up Victoria cluster randomised trial. *BMC Public Health* 2013;**13**:1057.

* Healy GN, Eakin EG, Owen N, Lamontagne AD, Moodie M, Winkler EA. A cluster randomized controlled trial to reduce office workers' sitting time: effect on activity outcomes. *Medicine and Science in Sports and Exercise* 2016;**48**(9):1787-97.

Winkler EA, Chastin S, Eakin EG, Owen N, LaMontagne AD, Moodie M. Cardiometabolic impact of changing sitting, standing, and stepping in the workplace. *Medicine and Science in Sports and Exercise* 2017;**50**(3):516-24.

Kress 2014 *{published data only}*

Kress MM. The use of stand-capable workstations for reducing sedentary time in office employees. *Dissertation Abstracts International: Section B: The Sciences and Engineering* 2015;**76**:6-B(E).

Kress MM. The use of stand-capable workstations for reducing sedentary time in office employees. Doctoral dissertation, Texas A & M University. 2014.

Li 2017 *{published data only}*

ACTRN12615001018505. Examining different sit-stand protocols in terms of health and behavioural outcomes: an office-based pilot study. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=369210 (accessed 12 September 2017).

* Li I, Mackey MG, Foley B, Pappas E, Edwards K, Chau JY, et al. Reducing office workers' sitting time at work using sit-stand protocols: results from a pilot randomized controlled trial. *Journal of Occupational Environmental Medicine* 2016;**59**(6):543-9.

MacEwen 2017 *{published data only}*

* MacEwen BT, Saunders TJ, MacDonald DJ, Burr JF. Sit-stand desks to reduce workplace sitting time In office workers with abdominal obesity: a randomized controlled trial. *Journal of Physical Activity and Health* 2017;**17**:1-18.

NCT02342301. Cardiometabolic Response to Sit-stand Workstations. https://clinicaltrials.gov/ct2/show/NCT02342301 (accessed 12 September 2017).

Mailey 2016 *{published data only}*

* Mailey EL, Rosenkranz SK, Casey K, Swank A. Comparing the effects of two different break strategies on occupational sedentary behavior in a real world setting. *Preventive Medicine Reports* 2016;**4**:423-8.

NCT02609438. An intervention to reduce sitting time at work: effects on metabolic health and inactivity (Up4Health). https://clinicaltrials.gov/ct2/show/NCT02609438 (accessed 12 September 2017).

Neuhaus 2014a *{published data only}*

ACTRN12612001246875. Reducing sitting time in office workers: comparison of a multifaceted workplace approach vs. installation of height-adjustable desks only using a three-armed controlled trial. http://www.anzctr.org.au/ACTRN12612001246875.aspx (accessed 15 March 2014).

* Neuhaus M, Healy GN, Dunstan DW, Owen N, Eakin EG. Workplace sitting and height-adjustable workstations: a randomised controlled trial. *American Journal of Preventive Medicine* 2014;**46**(1):30-40.

Pedersen 2013 *{published and unpublished data}*

Cooley D, Pedersen S, Mainsbridge C. Assessment of the impact of a workplace intervention to reduce prolonged occupational sitting time. *Qualitative Health Research* 2014;**24**(1):90-101.

* Pedersen SJ, Cooley PD, Mainsbridge C. An e-health intervention designed to increase workday energy expenditure by reducing prolonged occupational sitting habits. *Work* 2014;**49**(2):289-95.

Pickens 2016 *{published data only}*

Pickens AW, Kress MM, Benden ME, Zhao H, Wendel M, Congleton JJ. Stand-capable desk use in a call center:a six-month follow-up pilot study. *Public Health* 2016;**135**:131-4.

Priebe 2015 *{published data only}*

Priebe CS, Spink KS. Less sitting and more moving in the office: using descriptive norm messages to decrease sedentary behavior and increase light physical activity at work. *Psychology of Sport and Exercise* 2015;**19**:76-84.

Puig-Ribera 2015 *{published and unpublished data}*

NCT02960750. Effectiveness of a workplace "Sit Less and Move More" web-based program (Walk@WorkSpain) on occupational sedentary behavior, habitual physical activity, physical risk factors for chronic disease and efficiency-related outcomes in Spanish office employees. https://clinicaltrials.gov/ct2/show/NCT02960750 (accessed 12 September 2017).

Puig-Ribera A, Bort-Roig J, Gine-Garriga M, Gonzalez-Suarez AM, Martinez-Lemos I, Fortuno J, et al. Impact of a workplace 'sit less, move more' program on efficiency-related outcomes of office employees. *BMC Public Health* 2017;**17**(1):455.

* Puig-Ribera A, Bort-Roig J, González-Suárez AM, Martínez-Lemos I, Giné-Garriga M, Fortuño J, et al. Patterns of impact resulting from a 'sit less, move more' web-based program in sedentary office employees. *PLoS One* 2015;**10**(4):e01224.

Roig JB, Horcajo MM, Ribera AP, Gonzalez Á, Lemos IM. Walk and Work Spain: Participants' perspectives and experiences on reducing occupational sitting time. *Journal of Science and Medicine in Sport* 2012;**15**(Supplement 1):S303.

Sandy 2016 *{published data only}*

Sandy ME. Longitudinal Study of Adjustable Workstations. Graduate Theses and Dissertations 2016.

Schuna 2014 *{published and unpublished data}*

NCT01587092. Workstation Pilot Study. https://clinicaltrials.gov/ct2/show/NCT01587092 (accessed 3 June 2014).

* Schuna JM Jr, Swift DL, Hendrick CA, Duet MT, Johnson WD, Martin CK, et al. Evaluation of a workplace treadmill desk intervention: a randomized controlled trial. *Journal of Occupational and Environmental Medicine* 2014;**56**(12):1266-76.

Tudor-Locke C, Hendrick CA, Duet MT, Swift DL, Schuna JM Jr, Martin CK, et al. Implementation and adherence issues in a workplace treadmill desk intervention. *Applied Physiology, Nutrition, and Metabolism* 2014;**39**(10):1104-11.

Swartz 2014 *{published data only}*

Swartz AM, Rote AE, Welch WA, Maeda H, Hart TL, Cho YI, et al. Prompts to disrupt sitting time and increase physical activity at work. *Centers for Disease Control and Prevention, Preventing Chronic Disease* 2014;**11**:E73.

Tobin 2016 *{published data only}*

Tobin R, Leavy J, Jancey J. Uprising: An examination of sit-stand workstations, mental health and work ability in sedentary office workers, in Western Australia. *Work* 2016;**55**(2):359-71.

Urda 2016 *{published data only}*

Urda JL, Lynn JS, Gorman A, Larouere B. Effects of a minimal workplace intervention to reduce sedentary behaviors and improve perceived wellness in middle-aged women office workers. *Journal of Physical Activity and Health* 2016;**13**:838-44.

van Berkel 2014 *{published data only}*

van Berkel J, Boot CR, Proper KI, Bongers PM, van der Beek AJ. Effectiveness of a worksite mindfulness-related multi-component health promotion intervention on work engagement and mental health: results of a randomised controlled trial. *PLoS ONE* 2014;**9**(1):e84118.

van Berkel J, Boot CR, Proper KI, Bongers PM, van der Beek AJ. Mindful "Vitality in Practice": an intervention to improve the work engagement and energy balance among workers; the development and design of the randomised controlled trial. *BMC Public Health* 2011;**11**:736.

* van Berkel J, Boot CR, Proper KI, et al. Effectiveness of a worksite mindfulness-based multi-component intervention on lifestyle behaviours. International Journal of Behavioral Nutrition and Physical Activity 2014; Vol. 11.

Verweij 2012 *{published data only}*

ISRCTN73545254. Balance@Work: the cost effectiveness of an occupational health guideline to improve physical activity and dietary behaviour among workers in order to prevent weight gain. http://www.isrctn.com/ISRCTN73545254 2009 (accessed 28 November 2015).

Verweij LM, Proper KI, Weel AN, Hulshof CT, van Mechelen W. Design of the Balance@Work project: systematic development, evaluation and implementation of an occupational health guideline aimed at the prevention of weight gain among employees. *BMC Public Health* 2009;**9**:461.

Verweij LM, Proper KI, Weel AN, Hulshof CT, van Mechelen W. Long-term effects of an occupational health guideline on employees' body weight-related outcomes, cardiovascular disease risk factors, and quality of life: results from a randomised controlled trial. *Scandinavian Journal of Work, Environment & Health* 2013;**39**(3):284-94.

* Verweij LM, Proper KI, Weel AN, Hulshof CT, van Mechelen W. The application of an occupational health guideline reduces sedentary behaviour and increases fruit intake at work: results from an RCT. *Occupational and Environmental Medicine* 2012;**69**(7):500-7.

van Wier MF, Verweij LM, Proper KI, Hulshof CT, van Tulder MW, van Mechelen W. Economic evaluation of an occupational health care guideline for prevention of weight gain among employees. *Journal of occupational and environmental medicine* 2013;**55**(9):1100.

References to studies excluded from this review

Aadahl 2015 *{published data only}*

Aadahl M, Linneberg A, Møller TC, Rosenørn S, Dunstan DW, Witte DR, et al. Motivational counselling to reduce sitting time: a community-based randomized controlled trial in adults. *American Journal of Preventive Medicine* 2015;**47**(5):576-86.

NCT00289237. Lifestyle intervention in a general population for prevention of ischaemic heart disease. https://clinicaltrials.gov/show/NCT00289237 2012 (accessed 1 December 2015).

Adams 2012 *{published data only}*

Adams 2012. On our feet: Feasibility trial of an intervention to reduce sedentary behavior and increase physical activity (PhD Thesis). Greensboro: The University of North Carolina, 2012.

* Melanie M. Adams MM, Davis PG, Gill DL. A hybrid online intervention for reducing sedentary behavior in obese women. *Frontiers in Public Health* 2013;**1**:45.

Aittasalo 2004 *{published data only}*

Aittasalo M, Miilunpalo S, Suni J. The effectiveness of physical activity counselling in a work-site setting. A randomised, controlled trial. *Patient Education and Counselling* 2004;**55**(2):193-202.

Alderman 2014 *{published data only}*

Alderman BL, Olson RL, Mattina DM. Cognitive function during low-intensity walking: a test of the treadmill workstation. *Journal of Physical Activity and Health* 2014;**11**(4):752-8.

Arrogi 2017 *{published data only}*

Arrogi A, Schotte A, Bogaerts A, Boen F, Seghers J. Short- and long-term effectiveness of a three-month individualized need-supportive physical activity counseling intervention at the workplace.. *BMC Public Health* 2017;**17**(1):52.

Audrey 2015 *{published data only}*

Audrey S, Cooper AR, Hollingworth W, Metcalfe C, Procter S, Davis A, et al. Study protocol: the effectiveness and cost effectiveness of an employer-led intervention to increase walking during the daily commute: the Travel to Work randomised controlled trial. *BMC public Health* 2015;**15**:154.

Barbieri 2017 *{published data only}*

Barbieri DF, Srinivasan D, Mathiassen SE, Oliveira AB. Comparison of sedentary behaviors in office workers using sit-stand tables with and without semiautomated position changes. *Human Factors* 2017;**59**(5):782-95.

Ben-Ner 2014 *{published data only}*

Ben-Ner A, Hamann DJ, Koepp G, Manohar CU, Levine J. Treadmill workstations: the effects of walking while working on physical activity and work performance. *PLoS ONE* 2014;**9**(2):e88620.

Berberien 2016 *{published data only}*

Berberien V, Lowensteyn I. Evaluating the impact of a workplace wellness program on women: the experience at Merck Canada after one year. *Canadian Journal of Cardiology* 2016;**32**(4):S1-S2.

Biddle 2015 *{published data only}*

Biddle SJ, Edwardson CL, Wilmot EG, Yates T, Gorely T, Bodicoat DH, et al. A randomised controlled trial to reduce sedentary time in young adults at risk of Type 2 Diabetes Mellitus: project STAND (Sedentary Time ANd Diabetes). *PloS One* 2015;**10**(12):e0143398.

Bird 2014 *{published data only}*

Bird ML, Shing C, Mainsbridge C, Cooley D, Pederson S. Activity behaviours of University staff in the workplace: A pilot study. *Journal of Physical Activity and Health* 2014 [Epub ahead of print];**12**(8):1128-32.

Bjorklund 2015 *{published data only}*

Bjorklund M, Tronarp R, Granas M, Dahlgren G, McDonough S, Nyberg A, et al. Office-cycling while working: an innovative concept to prevent and reduce musculoskeletal pain in office workers-a controlled feasibility study. *Physiotherapy* 2015;**101**:eS155-6.

Boreham 2005 *{published data only}*

Boreham CA, Kennedy RA, Murphy MH, Tully M, Wallace WF, Young I. Training effects of short bouts of stair climbing on cardiorespiratory fitness, blood lipids, and homocysteine in sedentary young women. *British Journal of Sports Medicine* 2005;**39**(9):590-3.

Bouchard 2015 *{published data only}*

Bouchard DR, Strachan S, Johnson L, Moola F, Chitkara R, McMillan D, et al. Using shared treadmill workstations to promote less time spent in daily low intensity physical activities: A pilot study. *Journal of Physical Activity and Health* 2015;**8**:[Epub ahead of print].

Brown 2012 *{published data only}*

Brown DK, Barton JL, Pretty J, Gladwell VF. Walks4work: rationale and study design to investigate walking at lunchtime in the workplace setting. *BMC Public Health* 2012;**12**:550.

Buchholz 2016 *{published data only}*

Buchholz SW, Ingram D, Wilbur J, Fogg L, Sandi G, Moss A, et al. Bilingual Text4Walking food service employee intervention pilot study. *JMIR mHealth and uHealth* 2016;**4**(2):e68.

Carr 2013 *{published data only}*

Carr LJ, Karvinen K, Peavler M, Smith R, Cangelosi K. Multicomponent intervention to reduce daily sedentary time: a randomised controlled trial. *BMJ* 2013;**3**(10):e003261.

Carter 2015 *{published data only}*

Carter SE, Jones M, Gladwell VF. Energy expenditure and heart rate response to breaking up sedentary time with three different physical activity interventions. *Nutrition Metabolism and Cardiovascular Diseases* 2015;**25**(5):503-9.

Chae 2015 *{published data only}*

Chae D, Kim S, Park Y, Hwang Y. The effects of an academic-workplace partnership intervention to promote physical activity in sedentary office workers. *Workplace Health & Safety* 2015;**63**(6):259-66.

Cheema 2013 *{published data only}*

* Cheema BS, Houridis A, Busch L, Raschke-Cheema V, Melville GW, Marshall PW, et al. Effect of an office worksite-based yoga program on heart rate variability: outcomes of a randomised controlled trial. *BMC Complementary and Alternative Medicine* 2013;**13**:82.

Cheema BS, Marshall PW, Chang D, Colagiuri B, Machliss B. Effect of an office worksite-based yoga program on heart rate variability: a randomised controlled trial. *BMC Public Health* 2011;**11**:578.

Chia 2015 *{published data only}*

Chia M, Chen B, Suppiah H. Office sitting made less sedentary – A future-forward approach to reducing physical inactivity at work. *Montenegrin Journal of Sports Science and Medicine* 2015;**4**(2):5-10.

Cifuentes 2015 *{published data only}*

Cifuentes M, Jin Q, Fulmer S, Bello A. Facilitators and barriers to using treadmill workstations under real working conditions: a qualitative study in female office workers. *American Journal of Health Promotion* 2015;**30**(2):93-100.

Clemes 2014 *{published data only}*

Clemes SA, Patel R, Mahon C, Griffiths PL. Sitting time and step counts in office workers. *Occupational Medicine* 2014;**64**(3):188-92.

DeCocker 2015 *{published data only}*

De Cocker K, De Bourdeaudhuij I, Cardon G, Vandelanotte C. Theory-driven, web-based, computer-tailored advice to reduce and interrupt sitting at work: development, feasibility and acceptability testing among employee. *BMC Public Health* 2015;**15**(100968562):959.

Dewa 2009 *{published data only}*

Dewa CS, de Ruiter W, Chau N, Karioja K. Walking for wellness: using pedometers to decrease sedentary behaviour and promote mental health. *International Journal of Mental Health Promotion* 2009;**11**(2):24-8.

Elmer 2014 *{published data only}*

Elmer SJ, Martin JC. A cycling workstation to facilitate physical activity in office settings. *Applied Ergonomics* 2014;**45**(4):1240-6.

Engelen 2017 *{published data only}*

Engelen L, Chau J, Bohn-Goldbaum E, Young S, Hespe D, Bauman A. Is Active Design changing the workplace? - a natural pre-post experiment looking at health behaviour and workplace perceptions. *Work* 2017;**56**(2):229-37.

Fennell 2017 *{published data only}*

Fennell C. The effects of a 16-week exercise program and cell phone use on physical activity, sedentary behavior, and health-related outcomes. *Dissertation Abstracts International: Section B: The Sciences and Engineering* 2017;**78**:3-B(E).

Foley 2016 *{published data only}*

Foley B, Engelen L, Gale J, Bauman A, Mackey M. Sedentary behavior and musculoskeletal discomfort are reduced when office workers trial an activity based work environment. *Journal of Occupational & Environmental Medicine* 2016;**58**(9):924-31.

Freak-Poli 2011 *{published data only}*

Freak-Poli R, Wolfe R, Backholer K, de Courten M, Peeters A. Impact of a pedometer-based workplace health program on cardiovascular and diabetes risk profile. *Preventive Medicine* 2011;**53**(3):162-71.

Ganesan 2016 *{published data only}*

Ganesan AN, Louise J, Horsfall M, Bilsborough SA, Hendriks J, McGavigan AD, et al. International mobile-health intervention on physical activity, sitting, and weight: the Stepathlon cardiovascular health study. *Journal of the American College of Cardiology* 2016;**67**(21):2453-63.

Gardner 2015 *{published data only}*

Gardner B, Smith L, Aggio D, Iliffe S, Fox KR, Jefferis BJ, et al. 'On Your Feet to Earn Your Seat': update to randomised controlled trial protocol. *Trials* 2015;**16**:330.

Gilson 2012 *{published data only}*

Gilson N, Faulker G, Murphy M, Umstattd Meyer M, Ryde G, McCarthy K, et al. An international study of an automated web-based walking program (Walk@Work) to increase workday step counts in lower active office workers. *Journal of Science and Medicine in Sport* 2012;**15**:S235-6.

Gilson 2015 *{published data only}*

Gilson N, Ng N, Pavey T, Ryde G, Straker L, Brown W. Project energise: the impact of real-time prompts on sedentary and physically active work time in Australian office workers. *Journal of Science and Medicine in Sport* 2015;**19**:e10.

Gilson ND 2012 *{published data only}*

Gilson N, Suppini A, Ryde G, Brown H, Brown W. Do height adjustable 'hot' desks change sedentary work behaviour in an open plan office?. *Journal of Science and Medicine in Sport* 2011;**14**:e24-5.

* Gilson ND, Suppini A, Ryde GC, Brown HE, Brown WJ. Does the use of standing 'hot' desks change sedentary work time in an open plan office?. *Preventive Medicine* 2012;**54**(1):65-7.

Gorman 2013 *{published data only}*

Gorman E, Ashe MC, Dunstan DW, Hanson HM, Madden K, Winkler EA, et al. Does an 'activity-permissive' workplace change office workers' sitting and activity time?. *PLoS One* 2013;**8**(10):e76723.

Green 2016 *{published data only}*

Green N, Sigurdsson S, Wilder DA. Decreasing bouts of prolonged sitting among office workers. *Journal of Applied Behavior Analysis* 2016;**49**(3):717-22.

Grunseit 2012 *{published data only}*

Grunseit A, Chau J, Van der Ploeg H, Bauman A. Thinking on your feet: a qualitative evaluation of an installation of sit-stand desks in a medium-sized workplace. *Journal of Science and Medicine in Sport* 2012;**15**:S195-6.

Hadgraft 2017 *{published data only}*

Hadgraft NT, Winkler EA, Healy GN, Lynch BM, Neuhaus, M, Eakin EG, et al. Intervening to reduce workplace sitting: mediating role of social-cognitive constructs during a cluster randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity* 2017;**14**(1):27.

Hedge 2004 *{published data only}*

Hedge A, Ray EJ. Effect of an electronic height-adjustable work surface on computer worker musculoskeletal discomfort and productivity. Proceedings of Human Factors & Ergonomic Society, 48th Annual Meeting 2004. SAGE publications, 2004.

Irvine 2011 *{published data only}*

Irvine AB, Philips L, Seeley J, Wyant S, Duncan S, Moore RW. Get moving: a web site that increases physical activity of sedentary employees. *American Journal of Health Promotion* 2011;**25**(3):199-206.

Jancey 2016 *{published data only}*

Jancey JM, McGann S, Creagh R, Blackford KD, Howat P, Tye M. Workplace building design and office-based workers' activity: a study of a natural experiment. *Australian & New Zealand Journal of Public Health* 2016;**40**(1):78-82.

John 2011 *{published data only}*

John D, Thompson DL, Raynor H, Bielak K, Rider B, Bassett DR. Treadmill workstations: a worksite physical activity intervention in overweight and obese office workers. *Journal of Physical Activity and Health* 2011;**8**(8):1034-43.

Jones 2017 *{published data only}*

Jones CA. Examining the efficacy and feasibility of digital activity monitors and shared active desks to reduce employee sedentary behavior. *Dissertation Abstracts International: Section B: The Sciences and Engineering* 2017;**77**:11-B(E).

Júdice 2015 *{published data only}*

Júdice PB, Hamilton MT, Sardinha LB, Silva AM. Randomized controlled pilot of an intervention to reduce and break-up overweight/obese adults' overall sitting-time. *Trials* 2015;**16**(1):490.

Kennedy 2007 *{published data only}*

Kennedy RA, Boreham CA, Murphy MH, Young IS, Mutrie N. Evaluating the effects of a low volume stair climbing programme on measures of health-related fitness in sedentary office workers. *Journal of Sports Science and Medicine* 2007;**6**(4):448-54.

Kerr 2016 *{published data only}*

Kerr J, Takemoto M, Bolling K, Atkin A, Carlson J, Rosenberg D, et al. Two-arm randomized pilot intervention trial to decrease sitting time and increase sit-to-stand transitions in working and non-working older adults. *Plos one* 2016;**11**(1):e0145427.

Koepp 2013 *{published data only}*

Koepp GA, Manohar CU, McCrady-Spitzer SK, Ben-Ner A, Hamann DJ, Runge CF, et al. Treadmill desks: a 1-year prospective trial. *Obesity (Silver Spring)* 2013;**21**(4):705-11.

Lara 2008 *{published data only}*

Lara A, Yancey AK, Tapia-Conye R, Flores Y, Kuri-Morales P, Mistry R, et al. Pausa para tu Salud: reduction of weight and waistlines by integrating exercise breaks into workplace organizational routine. Preventing Chronic Disease Epub 2008; Vol. 5, issue 1:A12.

Liu 2016 *{published data only}*

Liu Y. Supporting working time interruption management through persuasive design. *Dissertation Abstracts International: Section B: The Sciences and Engineering* 2016;**77**:3-B(E).

Maeda 2014 *{published data only}*

Maeda H, Quartiroli A, Vos PW, Carr LJ, Mahar MT. Feasibility of retrofitting a university library with active workstations to reduce sedentary behavior. *American Journal of Preventive Medicine* 2014;**46**(5):525-8.

Mahmud 2015 *{published data only}*

Mahmud N, Kenny DT, Md Zein R, Hassan SN. The effects of office ergonomic training on musculoskeletal complaints, sickness absence, and psychological well-being: a cluster randomized control trial. *Asia-Pacific Journal of Public Health* 2015;**27**(2):NP1652-68.

Mainsbridge 2014 *{published data only}*

Mainsbridge CP, Cooley PD, Fraser SP, Pedersen SJ. The effect of an e-health intervention designed to reduce prolonged occupational sitting on mean arterial pressure. *Journal of Occupational and Environmental Medicine* 2014;**56**(11):1189-94.

Mair 2014 *{published data only}*

Mair JL, Boreham CA, Ditroilo M, McKeown D, Lowery MM, Caulfield B, et al. Benefits of a worksite or home-based bench stepping intervention for sedentary middle-aged adults - a pilot study. *Clinical Physiology and Functional Imaging* 2014;**34**(1):10-7.

Marshall 2003 *{published data only}*

Marshall AL, Leslie ER, Bauman AE, Marcus BH, Owen N. Print versus web site physical activity programs: a randomised trial. *American Journal of Preventive Medicine* 2003;**25**(2):88-94.

McAlpine 2007 *{published data only}*

McAlpine DA, Manohar CU, McCrady SK, Hensrud D, Levine JA. An office-place stepping device to promote workplace physical activity. *British Journal of Sports Medicine* 2007;**41**(12):903-7.

Miyachi 2015 *{published data only}*

* Miyachi M, Kurita S, Tripette J, Takahara R, Yagi Y, Murakami H. Installation of a stationary high desk in the workplace: effect of a 6-week intervention on physical activity. *BMC Public Health* 2015;**15**:368.

UMIN000016731. Installation of a stationary high desk in the workplace: effect of a 6-week intervention on physical activity. UMIN-CTR Clinical Trial (accessed 3 June 2015).

NCT01221363 *{published data only}*

NCT01221363. Reduction of sitting time - a randomised controlled intervention study. http://clinicaltrials.gov/ct2/show/NCT01221363 (accessed 15 March 2014).

Ognibene 2016 *{published data only}*

Ognibene GT, Torres W, von Eyben R, Horst KC. Impact of a sit-stand workstation on chronic low back pain: results of a randomized trial. *Journal of Occupational and Environmental Medicine* 2016;**58**(3):287-93.

Opdenacker 2008 *{published data only}*

Opdenacker J, Boen F. Effectiveness of face-to-face versus telephone support in increasing physical activity and mental health among university employees. *Journal of Physical Activity and Health* 2008;**5**(6):830-43.

Ouyang 2015 *{published data only}*

Ouyang P, Stewart KJ, Bedra ME, York S, Valdiviezo C, Finkelstein J. Text messaging to reduce inactivity using real-time step count monitoring in sedentary overweight females. *Circulation* 2015;**131**:AMP10.

Parry S 2013 *{published data only}*

ACTRN12612000743864. Can a participatory workplace intervention improve sedentary behaviour and physical activity in office workers?. http://www.anzctr.org.au/ACTRN12612000743864.aspx (accessed 14 March 2014).

* Parry S, Straker L, Gilson ND, Smith AJ. Participatory workplace interventions can reduce sedentary time for office workers - a randomised controlled trial. *PLoS One* 2013;**8**(11):e78957.

Pilcher 2017 *{published data only}*

Pilcher JJ, Morris DM, Bryant SA, Merritt PA, Feigl HB. Decreasing sedentary behavior: effects on academic performance, meta-cognition, and sleep. *Frontiers in Neuroscience* 2017;**11**(101478481):219.

Poirier 2016 *{published data only}*

Poirier J, Bennett WL, Jerome GJ, Shah NG, Lazo M, Yeh HC, et al. Effectiveness of an activity tracker- and internet-based adaptive walking program for adults: a randomized controlled trial. *Journal of Medical Internet Research* 2016;**18**(2):e34.

Pronk 2012 *{published data only}*

Pronk NP, Katz AS, Lowry M, Payfer JR. Reducing occupational sitting time and improving worker health: the Take-a-Stand Project. *Preventing Chronic Disease* 2012;**9**:e154.

Roossien 2017 *{published data only}*

Roossien CC, Stegenga J, Hodselmans AP, Spook SM, Koolhaas W, Brouwer S, et al. Can a smart chair improve the sitting behavior of office workers?. *Applied Ergonomics* 2017;**65**:355-61.

Schwartz 2016 *{published data only}*

Schwartz B, Kapellusch JM, Schrempf A, Probst K, Haller M, Baca A. Effect of a novel two-desk sit-to-stand workplace (ACTIVE OFFICE) on sitting time, performance and physiological parameters: protocol for a randomized control trial. *BMC Public Health* 2016;**16**(100968652):578.

Slootmaker 2009 *{published data only}*

Slootmaker SM, Chinapaw MJ, Schuit AJ, Seidell JC, Van Mechelen W. Feasibility and effectiveness of online physical activity advice based on a personal activity monitor: randomised controlled trial. *Journal of Medical Internet Research* 2009;**11**(3):e27.

Sternfeld 2009 *{published data only}*

Sternfeld B, Block C, Quesenberry CP Jr, Block TJ, Husson G, Norris JC, et al. Improving diet and physical activity with ALIVE: a worksite randomised trial. *American Journal of Preventive Medicine* 2009;**36**(6):475-83.

Straker 2013 *{published data only}*

Straker L, Abbott R, Heiden M, Mathiassen S, Toomingas A. Sit-stand desks and sedentary behavior in Swedish call centre workers. *Journal of Science and Medicine in Sport* 2012;**15**:S194.

* Straker L, Abbott RA, Heiden M, Mathiassen SE, Toomingas A. Sit-stand desks in call centres: associations of use and ergonomics awareness with sedentary behavior. *Applied Ergonomics* 2013;**44**(4):517-22.

Taylor 2016 *{published data only}*

Taylor WC, Paxton RJ, Shegog R, Coan SP, Dubin A, Page T, et al. Impact of booster breaks and computer prompts on physical activity and sedentary behavior among desk-based workers: a cluster-randomized controlled trial. *Preventing Chronic Disease* 2016;**13**(101205018):E155.

Thogersen-Ntoumani 2013 *{published data only}*

NCT01150084. Step by Step: a feasibility study of the promotion of lunchtime walking to increase physical activity and improve mental well-being in sedentary employees. http://clinicaltrials.gov/ct2/show/NCT01150084 (accessed 15 March 2014).

Thogersen-Ntoumani C, Loughren E, Duda J, Fox KR. "Step by Step": a feasibility study of a lunchtime walking intervention designed to increase walking, improve mental well-being and work performance in sedentary employees: rationale and study design. *BMC Public Health* 2010;**10**:578.

* Thogersen-Ntoumani C, Loughren E, Duda J, Fox KR. Step by Step: the feasibility of a 16-week workplace lunchtime walking intervention for physically inactive employees. *Journal of Physical Activity And Health* 2013;**10**:Epub ahead of print.

Thogersen-Ntoumani C, Loughren EA, Kinnafick F-E, Taylor IM, Duda JL, Fox KR. Changes in work affect in response to lunchtime walking in previously physically inactive employees: a randomized trial. *Scandinavian Journal of Medicine & Science in Sports* 2015;**25**(6):778-87.

Thompson 2014 *{published data only}*

Thompson WG, Koepp GA, Levine JA. Increasing physician activity with treadmill desks. Work 2014; Vol. 48, issue 1:47-51.

Thorp 2015 *{published data only}*

Thorp AA, Kingwell BA, English C, Hammond L, Sethi P, Owen N. Alternating sitting and standing increases the workplace energy expenditure of overweight adults. *Journal of Physical Activity and Health* 2015;**8**:[Epub ahead of print].

Torbeyns 2016 *{published data only}*

Torbeyns T, de Geus B, Bailey S, De Pauw K, Decroix L, Van Cutsem J, et al. Bike desks in the office: Physical health, cognitive function, work engagement, and work performance. *Journal of Occupational & Environmental Medicine* 2016;**58**(12):1257-63.

Torbeyns 2017 *{published data only}*

Torbeyns T, De Geus B, Bailey S, Decroix L, Meeusen R. The potential of bike desks to reduce sedentary time in the office: a mixed-method study. *Public Health* 2017;**144**:16-22.

Tucker 2016 *{published data only}*

Tucker S, Farrington M, Lanningham-Foster LM, Clark MK, Dawson C, Quinn GJ. Worksite physical activity intervention for ambulatory clinic nursing staff. *Workplace Health & Safety* 2016;**64**(7):313-25.

vanNassau 2015 *{published data only}*

van Nassau F, Chau JY, Lakerveld J, Bauman AE, van der Ploeg HP. Validity and responsiveness of four measures of occupational sitting and standing. *The International Journal of Behavioral Nutrition and Physical Activity* 2015;**12**:144.

Wirick 2016 *{published data only}*

Wirick SE. The promotion of regular exercise behavior among sedentary emerging adults based on social cognitive theory. *Dissertation Abstracts International: Section B: The Sciences and Engineering* 2016;**76**:7-B(E).

Yancey 2004 *{published data only}*

Yancey AK, McCarthy WJ, Taylor WC, Merlo A, Gewa C, Weber MD, et al. The Los Angeles Lift Off: a sociocultural environmental change intervention to integrate physical activity into the workplace. *Preventive Medicine* 2004;**38**(6):848-56.

Østerås 2005 *{published data only}*

Østerås H, Sigbjørn H. The effectiveness of a pragmatic worksite physical activity program on maximal oxygen consumption and the physical activity level in healthy people. *Journal of Bodywork and Movement Therapies* 2006;**10**(1):51-7.

References to studies awaiting assessment

Carpenter 2015 *{published data only}*

Carpenter K, Feltes L, Vuing B, Kalbes A, Koepp G, Dutta N, et al. Effect of sit-stand workstations on metabolic risk in sedentary workers: a randomized controlled trial. *The Journal of the Federation of American societies for Experimental Biology* 2015;**29**:supplement 1.

Dutta 2013 *{published data only}*

Dutta N, Koepp G, Schmitz C, Stovitz SD, Levine JA, Pereira MA. Impact of adjustable sit-stand workstations on physical activity in sedentary office workers. *Diabetes* 2013;**62**:A186.

Kirk 2012 *{published data only}*

Kirk A, Fitzsimons C, Murphy M, Mutrie N. Effect of a person centred consultation intervention to reduce the sedentary behaviour of working Scottish adults. *Journal of Science and Medicine in Sport* 2012;**15**:S314.

NCT02932787 *{published data only}*

NCT02932787. Effects of installing height-adjustable workstations on office workers workplace sitting time and productivity. https://clinicaltrials.gov/show/NCT02932787 (accessed 12 September 2017).

References to ongoing studies

ACTRN12612001290886 *{published data only}*

ACTRN12612001290886. The effectiveness of the 10,000 Steps workplace challenge in increasing health outcomes for employees at Rockhampton Regional Council. http://www.anzctr.org.au/ACTRN12612001290886.aspx (accessed 15 March 2014).

ACTRN12614000252617 *{published data only}*

ACTRN12614000252617. Comparison of organisational support vs. organisational plus technology support for reducing prolonged sitting in the office workplace. http://www.anzctr.org.au/ACTRN12614000252617.aspx (accessed 15 March 2014).

Bergman 2015 *{published data only}*

Bergman F, Boraxbekk CJ, Wennberg P, Sörlin A Olsson T. Increasing physical activity in office workers – the Inphact Treadmill study; a study protocol for a 13-month randomized controlled trial of treadmill workstations. *BMC Public Health* 2015;**15**(1):632.

NCT01997970. NEAT - Prevention and treatment of overweight and obesity. (InphactUm). https://clinicaltrials.gov/ct2/show/NCT01997970 (accessed 3 June 2015).

Buman 2017 *{published data only}*

Buman MP, Mullane SL, Toledo MJ, Rydell SA, Gaesser GA, Crespo NC, et al. An intervention to reduce sitting and increase light-intensity physical activity at work: design and rationale of the 'Stand & Move at Work' group randomized trial. *Contemporary Clinical Trials* 2017;**53**:11-9.

NCT02566317. Stand & Move at Work. https://clinicaltrials.gov/ct2/show/NCT02566317 (accessed 12 September 2017).

Finkelstein 2015 *{published data only}*

Finkelstein EA, Sahasranaman A, John G, Haaland, BA, Bilger M, Sloan RA, et al. Design and baseline characteristics of participants in the TRial of Economic Incentives to Promote Physical Activity (TRIPPA): a randomized controlled trial of a six month pedometer program with financial incentives. *Contemporary Clinical Trials* 2015;**41**:238-47.

NCT01855776. A randomized trial of economic incentives to promote walking among full time employees. https://clinicaltrials.gov/ct2/show/NCT01855776 (accessed 12 September 2017).

Finni 2011 *{published data only}*

* Finni T, Saakslahti A, Laukkanen A, Pesola A, Sipilä S. A family based tailored counselling to increase non-exercise physical activity in adults with a sedentary job and physical activity in their young children: design and methods of a year-long randomised controlled trial. BMC Public Health 2011; Vol. 11.

ISRCTN28668090. Actions to reduce sedentary time in parents and their young children. http://www.isrctn.com/ISRCTN28668090 (accessed 15 March 2014).

Hall 2015 *{published data only}*

Hall J, Mansfield L, Kay T, McConnell AK. The effect of a sit-stand workstation intervention on daily sitting, standing and physical activity: protocol for a12 month workplace randomised control trial. *BMC Public Health* 2015;**15**:152.

NCT02172599. Take a stand for workplace health: A sit-stand workstation project evaluation. https://clinicaltrials.gov/ct2/show/NCT02172599?term=workplace+and+sitting&rank=1 (accessed 3 June 2015).

ISRCTN25767399 *{published data only}*

ISRCTN25767399. Impact of Booster Breaks on physical activity among sedentary employees: a cluster randomized controlled trial. http://apps.who.int/trialsearch/Trial2.aspx?TrialID=ISRCTN25767399 (accessed 3 June 2015).

Mackey 2011 *{published data only}*

ACTRN12610000301066. Walking to Wellness in an ageing sedentary university community. http://www.anzctr.org.au/ACTRN12610000301066.aspx (accessed 15 March 2014).

Mackey M, Bohle P, Taylor P, Di Biase T, McLoughlin C, Purnell K. 'Walking to wellness' in an ageing sedentary university community-a randomised controlled feasibility study. Physiotherapy. 2011; Vol. 97:eS733-eS4.

* Mackey MG, Bohle P, Taylor P, Di Biase T, McLoughlin C, Purnell K. Walking to wellness in an ageing sedentary university community: design, method and protocol. *Contemporary Clinical Trials* 2011;**32**(2):273-9.

Mantzari 2016 *{published data only}*

ISRCTN44827407. Does using sit-stand desks at work affect how many calories people burn and how much time they spend sitting over the entire day? A feasibility study. http://www.isrctn.com/ISRCTN44827407 (accessed 12 September 2017).

Mantzari E, Wijndaele K, Brage S, Griffin SJ, Marteau TM. Impact of sit-stand desks at work on energy expenditure and sedentary time: protocol for a feasibility study. *Pilot and Feasibility Studies* 2016;**2**(30):eCollection.

Martin-Borras 2014 *{published data only}*

* Borras CM, Garriga MG, Martinez E, Cantera CM, Puigdoménech E, Solà M, et al. Effectiveness of a primary care-based intervention to reduce sitting time in overweight and obese patients (SEDESTACTIV): a randomised controlled trial; rationale and study design. BMC Public Health 2014; Vol. 14.

NCT01729936. SedestActiv Project: intervention to reduce diary hours of sitting time in overweight and obese patients. http://clinicaltrials.gov/ct2/show/NCT01729936 (accessed 15 March 2014).

NCT01787643 *{published data only}*

NCT01787643. Standing behavior after installation of height-adjustable desks. http://clinicaltrials.gov/ct2/show/NCT01787643 (accessed 15 March 2014).

NCT01846013 *{published data only}*

NCT01846013. Increasing workplace physical activity in sedentary office workers. http://clinicaltrials.gov/ct2/show/NCT01846013 (accessed 15 March 2014).

NCT02376504 *{published data only}*

NCT02376504. Modifying the workplace to decrease sedentary behavior and improve health. https://clinicaltrials.gov/ct2/show/NCT02376504?term=workplace+and+sitting&rank=3 (accessed 3 June 2015).

NCT02609282 *{published data only}*

NCT02609282. The impact of hourly prompts on reducing prolonged sitting at work. https://clinicaltrials.gov/show/NCT02609282 (accessed 12 September 2017).

NCT02785640 *{published data only}*

NCT02785640. A study to assess the impact of a multicomponent intervention to reduce prolonged sitting in the workplace. https://clinicaltrials.gov/show/NCT02785640 (accessed 12 September 2017).

NCT03236597 *{published data only}*

NCT03236597. Assessing the effects of treadmill and sit-to-stand desks on light physical activity, sitting time, and cardio-metabolic risk. https://clinicaltrials.gov/show/NCT03236597 (accessed 12 September 2017).

O'Connell 2015 *{published data only}*

ISRCTN10967042. SMArT Work: Stand More AT Work. http://www.isrctn.com/ISRCTN10967042 (accessed 25 December 2015).

* O'Connell SE, Jackson BR, Edwardson CL, Yates T, Biddle SJH, Davies MJ, et al. Providing NHS staff with height-adjustable workstations and behaviour change strategies to reduce workplace sitting time:protocol for the Stand More AT (SMArT)Work cluster randomised controlled trial. *BMC Public Health* 2015;**15**:1219.

Radas 2013 *{published data only}*

ACTRN12613000366752. Reducing sedentary behaviour in office workers. https://www.anzctr.org.au/Trial/Registration/TrialReview.aspx?id=363960 (accessed 15 March 2014).

* Radas A, Mackey M, Leaver A, Bouvier AL, Chau JY, Shirley D, et al. Evaluation of ergonomic and education interventions to reduce occupational sitting in office-based university workers: study protocol for a randomised controlled trial. Trials 2013; Vol. 14.

Van Hoye 2012 *{published data only}*

Van Hoye K, Boen F, Lefevre J. The effects of physical activity feedback on behavior and awareness in employees: study protocol for a randomised controlled trial. *International Journal of Telemedicine and Applications* 2012;**2012**:10.

Additional references

Aadahl 2003

Aadahl M, Jorgensen T. Validation of a new self-report instrument for measuring physical activity. *Medicine and Science in Sports and Exercise* 2003;**35**(7):1196-202.

AFOEM 2014

The Royal Australasian College of Physicians. Australasian Faculty of Occupational and Environmental Medicine. https://www.racp.edu.au/page/about-afoem (accessed 12 December 2014).

AIHW 2008

Australian Institute of Health and Welfare. Australia's health 2008. http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=6442453674 (accessed 15 September 2013).

Ainsworth 2000

Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise* 2000;**32**(9 Suppl):S498-504.

Ainsworth 2011

Ainsworth BE, Haskell WL, Herrmann SD, Meckes N, Bassett DRJ, Tudor-Locke C, et al. 2011 Compendium of physical activities: a second update of codes and MET values. *Medicine and Science in Sports and Exercise* 2011;**43**(8):1575-81.

Andersen 2007

Andersen JH, Haahr JP, Frost P. Risk factors for more severe regional musculoskeletal symptoms: a two-year prospective study of a general working population. *Arthritis and rheumatism* 2007;**56**(4):1355-64.

Atkinson 2014

Atkinson J, Haynes K. Standing meeting rooms – exploring enablers and barriers of interventions to reduce sitting time in the workplace. *Australian and New Zealand Journal of Public Health* June 2014;**38**(3):291-2.

Australian Government 2014

Australian Government, Department of Health and Aging. Make your Move – sit less. Be active for life! Australia's physical activity and sedentary behaviour guidelines. Canberra: Commonwealth of Australia. http://www.health.gov.au/internet/main/publishing.nsf/content/health-pubhlth-strateg-phys-act-guidelines#npa05 2014.

Bailey 2015

Bailey DP, Locke CD. Breaking up prolonged sitting with light-intensity walking improves postprandial glycemia, but breaking up sitting with standing does not. *Journal of Science and Medicine in Sport* 2015;**18**(3):294-8.

Beers 2008

Beers EA, Roemmich JN, Epstein LH, Horvath PJ. Increasing passive energy expenditure during clerical work. *European Journal of Applied Physiology* 2008;**103**(3):353-60.

Bey 2003

Bey L, Hamilton MT. Suppression of skeletal muscle lipoprotein lipase activity during physical inactivity: a molecular reason to maintain daily low-intensity activity. *The Journal of Physiology* 2003;**1**(551):673-82.

Botter 2015

Botter J, Ellegast RP, Burford EM, Weber B, Könemann R, Commissaris DA. Comparison of the postural and physiological effects of two dynamic workstations to conventional sitting and standing workstations. *Ergonomics* 2015;**(Epub ahead of print)**:1-15.

Buckley 2015

Buckley JP, Hedge A, Yates T, Copeland RJ, Loosemore M, Hamer M, et al. The sedentary office: an expert statement on the growing case for change towards better health and productivity. *British Journal of Sports Medicine* 2015;**49**(21):1357-62.

Campbell 2001

Campbell MK, Mollison J, Grimshaw JM. Cluster trials in implementation research: estimation of intracluster correlation coefficients and sample size. *Statistics in Medicine* 2001;**20**(3):391-9.

Chaput 2015

Chaput JP, Saunders TJ, Tremblay MS, Katzmarzyk PT, Tremblay A, Bouchard C. Workplace standing time and the incidence of obesity and type 2 diabetes: a longitudinal study in adults. *BMC Public Health* 2015;**10**(15):111.

Chau 2012

Chau JY, Van Der Ploeg HP, Dunn S, Kurko J, Bauman AE. Validity of the occupational sitting and physical activity questionnaire. *Medicine and Science in Sports and Excercise* 2012;**44**(1):118-25.

Chau 2014a

Chaua JY, Grunseita A, Midthjellb K, Holmen J, Holmenabb TL, Baumana AE, et al. Cross-sectional associations of total sitting and leisure screen time with cardio metabolic risk in adults. Results from the HUNT study, Norway. *Journal of Science and Medicine in Sport* 2014;**17**:78-84.

Clark 2009

Clark BK, Sugiyama T, Healy GN, Salmon J, Dunstan DW, Owen N. Validity and reliability of measures of television viewing time and other non-occupational sedentary behaviour of adults: a review. *Obesity Reviews* 2009;**10**(1):7-16.

Coenen 2015

Coenen P, Healy GN, Winkler E, Dunstan DW, Straker L. Musculoskeletal pain is a barrier for sedentary behavior interventions. Proceedings 19th triennial congress of the IEA. Melbourne, 2015.

Commissaris 2007

Commissaris DACM, Douwes M, Schoenmaker N, de Korte EM. Recommendations for sufficient physical activity at work. 2007. http://www.nordiskergonomi.org/nes2007/CD_NES_2007/papers/A79_Commissaris.pdf. Elsevier, Oxford, (accessed 25 November 2013).

Commissaris 2014

Commissaris DACM, Konemann R, Mastrigt SH, Burford EM, Botter J, Douwes M, et al. Effects of a standing and three dynamic workstations on computer task performance and cognitive function tests. *Applied Ergonomics* 2014;**45**:1570-8.

Commissaris 2016

Commissaris DACM, Huysmans MA, Mathiassen SE, Srinivasan D, Koppes LLJ, Hendriksen IJM. Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. *Scandinavian Journal of Work Environment and Health* 2016;**42**:181-91.

Cooley 2014

Cooley D, Pedersen S, Mainsbridge C. Assessment of the impact of a workplace intervention to reduce prolonged occupational sitting time. Qualitative Health Research 2014; Vol. 24:90-101.

Craft 2012

Craft LL, Zderic TW, Gapstur SM, Vaniterson EH, Thomas DM, Siddique J, et al. Evidence that women meeting physical activity guidelines do not sit less: an observational inclinometry study. *International Journal of Behavioral Nutrition and Physical Activity* 2012;**9**:122.

Craig 2002

Craig CL, Brownson RC, Cragg SE, Dunn AL. Exploring the effect of the environment on physical activity: a study examining walking to work. *American Journal of Preventive Medicine* 2002;**23**(2 Suppl):36-43.

Department of Health 2011

Department of Health. Start active, stay active: a report on physical activity for health from the Four Home Countries' Chief Medical Officers. London, UK: Department of Health. https://www.gov.uk/government/publications/start-active-stay-active-a-report-on-physical-activity-from-the-four-home-countries-chief-medical-officers 2011.

Dunstan 2011

Dunstan DW, Thorp AA, Healy N. Prolonged sitting: is it a distinct coronary heart disease risk factor?. *Current Opinion in Cardiology* 2011;**26**(5):412-9.

Duvivier 2013

Duvivier BM, Schaper NC, Bremers MA, van Crombrugge G, Menheere PP, Kars M, et al. Minimal intensity physical activity (standing and walking) of longer duration improves insulin action and plasma lipids more than shorter periods of moderate to vigorous exercise (cycling) in sedentary subjects when energy expenditure is comparable. *PLoS ONE* 2013;**8**(2):1-8.

Egger 1997

Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;**315**(7109):629-34.

EPOC

Cochrane Effective Practice and Organisation of Care Group. EPOC resources for review authors. http://epoc.cochrane.org/epoc-resources-review-authors (accessed 10 June 2014).

Franklin 2011

Franklin BA. Health implications of low cardiorespiratory fitness, too little exercise, and too much sitting time: changing paradigms and perceptions. *American Journal of Health Promotion* 2011;**25**(4):exi-v.

Gardner 2015a

Gardner B, Smith L, Lorencatto F, Hamer M, Biddle SJH. How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychology Review* 2015;**16**:1-24.

Gomersall 2013

Gomersall SR, Rowlands AV, English C, Maher C, Olds TS. The Activitystat hypothesis: The concept,the evidence and the methodologies. *Sports Medicine* 2013;**43**(2):135-49.

GRADE

Guyatt GH, Oxman AD, Vist G, Kunz R, Falck-Ytter Y, Alonso-Coello P, et al. Rating quality of evidence and strength of recommendations GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ* 2008;**336**:924-6.

Graf 2015

Graf M, Krieger R, Läubli T, Martin B. Should we recommend people to stand more than sit at work?. Proceedings 19th triennial congress of the IEA. Melbourne, 2015.

Healy 2011

Healy GN, Clark BK, Winkler EA, Gardiner PA, Brown WJ, Matthews CE. Measurement of adults' sedentary time in population-based studies. *American Journal of Preventive Medicine* 2011;**41**:216-27.

Higgins 2009

Higgins JPT, Thompson SG, Spiegelhalter DJ. A re-evaluation of random-effects meta-analysis. *Journal of Royal Statistical Society. Series A, (Statistics in Society)* 2009;**172**(1):137-59.

Higgins 2011

Higgins JPT, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from www.cochrane-handbook.org.

Hu 2003

Hu FB, Li TY, Colditz GA, Willett WC, Manson JE. Television watching and other sedentary behaviours in relation to risk of obesity and type 2 diabetes mellitus in women. *JAMA* 2003;**289**(14):1785-91.

Ijaz 2014

Ijaz S, Verbeek JH, Mischke C, Ruotsalainen J. Inclusion of non randomized studies in Cochrane systematic reviews was found to be in need of improvement. *Journal of Clinical Epidemiology* 2014;**67**(6):645-53. [DOI: 10.1016/j.jclinepi.2014.01.001; PUBMED: 24725644]

IntHout 2016

IntHout J, Ioannidis JPA, Rovers MM, Goeman JJ. Plea for routinely presenting prediction intervals in meta-analysis. *BMJ Open* 2016;**6**:e010247.

Janssen 2015

Janssen X, Cliff DP. Issues related to measuring and interpreting objectively measured sedentary behavior data. *Measurement in Physical Education and Exercise Science* 2015;**19**(3):116-24.

John 2009

John D, Bassett D, Thompson D, Fairbrother J, Baldwin D. Effect of using a treadmill workstation on performance of simulated office work tasks. *Journal of Physical Activity and Health* 2009;**6**(5):617-24.

Júdice 2015b

Júdice PB, Hamilton MT, Sardinha LB, Zderic TW, Silva AM. What is the metabolic and energy cost of sitting, standing and sit/stand transitions?. *European Journal of Applied Physiology* 2015;**116**(2):263-73.

Kanoun 2009

Kanoun N. Validation of the ActivPAL activity monitor as a measure of walking at pre-determined slow walking speeds in a healthy population in a controlled setting. Reinvention: a Journal of Undergraduate Research 2009, http://www.warwick.ac.uk/go/reinventionjournal/issues/volume2issue2/kanoun (accessed 13 November 2013).

Katzmarzyk 2014

Katzmarzyk PT. Standing and mortality in a prospective cohort of Canadian adults. *Medicine and Science in Sports and Exercise* 2014;**46**(5):940-6.

Kim 2015

Kim Y, Barry VW, Kang M. Validation of the ActiGraph GT3X and activPAL accelerometers for the assessment of sedentary behavior. *Measurement in Physical Education and Exercise Science* 2015;**19**(3):125-37.

Lagersted-Olsen 2014

Lagersted-Olsen J, Korshøj M, Skotte J, Carneiro IG, Søgaard K, Holtermann A. Comparison of objectively measured and self-reported time spent sitting. *International Journal of Sports Medicine* 2014;**35**(6):534-40.

Larsen 2014

Larsen RN, Kingwell BA, Sethi P, Cerin E, Owen N, Dunstan DW. Breaking up prolonged sitting reduces resting blood pressure in overweight/obese adults. *Nutrition Metabolism and Cardiovascular Diseases* 2014;**24**(9):976-82.

Levine 2007

Levine JA, Miller JM. The energy expenditure of using a "walk-and-work" desk for office workers with obesity. *British Journal of Sports Medicine* 2007;**41**(9):558-61.

Manini 2015

Manini TM, Carr LJ, King AC, Marshall S, Robinson TN, Rejeski WJ. Interventions to reduce sedentary behavior. *Medicine and Science in Sports and Exercise* 2015;**47**(6):1306-10.

Mansoubi 2014

Mansoubi M, Pearson N, Biddle SJ, Clemes S. The relationship between sedentary behaviour and physical activity in adults: a systematic review. *Preventive Medicine* 2014;**69C**:28.

Mansoubi 2015

Mansoubi M, Pearson N, Clemes SA, Biddle SJH, Bodicoat DH, Tolfrey K, et al. Energy expenditure during common sitting and standing tasks: examining the 1.5 MET definition of sedentary behaviour. *BMC Public Health* 2015;**15**:516.

Mansoubi 2016

Mansoubi M, Pearson N, Biddle SJH, Clemes SA. Using sit-to-stand workstations in offices: is there a compensation effect?. *Medicine & Science in Sports & Excercise* 2016;**48**:720-5.

Marszalek 2014

Marszalek J, Morgulec-Adamowicz N, Rutkowska I, Kosmol A. Using ecological momentary assessment to evaluate current physical activity. *BioMed Research International* 2014;**Article ID 915172**:1-9.

Martin 2015

Martin A, Fitzsimons C, Jepson R, Saunders DH, van der Ploeg HP, Teixeira PJ, et al. Interventions with potential to reduce sedentary time in adults: systematic review and meta-analysis. *British Journal of Sports Medicine* 2015;**49**(16):1056-63.

McCrady 2009

McCrady SK, Levine JA. Sedentariness at work: how much do we really sit?. *Obesity (Silver Spring, Md)* 2009;**17**(11):2103-5.

McEachan 2011

McEachan RR, Lawton RJ, Jackson C, Conner M, Meads DM, West RM. Testing a workplace physical activity intervention: a cluster randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity* 2011;**8**:29.

Moher 2009

Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Medicine* 2009;**6**(7):e1000097.

Ng 2012

Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. *Obesity Reviews* 2012;**13**(8):659-80.

Ogilvie 2007

Ogilvie D, Foster CE, Rothnie H, Cavill N, Hamilton V, Fitzsimons CF, et al. Interventions to promote walking: systematic review. *BMJ* 2007;**334**(7605):1204.

Parry 2013

Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. *BMC Public Health* 2013;**13**(1):296.

Pedišić 2015

Pedišić Ž, Bauman A. Accelerometer-based measures in physical activity surveillance: current practices and issues. *British Journal of Sports Medicine* 2015;**49**(4):219-23.

Pedišić 2017

Pedišić Z, Dumuid D, Olds TS. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. Kinesiology 2017; Vol. 49, issue 2.

Plotnikoff 2012

Plotnikoff R, Karunamuni N. Reducing sitting time: the new workplace health priority. *Archives of Environmental and Occupational Health* 2012;**67**(3):125-7.

Prince 2014

Prince SA, Saunders TJ, Gresty K, Reid RD. A comparison of the effectiveness of physical activity and sedentary behaviour interventions in reducing sedentary time in adults: a systematic review and meta-analysis of controlled trials. *Obesity Reviews* 2014;**15**(11):905.

Review Manager 2014 [Computer program]

Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager 5 (RevMan 5). Version 5.3. Copenhagen: Nordic Cochrane Centre, The Cochrane Collaboration, 2014.

Ryan 2011

Ryan CG, Dall PM, Granat MH, Grant PM. Sitting patterns at work: objective measurement of adherence to current recommendations. *Ergonomics* 2011;**54**(6):531-8.

Rzewnicki 2003

Rzewnicki R, Yves VA, Ilse DB. Addressing over reporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutrition* 2003;**6**(3):299-305.

Sallis 2006

Sallis JF, Cervero RB, Ascher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. *Annual Review of Public Health* 2006;**27**:297-322.

Shephard 2003

Shephard RJ. Limits to the measurement of habitual physical activity by questionnaires. *British Journal of Sports Medicine* 2003;**37**(3):197-206.

Shrestha 2016

Shrestha N, Pedisic Z, Neil-Sztramko S, Kukkonen-Harjula KT, Hermans V. The impact of obesity in the workplace: a review of contributing factors, consequences and potential solutions. *Current Obesity Reports* 2016;**5**(3):344-60.

Shrestha 2018

Shrestha N, Grgic J, Wiesner G, Parker A, Podnar H, Bennie JA, et al. Effectiveness of interventions for reducing non-occupational sedentary behaviour in adults and older adults: a systematic review and meta-analysis. British Journal of Sports Medicine 2018; Vol. Epub ahead of print.

Tan 2011

Tan DA. Changing disease trends in the Asia-Pacific. *Climacteric* 2011;**14**(5):529-34.

Thorp 2012

Thorp AA, Healy GN, Winkler E, Clark BK, Gardiner PA, Owen N, et al. Prolonged sedentary time and physical activity in workplace and non-work contexts: a cross-sectional study of office, customer service and call centre employees. *International Journal of Behavioral Nutrition and Physical Activity* 2012;**9**:128.

Tudor-Locke 2013

Tudor-Locke C, Schuna JM Jr, Frensham LJ, Proenca M. Changing the way we work: elevating energy expenditure with workstation alternatives. *International Journal of Obesity* 2013;**38**(6):755-6.

USPTO 2000

United States Patent and Trademark Office (USPTO). United States Patent 6,070,943. Guery-Strahm R. Ergonomic seating unit. June 6, 2000. http://patft.uspto.gov/netacgi/nph-Parser?Sect2=PTO1&Sect2=HITOFF&p=1&u=/netahtml/PTO/search-bool.html&r=1&f=G&l=50&d=PALL&RefSrch=yes&Query=PN/6070943 (accessed 2 December 2013).

Van der Ploeg 2012

van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222 497 Australian adults. *Archives of Internal Medicine* 2012;**172**(6):494-500.

van Uffelen 2010

van Uffelen JG, Wong J, Chau JY, van der Ploeg HP, Riphagen I, Gilson ND, et al. Occupational sitting and health risks: a systematic review. *American Journal of Preventive Medicine* 2010;**39**(4):379-88.

VicHealth 2012

Victorian Health Promotion Foundation. Reducing prolonged sitting in the workplace. An evidence review: summary report. 2012. http://www.vichealth.vic.gov.au/~/media/ResourceCentre/PublicationsandResources/Economic%20participation/2012%20workplace/VH_Reducing_prolonged_sitting_07.ashx (accessed 4 December 2013).

Wang 2011

Wang YC, McPherson K, Marsh T, Gortmaker SL, Brown M. Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet* 2011;**378**(9793):815-25.

WHO/WEF 2008

World Health Organization/World Economic Forum. Preventing non communicable diseases in the workplace through diet and physical activity. http://www.weforum.org/pdf/Wellness/WHOWEF_report.pdf 2008, (accessed 10 June 2014).

Wilks 2006

Wilks S, Mortimer M, Nylén P. The introduction of sit-stand worktables; aspects of attitudes, compliance and satisfaction. *Applied Ergonomics* 2006;**37**(3):359-65.

* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Alkhajah 2012

Methods	Non-random allocation by clusters: CBA Single-blind Study duration: 3 months Dropout: 9% **Location:** Australia **Recruitment:** control group participants were recruited from locations separated from the intervention group participants by at least 1 building level

Alkhajah 2012 *(Continued)*

Participants	**Population:** employees in public health research centres within 2 academic institutions, aged 20-65 years **Intervention group:** 18 participants **Control group:** 12 participants **Demographics:** BMI: intervention group 22.6 (SD 2.6) kg/m², control group 21.5 (SD 2.6) kg/m²
Interventions	**Duration:** 3 months **Intervention:** sit-stand desk **Control:** sit-desk

Outcomes	**Outcome name, measurement time/tool (units of measurement)**
	
	• Changes in sitting/standing/stepping time (minutes/8-hour workday) measured at 1 week and 3 months. Transitions in positions measured by activPAL3 accelerometer-inclinometer and a self-administered questionnaire
	• Weight (kg), waist circumference (cm), hip circumference (cm), fat free mass (kg), fat mass (kg), fasting blood lipids (Total cholesterol/HDL/Triglycerides) (mmol/L) and glucose (mmol/L) at 1 week and 3 months
	• Self-reported health- and work-related outcomes
	  * Musculoskeletal symptoms by anatomical regions
	  * Other health symptoms: eye strain, headaches, digestion problems, trouble walking, trouble sleeping, fatigue (scale 1-5)
	  * Work-related outcomes: ≥ 1 day off sick (last 3 months), work performance (scale 1-10)

Notes	This study was funded by a University of Queensland Major Equipment and Infrastructure grant. Alkhajah was supported by a United Arab Emirates Ministry of Higher Education and Scientific Research Scholarship; Reeves was supported by a National Health and Medical Research Council (NHMRC) Early Career Fellowship; Eakin was supported by an NHMRC Senior Research Fellowship; Owen was supported by an NHMRC Senior Principal Research Fellowship; and Healy was supported by an NHMRC Early Career Fellowship. Authors reported no financial disclosures.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomisation was not done as participants in intervention and control groups were selected from different building locations.
Allocation concealment (selection bias)	High risk	Intervention and control groups were selected from two separate locations. However no information on allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	The intervention group had sit-stand desks installed at their workplace and received verbal instruction on their use, as well as written instructions on the correct ergonomic posture for both sitting and standing and the importance of regular postural change throughout the day. The control group had no change in desks and participants were advised to maintain usual day-to-day activity. The participants were probably aware of their allocation. The authors do not report who gave the instructions to the intervention and control groups.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported

Alkhajah 2012 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	Virtually no attrition: only one participant was missing from the control group because of a malfunctioning accelerometer-inclinometer.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported. Study protocol was not available.
Baseline comparability/ imbalance	High risk	Baseline data for age and gender were similar. It seems probable that there were baseline imbalances in awareness and physical activity levels between intervention and control groups as participants to the intervention group were selected from an academic institution focused on sedentary behaviour research whereas participants in the control group were never involved in physical activity research.
Validity of outcome measure	Low risk	The accelerometer-inclinometer is a valid instrument for the measurement of sitting time.

Brakenridge 2016

Methods	Random allocation by clusters Single-blind Study duration: 12 months Dropout: more than 45% in both groups. **Location:** Australia **Recruitment:** participants were invited to attend an information session, during which eligibility was confirmed and informed written consent was obtained.
Participants	**Population:** employees from an international property and infrastructure group, located at two cities: Sydney and Brisbane. **Organisational-support intervention (ORG) group:** 9 teams with 117 employees **ORG + tracker group:** 9 teams with 93 employees **Demographics:** Mean age: ORG group: 40.0 (SD 8.0), ORG + tracker group: 37.6 (SD 7.8) % of males: ORG group 60 %, ORG+ tracker group 47 % BMI: ORG group 25.0 (SD 3.4) kg/m^2, ORG + tracker group 24.1 (SD 3.4) kg/m^2
Interventions	**Duration:** 12 months **Organisational-support intervention (ORG group):** information booklet, five fortnightly emails consisting of chosen activity-promoting tips, comments from participants or managers, images of participants taking part in the ‘Stand Up, Sit Less, Move More’ message and the organisation’s branding. **ORG + tracker group:** organisational support combined with activity tracker
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting/standing/stepping time during work hours (minutes/10-hour workday) and overall hours (minutes/16-hour) measured at 3 months and 12 months. Transitions in positions measured by activPAL3 accelerometer-inclinometer

Brakenridge 2016 *(Continued)*

	• Self-reported health- and work-related outcomes * Health-related outcomes: stress (single item, 1–10 scale; higher scores indicate more stress), physical and mental health quality of life (12 items, 0–100 scale; higher scores indicate better quality of life) * Work-related outcomes (scale 1–10): job performance, job control, work satisfaction
Notes	The authors declared that they have no competing interests.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Randomisation sequence was generated using randomisation website.
Allocation concealment (selection bias)	Low risk	A university staff member not involved in the study randomised teams by strata (location B/small location A teams/large location A teams) to either Group ORG or Group ORG + tracker.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Neither the research team nor participants were blinded to participants' randomisation status.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing data were imputed by chained equations.
Selective reporting (reporting bias)	Low risk	All the outcomes mentioned in the protocol were reported.
Baseline comparability/imbalance	High risk	Group ORG had a higher proportion of males, senior leaders and overweight participants, had fewer managers and reported more lower-extremity musculoskeletal problems than Group ORG + tracker.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Carr 2015

Methods	Random allocation Single-blind Study duration: 8 months Drop out: 10% (five participants were lost to follow-up and one discontinued the intervention). **Location:** USA

Carr 2015 *(Continued)*

	Recruitment: participants were recruited via an electronic advertisement on the company's well-being website. The advertisement included a link to an online eligibility survey. Research staff contacted interested and eligible employees via telephone to schedule a baseline testing session.
Participants	**Population:** healthy adults working in full-time sedentary jobs at a large private company were invited to participate via an electronic advertisement on the company's well-being website. They were physically inactive, overweight/obese. **Intervention group:** 27 participants **Control group:** 27 participants **Demographics:** Mean age: intervention: 45.2 (SD 10.9), control 45 (SD 10.7), 70% participants were females in both intervention and control groups BMI: intervention 34.5 (SD 6.8) kg/m^2, control 33 (SD 5.6)kg/m^2
Interventions	**Duration of intervention:** 16 weeks **Intervention:** ergonomic workstation intervention; three activity-promoting emails/week and access to a seated active workstation (elliptical machine, activeLife Trainer). **Control:** ergonomic intervention and emails only.
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Occupational sedentary time and physical activity (% workday in light, moderate and vigorous intensity) measured by accelerometer-inclinometer • Cardiometabolic risk factors (weight, fat mass, lean mass, waist circumference, resting systolic and diastolic blood pressure and resting heart rate) • Musculoskeletal discomfort (self reported) • Work productivity measured by Health and Work Performance Questionnaire • Cognitive function measured as self reported time spent concentrating on work
Notes	The second author, Dr Christoph Leonhard, owns propriety rights to the activeLife Trainer. No other financial disclosures were reported by the authors.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	A 1:1 randomisation scheme was generated by the principal investigator using an online random sequence generator.
Allocation concealment (selection bias)	Low risk	Based on the randomisation scheme, participants were provided a sealed envelope indicating their treatment assignment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	The envelope was provided by a research assistant who was previously unaware of the randomisation schedule, but the participants were not blinded.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported

Carr 2015 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	54 of the 60 participants completed all assessments. Five were lost to follow-up and one discontinued the intervention thus yielding a total attrition of 10%.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported.
Baseline comparability/imbalance	Low risk	Mean age: intervention: 45.2 (10.9), control 45 (10.7), 70% participants were females in both intervention and control groups, BMI: intervention 34.5 (6.8) kg/m^2, control 33 (5.6)kg/m^2
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Chau 2014

Methods	Random allocation with cross-over and wait-list control Participants were allocated randomly by drawing from the ballot four at a time. The first four were allocated to intervention group and next four to control group for four weeks. The remaining participants were assigned to the wait-list control condition and were placed on the waiting list in seven groups (four to five people per group). After the initial four weeks, the previous control group received the intervention with the next group from the ballot draw serving as their controls. This was repeated until all nine groups had received the intervention. Unblinded **Study duration:** 9 weeks **Dropout:** 7% **Location:** Australia **Recruitment:** project was advertised to staff as part of their workplace wellness program via internal mail, staff meetings and information fliers in the office. Staff members who were interested in participating contacted the research team and received additional project information and an expression of interest form. They could then join the study ballot by returning the expression of interest form.
Participants	**Population:** staff from a non-government health agency in New South Wales, Australia **Demographics:** BMI (kg/m^2): underweight (< 18.5): 13%, normal range (18.5–24.9): 50%, overweight (25–29.9): 25%, obese (≥ 30): 13%
Interventions	**Duration of intervention:** 9 weeks **Intervention:** sit-stand desk **Control:** no sit-stand desk
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in self-reported and objectively assessed time spent sitting, standing and walking/stepping (minutes/day) before and after the use of a sit-stand desk measured by ActivPALs and self-report questionnaires. • Domain specific sitting (minutes/day) over the whole day, assessed by self-report.

Chau 2014 *(Continued)*

Notes	This research was supported by funding from Heart Foundation New South Wales, and Australian National Health and Medical Research Council Program Grant (#569940).

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomly drawn from a ballot by a researcher in the presence of potential participants and other researchers. Participants were allocated to the intervention group, control group and wait-list control condition.
Allocation concealment (selection bias)	High risk	Allocation concealment was not possible due to the open plan nature of the study office environment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Research staff, participants, and assessors were not blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Three participants who were missing age or BMI values were not included in the analyses. Imputing values for these missing covariate values did not influence the effect of the intervention on the adjusted estimates for the outcomes, nor did it change the effects age or BMI had on the outcome.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. The study protocol was not available.
Baseline comparability/ imbalance	Low risk	Since the trial used a cross-over design, all the participants would receive the interventions at some point.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Chau 2016

Methods	Non-random allocation: CBA Single-blind Study duration: 20 weeks Dropout: 22% **Location:** Australia **Recruitment:** the research team gave a presentation about the study to team leaders and managers, who then discussed the study with their staff. Participants joined the study by returning a signed consent form to the researchers.
Participants	**Population:** customer care (call centre) staff from two teams working at one worksite of a large telecommunications company in Sydney, Australia. **Intervention group:** 16 participants

Chau 2016 *(Continued)*

	Control group: 15 participants **Demographics:** Mean age: control 35.1 (SD 11.5), intervention 31.0 (SD 10.0) The intervention group had higher BMI than control group.
Interventions	**Duration:** 19 weeks **Intervention:** sit-stand desk + email reminders **Control:** no sit-stand desk
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting/standing/walking time (minutes/8-hour workday) measured at 1 week, 4 weeks and 19 weeks. Transitions in positions measured by activPAL3 accelerometer-inclinometer and a self-administered questionnaire • Self-reported perceptions about work, work-related energy, and feelings at work at baseline, 4, and 19 weeks post-installation of sit-stand desks (intervention)
Notes	A co-author, Amanda Sainsbury has received payment from Eli Lilly, the Pharmacy Guild of Australia, Novo Nordisk, and the Dietitians Association of Australia for seminar presentations at conferences. She is also the author of The Don't Go Hungry Diet (Bantam, Australia, and New Zealand, 2007) and Don't Go Hungry For Life (Bantam, Australia, and New Zealand, 2011).

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomisation was not performed.
Allocation concealment (selection bias)	High risk	Allocation was not concealed.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Neither the research team nor participants were blinded.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	Low participant adherence to activity monitor use and device malfunction resulted in high attrition rates.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported. Study protocol was not available.
Baseline comparability/ imbalance	Low risk	Both groups were comparable at baseline for age, sex and BMI.
Validity of outcome measure	Low risk	The accelerometer and Occupational Sitting and Physical Activity Questionnaire (OSPAQ) are valid tools for the measurement of sitting time.

Coffeng 2014

Methods	Random allocation by clusters Single-blind **Location:** Amsterdam, the Netherlands **Recruitment:** a top-down communication approach was used, starting with the management • An explanatory meeting with team leaders • Invitation to all employees from the department to participate in the study • Data on sick leave, salary and the duration of employment was obtained through the Human Resource Management department
Participants	**Population description:** office employees (18 years or above), working at the Dutch financial service provider **Demographics:** Age in years: group motivational interviewing (GMI) 43.6 (SD 10.3); environmental modification 42.2 (SD 10.5); GMI + environmental modification 38.0 (SD 10.5); no intervention 40.7 (SD 9.2) Male [n (%)]: GMI 73 (SD 61.9); Environmental modification 60 (SD 62.5); GMI + Environmental modification 51 (SD 55.4); no intervention 65 (SD 61.3)
Interventions	**Duration of intervention:** environmental modification: 12 months and GMI: 3.5 months The Be Active & Relax program was evaluated using 4 arms: • GMI (group motivational interviewing) and environmental modifications (3 clusters 92 employees); GMI derived from Motivational Interviewing (MI). MI is a counselling style that stimulates behavioural change by focusing on exploring and resolving ambivalence. A group setting has several benefits, e.g. sharing experiences, providing feedback and giving support. • Environmental modifications (3 clusters; 96 employees): 1) the VIP Coffee Corner Zone – the coffee corner was modified by adding a bar with bar chairs, a large plant and a giant wall poster (a poster visualizing a relaxing environment, e.g. wood, water and mountains); 2) the VIP Open Office Zone – the office was modified by introducing exercise balls and curtains to divide desks in order to reduce background noise; 3) the VIP Meeting Zone – conference rooms were modified by placing a standing table (a table that allows you to stand while working) and a giant wall poster (as before); and 4) the VIP Hall Zone - table tennis tables were placed and lounge chairs were introduced in the hall for informal meetings. In addition, footsteps were placed on the floor in the entrance hall to promote stair walking. • GMI (7 cluster; 118 employees); • No intervention or control group (6 cluster; 106 employees)
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Primary outcome: need for recovery • Secondary outcomes: daily physical activity, sedentary behaviour at work, detachment and relaxation, exhaustion, absenteeism, work performance, work engagement
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation was executed by an independent researcher by using a computer generated list from SPSS.
Allocation concealment (selection bias)	Unclear risk	No information

Coffeng 2014 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	High risk	Blinding of the participants and intervention providers for the social environmental intervention was impossible.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Incompleteness of the data is taken into account with the multilevel analysis. Loss to follow-up at 6 months was considerable (> 20%). However, there were no significant differences at baseline between responders and non-responders.
Selective reporting (reporting bias)	Low risk	All mentioned outcomes in the study protocol were reported.
Baseline comparability/imbalance	Low risk	No differences regarding age, gender, education, marital status, ethnicity, working hours, general health, job demands, supervisor support. Males were slightly over-represented.
Validity of outcome measure	High risk	Validity of the questionnaire used in the study has not been tested.

Danquah 2017

Methods	Random allocation by clusters Single-blind Study duration: 3 months Dropout: **Location:** Denmark **Recruitment:** recruited through a press release and an open invitation in an electronic newsletter aimed at practitioners and health workers in municipalities and private workplaces all over Denmark
Participants	**Population:** practitioners and health workers in municipalities and private workplaces all over Denmark **Intervention group:** 173 participants in 10 offices **Control group:** 144 participants in 9 offices **Demographics:** Mean age: intervention 46 (SD 10), control 45 (SD 11) % of females: intervention 61%, control 73% BMI: intervention group 26 (SD 5.0) kg/m^2, control group 27 (SD 4.8) kg/m^2
Interventions	**Duration:** 3 months **Intervention:** a multi-component work-based intervention (ambassadors, environmental changes, lecture, workshop, emails and texts).

Danquah 2017 *(Continued)*

	Control: no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting, standing and number of prolonged sitting periods (> 30 min) - minutes/ 8-hour workday, number of sit-to-stand transitions per hour in a workday, leisure sitting time and MVPA in leisure (minutes/8-hour leisure) measured at 1 and 3 months. Transitions in positions measured by activPAL3 accelerometer-inclinometer and a self-administered questionnaire • Weight (kg), waist circumference (cm), fat free mass (kg), fat mass (kg), body fat percentage at 3 months
Notes	Funded by Tryg Fonden, Denmark. The funders had no role in study design, data collection or analysis, decision to publish or preparation of the manuscript.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	A senior researcher carried out the randomisation, using random number sequence in Stata
Allocation concealment (selection bias)	Low risk	Randomisation took place before baseline measurements were recorded, but allocation was not disclosed to participants, researchers or data collectors until the baseline assessments had been completed
Blinding of participants and personnel (performance bias) All outcomes	High risk	The researchers were not blinded at follow-up.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	A blinded version of the data was used for data management and analysis.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Final levels of missing data on primary outcomes were 9% at baseline, 15% at 1-month follow-up and 20% at 3- months follow-up. however missing data were imputed by multiple imputations using chained equations.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the study protocol has been reported.
Baseline comparability/ imbalance	Low risk	Both groups were comparable at baseline for age, sex and BMI.
Validity of outcome measure	Low risk	ActiGraph GT3X accelerometer is a valid instrument for assessing physical activity and sedentary behaviour

De Cocker 2016

Methods	Random allocation by clusters Single-blind Study duration: 3 months Dropout: **Location:** Belgium

De Cocker 2016 *(Continued)*

	Recruitment: employees were invited to participate by email
Participants	**Population:** employees of 2 companies (a university and an environmental agency) in Flanders **Intervention group:** tailored group: 78 participants (2 departments), Generic group: 84 participants (2 departments) **Control group:** 51 participants (2 departments) **Demographics:** Age in years: tailored 40.5 (SD 8.6), generic 40.7 (SD 9.7), control 39.3 (SD 9.0) % of males: tailored 32%, generic 27%, control 15% % of participants with high school/university education: tailored 58%, generic 70%, control 46% BMI: tailored 24.2 (3.1) kg/m^2, generic 23.6 (SD 3.5) kg/m^2, control group 23.7 (SD 3.5) kg/m^2
Interventions	**Duration:** 3 months **Intervention:** tailored group: personalised computer-tailored feedback about sitting time, including tips and suggestions on how to interrupt (taking short standing breaks) and reduce (replacing sitting by periods of standing) sitting, and in the end motivated participants were invited to create an action plan to convert intentions into specific actions. Generic group: generic information on the importance of reducing and interrupting sitting **Control:** usual lifestyle
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Self-reported changes in sitting (total sitting, sitting at work, domains of leisure sitting) measured at 3 months
Notes	The first author is supported by the Research Foundation Flanders (FWO) (postdoctoral research fellowship: FWO11/PDO/097). Authors declared no conflict of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	More than 10% participants were lost to follow-up in each comparison groups.

De Cocker 2016 *(Continued)*

Selective reporting (reporting bias)	High risk	Not every outcome mentioned in the study protocol has been reported.
Baseline comparability/imbalance	Low risk	The comparison groups did not differ in sociodemographic, work-related, and health-related variables.
Validity of outcome measure	Low risk	The WSQ has acceptable reliability (interclass correlation coefficient = .63) and validity against objectively accelerometer-measured sitting time (r = .34 to r = .45).

Donath 2015

Methods	Random allocation by minimization Single-blind Study duration: 12 weeks Drop out: 8% **Location:** Switzerland
Participants	**Population:** staff from the confederate Swiss health insurance company EGK **Intervention:** 15 participants **Control:** 16 participants **Demographics:** Age: intervention: 45 (SD 12), control: 40 (SD10) Sex (m/f): intervention 4/11, control 4/12 BMI (kg/m^2): Intervention: 23.7 (SD 3.7), control: 24.7 (SD 5)
Interventions	**Duration of intervention:** 12 weeks **Intervention:** computer prompt + information **Control:** information only
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Sitting and standing time (hours/week) at 6 and 12 weeks of intervention measured by using the ActiGraph wGT3X-BT • Test d2 of Brickenkamp (paper and pencil test used to examine attention and concentration processes) • Neuromuscular outcomes (strength-endurance and balance outcome).
Notes	Authors reported no conflict of interest

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Donath 2015 *(Continued)*

Random sequence generation (selection bias)	Low risk	Group assignment was randomly conducted according to the minimization method: age, gender, BMI, physical activity and working time served as strata criteria in order to minimize group differences in demographical variables.
Allocation concealment (selection bias)	Unclear risk	No information
Blinding of participants and personnel (performance bias) All outcomes	High risk	Testing personnel were blinded to group allocation. Participants were not blinded.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	3 participants in the control group and 4 participants in the intervention group withdrew due to job changes and illness (8% of participants). They were not included in the analysis (i.e. no intention-to-treat analysis).
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported. Study protocol was not available.
Baseline comparability/imbalance	Low risk	Group differences were minimized.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Dutta 2014

Methods	Random allocation with cross-over Unblinded Study duration: 10 weeks Dropout: 1231 working hours data were missing **Location:** USA **Recruitment:** a word-of-mouth search was performed for finding interested companies to host the study and Caldrea Inc. volunteered. A recruitment presentation was made at an all-employee meeting (n ˜ 50) and was followed a few days later by enrolment interviews.
Participants	**Population:** employees of Caldrea Inc. company, USA **Demographics:** average age: 40.4 years; out of 28 participants, 19 were female
Interventions	**Duration of intervention:** 4 weeks **Intervention:** sit-stand desk Three different models of desks were used: Workfit-S, a setup that attaches to the front of one's existing desk that can hold the computer monitor, keyboard and mouse; Workfit-A, a setup that is identical to Workfit-S but attaches to the back of one's existing desk; and Workfit-D, a whole desk that is easily moved up and down. The Workfit-A and S also came with an added work-surface and all three types of desks came with anti-fatigue floor mats for comfort during standing.

Dutta 2014 *(Continued)*

	Control: no sit-stand desk
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Sitting time, standing time, and light activity at work self-reported and objectively assessed with accelerometer-inclinometer Self-reported energy and relaxation levels
Notes	James A. Levine has patents in accelerometer algorithms with Gruve Technologies Inc. but he did not access or analyse the raw the data from the Gruve device.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomly assigned to receive the intervention during period 1 or period 2, using a 1:1 allocation in 1 block of 35, using Microsoft Excel 2007.
Allocation concealment (selection bias)	High risk	Allocation concealment was not possible due to the nature of the intervention.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Blinding of participants and personnel was not possible due to the nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	If we assume a person works for 40 hours per week, then for 28 participants the working hours will be 8960 hours for 8 weeks (4 weeks intervention and 4 weeks control period). However the study reported only 7,729 working hours based on accelerometer data.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. The study protocol was not available.
Baseline comparability/ imbalance	Low risk	There were no significant differences in age or BMI between interventions and control groups. Most of the participants were female.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Ellegast 2012

Methods	Random allocation Unblinded Study duration: 12 weeks No dropouts **Location:** Germany Only part of the study was presented as all the data have not been analysed.

Ellegast 2012 *(Continued)*

Participants	**Population:** desk-based employees at VDU workplaces **Demographics:** mean age (years): 40.7 (range 24 to 58), control 42.1 (range 25 to 61) 4 female participants in both intervention and control groups Mean BMI: 26.3 (SD 3.2) kg/m^2
Interventions	**Duration of intervention:** 12 weeks **Intervention** • A recreational intervention consisting of sit-stand workplaces: 1) electrically adjustable (68cm to 118cm) writing desk and PC-table; 2) height and angle adjustable lecterns in that were also movable in the room combined with a foot stand; 3) stand tables during breaks; 4) table tennis in the cellar; 5) individual changes to the VDU station plus oral and written instructions to use printers further away and to use stairs. • A behavioural intervention: 1) midday gymnastics (11.45am-12.00 am) with relaxation, stretch, power and co-ordination exercises; participants were instructed to participate every day; 2) action: cycle to work: every day participants could indicate if they cycled to work and be eligible for a prize; 3) afternoon (lunch?) walk; 4) company sports offer; 5) bonus point system: for every activity performed the participants got points that could be exchanged for small extras: apples, muesli bar etc.; 6) AiperMotion: participants wore an activity monitoring device that they could read anytime; 7) step barometer; every week the results of the step counter in the AiperMotion device was published as an average over the week for every participant in one chart. **Control:** usual office work
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Assessment of physical activity: changes in standing and sitting (min/day), number of steps and energy expenditure • Assessment of well-being and medical check-up: body mass index, multidimensional mood questionnaire, general medical examination
Notes	This project was initiated and funded by the German Social Accident Insurance (DGUV).

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Following correspondence with the authors, they replied: "Randomization by computer generated list".
Allocation concealment (selection bias)	Low risk	Following correspondence with the authors, they replied: "our secretary, who was not involved in the project, generated the allocation list".
Blinding of participants and personnel (performance bias) All outcomes	High risk	Following correspondence with the authors, they replied: "The participants were blinded, the personnel was not blinded (they knew according to the subject code, who belongs to the Intervention group and to the Control group)".
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	No attrition

Ellegast 2012 *(Continued)*

Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported.
Baseline comparability/imbalance	Low risk	Participants were recruited from different VDU workplaces. No significant difference in age of participants between intervention and control groups. 4 female participants in both intervention and control groups.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Evans 2012

Methods	Random allocation: RCT Single-blind Study duration: 10 days Dropout: 7% **Location:** United Kingdom **Recruitment:** healthy working adults who could stand unassisted recruited via poster and email
Participants	**Population:** healthy adults working in an office at Glasgow Caledonian University in Scotland **Intervention group:** 14 participants (computer prompts (CP)) **Control group:** 14 participants (education) **Demographics:** CP group (mean age 49 (SD 8 years) were older than the education group (mean age 39 (SD 10) years), predominantly female (11 in CP group and 11 in education group), worked as administrators (4 in CP group and 3 in education group), researchers (5 in CP group and 7 in education group), lecturers (5 in CP group and 4 in education group) BMI: CP group 23.7 (SD 3.5) vs. education group 23.6 (SD 2.8)
Interventions	**Duration of intervention:** 5 days but the participants were followed up for 10 days. **Intervention:** CP + information **Control:** information only (a short educational talk) All participants received a short educational talk regarding the health risks of prolonged sitting stating that standing every 30 minutes could be beneficial, and a short information leaflet was also provided. Then participants in the intervention group had a prompting software installed in their personal computer to remind them to take a break for 1 min every 30 minutes.
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Assessed with thigh-mounted accelerometer-inclinometer • Total sitting time (h/day) • Number of sitting events (events/day) • Number of prolonged sitting events (events/day) • Duration of prolonged sitting events (h/day)
Notes	This study was funded by the School of Health, Glasgow Caledonian University and formed the dissertation project for Masters of Rehabilitation Science of Rhian Evans, Henrietta Fawole, and Stephanie

Evans 2012 *(Continued)*

	Sheriff. No financial support was received from any commercial company. No financial disclosures were reported by the authors of this publication.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Random number generation was used.
Allocation concealment (selection bias)	Low risk	Information on the group assignment was placed into sequentially numbered sealed opaque envelopes. The researcher was involved in opening the envelope immediately after the education.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Both the researcher and participants were aware of the allocation. Awareness of the purpose of the study may have led the education group participants to behave differently during the study, which may have affected the outcomes.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Data treatment was conducted by a researcher blinded to the allocation of the participants.
Incomplete outcome data (attrition bias) All outcomes	Low risk	2 participants were excluded from analyses due to incomplete data: 1 from the CP group and 1 from the education group. As the same proportion of participants were excluded from both groups, the missing data did not have much impact on outcomes.
Selective reporting (reporting bias)	High risk	Not all outcomes mentioned in the study protocol were reported.
Baseline comparability/ imbalance	Low risk	CP group (mean age 49 (SD 8) years) was older than the education group (mean age 39 (SD 10) years), participants worked as administrators (4 in CP group, 3 in education group), researchers (5 in CP group, 7 in education group), or lecturers (5 in CP group, 4 in education group) and were predominantly female (11 in CP group, 11 in education group)
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Gao 2015

Methods	Non-random allocation Unblinded Study duration: 6 months Dropouts: 49% **Location:** University of Jyväskylä, Finland **Recruitment:** all faculty employees (n = 170) were invited to fill out a questionnaire between August and September 2012 and again in February 2013.
Participants	**Population:** healthy adults working in a university setting: researchers, teachers, administrative workers, assistants, professors and technical workers.

Gao 2015 *(Continued)*

	Intervention group: 24 participants **Control group:** 21 participants **Demographics:** mean age: intervention 47.8 (SD 10.8) years, control 39 (SD 8.5) years. 70.8% were females in the intervention group and 81% were females in the control group. BMI (kg/m^2): intervention: 24.8 (SD 3.9), control: 23.3 (SD 3.8)
Interventions	**Duration of intervention:** 6 months **Intervention:** sit-stand desk **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in occupational sedentary time (% of work time spent sitting and standing) measured by self-reported questionnaire • Changes in health outcomes and work ability measured by self-reported questionnaire • Daily usage of the sit–stand function measured by self-reported questionnaire
Notes	The study was funded by the China Scholarship Council (201206320092).

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	The study did not employ randomisation. Part of the personnel moved to a renovated building with sit-stand desks.
Allocation concealment (selection bias)	High risk	Allocation was not concealed.
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	The questionnaire was returned by 92 employees at baseline, before working at sit–stand desks, and 61 employees after 6 months. Those who completed the questionnaire only once were excluded, leaving 45 individuals who were included in the analysis. The study lost 49% participants during follow-up.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the protocol were reported.
Baseline comparability/ imbalance	High risk	In the intervention group participants were older and had more experience of office work. 70.8% were females in the intervention group and 81% were females in the control group. BMI (kg/m^2): intervention: 24.8 (3.9), control: 23.3 (3.8)
Validity of outcome measure	High risk	Validity of the questionnaire used in the study has not been tested.

Gilson 2009

Methods	Random allocation Unblinded Study duration: 10 weeks Dropout: 16% **Location:** UK, Australia and Spain **Recruitment:** participants came from 3 major regional universities in 3 countries, represented by a lead investigator in each university, who had expressed an interest in running an employee intervention at their respective university as part of an evolving, international project.
Participants	**Population:** white-collar (i.e. professional, managerial, or administrative) university staff from the UK (n = 64), Australia (n = 70) and Spain (n = 80) **Intervention groups:** • route walking group 60 participants; • incidental walking group 59 participants. **Control group:** 60 participants **Demographics:** mean age (years): route walking group 42.1 (SD 9.2); incidental walking group 41 (SD 9.7), control group 40.8 (SD 11.4) Women were predominant in all 3 groups Mean BMI (kg/m^2): route walking group 25.1 (SD 4), incidental walking group 25.4 (SD 4.3), control group 24.2 (SD 3.8)
Interventions	**Duration of intervention**: 10 weeks **Interventions**: walking strategies (route and incidental walking) **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Number of steps assessed by an unsealed pedometer (Yamax SW-200) accompanied by a diary • Sitting time (minutes/day) assessed by a logbook
Notes	Authors declared that they had no competing interests.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Pre-intervention workday step counts and block stratification were used to assign participants at each site randomly and equally to a waiting list control or one of two intervention groups.
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias)	Unclear risk	Not reported

Gilson 2009 *(Continued)*

All outcomes		
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	From a potential sample size of 214 participants, 16% (n = 35) had missing data at pre-intervention or 2 or more intervention measurement points. These data were removed prior to analyses, resulting in a final sample size of n = 179.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. The study protocol was not available.
Baseline comparability/ imbalance	Low risk	Age was not significantly different between groups: 42.1 (SD 9.2) years in the route walking group; 41 (SD 9.7) years in the incidental walking group and 40.8 (SD 11.4) years in the control group. Study participants were predominantly women. All participants were white collar workers (i.e. professional, managerial, or administrative).
Validity of outcome measure	Low risk	Paper-based diaries were used to report sitting time at work.

Gordon 2013

Methods	Random allocation Unblinded Study duration: 10 weeks Dropout: 14% **Location:** USA **Recruitment:** strategically placed fliers posted around the Arizona State University Downtown Phoenix Campus, email advertisements delivered to employees through the Employee Wellness Committee, and word of mouth.
Participants	**Population:** currently employed adults with predominantly sedentary occupations working in the Greater Phoenix area in 2012-2013 **Intervention group:** 12 participants **Control group:** 10 participants **Demographics:** **Mean age:** intervention 44.2 (SD 12.5), control 47.2 (SD 13.5) 50% females in both groups BMI: intervention 24.1 (SD 3) kg/m², control 30.6 (SD 5) kg/m² Intervention group composed of significantly more “official and managerial level” individuals.
Interventions	**Duration of intervention:** 10 weeks **Intervention:** one orientation to walking workstation, 5 bi-weekly newsletters, specifically targeting workplace sitting behaviours, 5 bi-weekly FAQ’s and access to study website for intervention content, latest sedentary behaviour research and links for tools for decreasing sitting time at work.

	Control: health education
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Sitting time/workday (minutes/8-hour workday) measured by accelerometer-inclinometer. Participants were also asked to complete a daily log to determine work schedule and verify obtained inclinometer and accelerometer data
Notes	Thesis presented in partial fulfilment of the requirements for the degree Master of Science.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Group allocation was decided by tossing a coin.
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	One participant from both groups withdrew, due to busy schedule; 1 participant from both groups was excluded due to device malfunction; and 1 participant from the control group was excluded due to refusal to wear accelerometer. Intention-to-treat analysis was followed for data analysis.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported. Study protocol was not available.
Baseline comparability/ imbalance	High risk	Intervention group composed of significantly more “official and managerial level” individuals. Age of participants in the control group was 47.2 (SD 13.5) and in the intervention group was 44.2 (SD 12.5). There were 50% females in both groups. There was significant difference in BMI of participants between intervention and control groups.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Graves 2015

Methods	Random allocation Unblinded Study duration: 8 weeks Dropout: 4% **Location:** UK

Graves 2015 *(Continued)*

	Recruitment: consent was sought from 11 departmental managers for employee recruitment. All employees in consenting departments received an overview of the study and participant information sheet, and were invited to a study information session via an email from the research team.
Participants	**Population:** office workers from one organisation (Liverpool John Moores University, Liverpool, UK). Employees within the approached departments were predominantly administrative staff. **Intervention group:** 26 participants **Control group:** 21 participants **Demographics:** **Mean age:** intervention 38.8 (SD 9.8) years, control 38.4 (SD 9.3) years 89% in intervention group and 67% in control group were females BMI (kg/m^2): intervention 67.4 (SD 13.8), control 70.5 (SD 16.4)
Interventions	**Duration of intervention:** 8 weeks **Intervention:** sit-stand desk combined with face-to-face training and ergonomic information. **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Sitting time, standing and walking time (minutes/day) measured by paper-based diary to record • Vascular outcomes: B-mode images of the brachial artery • Plasma glucose, triglycerides and total cholesterol • Musculoskeletal outcomes on a Likert scale from 0 (no discomfort) to 10 (extremely uncomfortable) • Acceptability and feasibility
Notes	Ergotron Ltd provided the sit-stand desks but had no involvement on the provenance, commissioning, conduct or findings of the study. No other financial disclosures were reported by the authors of this paper.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomised using a randomised block design and random number table.
Allocation concealment (selection bias)	High risk	One member of the research team assigned the participants to a treatment arm, based on a design and table with alternating scheme.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Researchers were aware of the allocation and participants may have also been aware of the allocation due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	The authors conducted a per-protocol analysis and excluded participants from analyses for outcomes to which they did not contribute data. For workplace sitting, standing and walking, the per-protocol analysis was compared with an intention-to-treat analysis, as a sensitivity analysis.

Graves 2015 *(Continued)*

Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported.
Baseline comparability/ imbalance	Low risk	Groups were comparable at baseline except for a higher proportion of women in the intervention group (89% versus 67% in the control group).
Validity of outcome measure	Low risk	Ecological Momentary Assessment diaries were used to report sitting time at work.

Healy 2013

Methods	Non-random allocation by clusters (floor): CBA Unblinded Study duration: 3 months Dropout: 14% **Location:** Melbourne, Australia **Recruitment:** an invitation email was sent to all potential participants to attend one of two 30-minute study information sessions delivered by research staff. Participants who subsequently expressed interest were screened via telephone for eligibility.
Participants	**Population:** from a single workplace (Comcare: the government agency responsible for workplace safety, rehabilitation and compensation for Australian government workplaces) in metropolitan Melbourne, Australia **Intervention group:** 19 participants **Control group:** 19 participants **Demographics:** mean age 42.4 (SD 10.6) years in the intervention group and 42.9 (SD 10.3) years in the control group Women were predominant in the intervention group and men were predominant in the control group. Mean BMI (kg/m^2): intervention group 27.5 (SD 6.1); control group 26.2 (SD 4.6)
Interventions	**Duration of intervention:** 4 weeks **Intervention:** the intervention communicated 3 key messages: “Stand Up, Sit Less, Move More” and had the following components: • organisational (a 45-minute researcher-led consultation with unit representatives from the intervention group and management followed by a workshop for all intervention participants); • environmental (installation of sit–stand desks); and • individual elements (30-minute face-to-face consultation with each intervention participant, followed by 3 telephone calls (1/week)). **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Sitting, standing, and moving at the workplace (minutes/8-h workday) assessed by accelerometer-inclinometer at baseline and their changes at 3-month follow-up • Weight (kg), waist circumference (cm), hip circumference (cm), fat free mass (kg), fat mass (kg), fasting blood lipids (mmol/L) and glucose (mmol/L) baseline vs. 3 months

Healy 2013 *(Continued)*

	• Self-reported health- and work-related outcomes baseline vs. 3 months * Musculoskeletal symptoms by anatomical regions * Other health symptoms: eye strain, headaches, digestion problems, trouble walking, trouble sleeping, fatigue (1-5 scale) * Work-related outcomes ≥ 1 sick day (in the last month), > 1 day worked while suffering health problems (in the last month), work performance (1-10 scale)
Notes	This study was funded by an NHMRC project grant and the Victorian Health Promotion Foundation. Ergotron provided the height-adjustable desks (www.ergotron.com). No financial disclosures were reported by the authors and the authors declared that there were no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Randomisation was not done.
Allocation concealment (selection bias)	High risk	Allocation into groups was by floor, with intervention participants (primarily administrative staff) working on the floor above the control participants (predominantly senior administrative staff).
Blinding of participants and personnel (performance bias) All outcomes	High risk	Research staff, participants, and assessors were not blinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	High risk	Assessors were not blinded to group allocation.
Incomplete outcome data (attrition bias) All outcomes	Low risk	4 participants, 2 each from the intervention and control groups withdrew and 2 further participants, 1 each from the intervention and control groups were lost during follow-up. As the same proportion of participants were excluded from both groups, the missing data did not have much impact on outcomes.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. The study protocol was not available.
Baseline comparability/ imbalance	Low risk	There were more women in the intervention group than in the control group. The mean age of both groups was similar. All participants were recruited from a single workplace in metropolitan Melbourne, Australia.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Healy 2016

Methods	Random allocation by clusters Single-blind Study duration: 3 months Dropout: 12 months **Location:** Australia

Healy 2016 *(Continued)*

	Recruitment: an information session about the study was presented for consenting teams within each site, with summary material also provided via e-mail. Employees within these participating teams were then screened by telephone for eligibility.
Participants	**Population:** staff from the department of human services (a large Australian Government organisation), desk-based office workers **Intervention group:** 7 worksites, 164 participants **Control group:** 7 worksites, 144 participants **Demographics:** Mean age in years: intervention 44.6 (SD 9.1), control 47.0 (SD 9.7) % females: intervention 65.4%, control 72.6% BMI: intervention group 28.61 (SD 6.46) kg/m^2, control group 28.61 (SD 5.48) kg/m^2
Interventions	**Duration:** 3 months **Intervention:** multicomponent intervention composed of organisational (Consultation workshop, tailored email messages to promote organisational strategies by team champions) environmental (dual screen sit-stand desk), and individual-level strategies and targeted change at both the individual and the cluster levels (face to face coaching and telephone calls by study-trained health coaches). **Control:** usual practice
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting/standing/stepping time (minutes/8-hour workday) and overall sitting time (minutes/16-hour) measured at 3 months and 12 months. Transitions in positions measured by activPAL3 accelerometer-inclinometer • Adverse events
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation was done by generating a randomisation plan for up to 24 clusters in one block.
Allocation concealment (selection bias)	Low risk	Randomisation was performed by a research staff member not involved in recruitment or data collection.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants and study staff were unblinded to group allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	The sensitivity of results were assessed by using multiple imputation by chained equations.

Healy 2016 *(Continued)*

Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the protocol section were reported.
Baseline comparability/imbalance	Low risk	There were more females in the intervention group compared to control group. Both groups were comparable in terms of age and BMI.
Validity of outcome measure	Low risk	activPal accelerometer is a valid instrument for assessing physical activity and sedentary behaviour.

Kress 2014

Methods	Non-random allocation Study duration: 6 months Drop outs: 47% **Location:** United States **Recruitment:** participants were contacted by email with an invitation to participate in the study
Participants	**Population:** call centre workers in a company (healthways) in USA. Healthways Inc., a well-being improvement company with headquarters in Franklin, Tennessee, has multiple call centres in which their Health Coaches, Clinicians (Nurses and Dieticians), and Customer Service Representatives work. **Intervention:** sit-stand desks (45 participants0, standing desks**(**46 participants) **Control:** seated (47 participants) **Demographics:** mean age in years: sit-stand 34.8 (SD 11.5), standing 28.9 (6.8), seated 35 (SD 13.2) % female participants: sit-stand 71%, standing 59%, seated 70% BMI: sit-stand 29 (SD 9.13), standing 26.8 (SD 5.5), seated 27.8 (SD 5.7)
Interventions	**Duration of intervention:** 6 months Sit-stand desk vs. standing desk
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Self reported changes in sitting/standing (minutes/ workday) measured at 6 months • Energy expenditure (calories/minute) • Participants experiences with the new workstation at 6 months
Notes	Data for seated group not reported.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Likely not random and it may be that people swapped desks because of open design of call centre.
Allocation concealment (selection bias)	High risk	Assignment to the workstation type was dependent on Healthways, and it made assignments as random as possible.

Kress 2014 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	High dropout (47% attrition)
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. The study protocol was not available.
Baseline comparability/ imbalance	Low risk	Mean age of participants was higher for sit-desk (control) group. Both groups were comparable at baseline for gender and BMI.
Validity of outcome measure	Unclear risk	The armband accelerometer (SenseWear model) is a valid instrument for assessing physical activity and sedentary behaviour

Li 2017

Methods	Random allocation Single-blind Study duration: 5 weeks Dropout: 18% **Location:** Australia **Recruitment:** employees were invited to participate through internal email communication.
Participants	**Population:** employees from the Health Promotion Unit (HPU) of a local health district in the Sydney metropolitan region. **Control group:** Group 1 (10 participants) **Intervention group:** Group 2 with 8 participants, Group 3 with 7 participants, Group 4 with 7 participants **Demographics:** BMI: intervention group 22.6 (SD 2.6) kg/m^2, control group 21.5 (SD 2.6) kg/m^2
Interventions	**Duration:** 4 weeks **Control:** Group 1 usual seated work **Intervention:** sit-stand desk: Group 2 alternated between 40 minutes sitting and 20 minutes standing, Group 3 alternated between 30 minutes sitting and 30 minutes standing, Group 4 alternated between 20 minutes sitting and 40 minutes standing; in addition all intervention group received email reminders
Outcomes	**Outcome name, measurement time/tool (units of measurement)**

Li 2017 *(Continued)*

	• Objectively measured total sitting, standing and stepping/walking time, and sit-to-stand (STS) transitions during work and non-work hours assessed by an activPAL accelerometer-inclinometer and self-reported using Occupational sitting and physical activity questionnaire and The Active Australia Survey (AAS) • Self-reported leisure time physical activity (LTPA) • Sleep duration
Notes	Authors reported no conflict of interest.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Participants were assigned identification codes that were randomised using permuted blocks with block size 8 and 4.
Allocation concealment (selection bias)	Low risk	Group allocation sequence was generated by a study investigator who was not involved in data analysis.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Blinding participants or all members of the research team to group allocation was not possible due to the nature of the trial.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	The researcher conducting the data analysis was blinded to the group allocation of participants until analyses were completed.
Incomplete outcome data (attrition bias) All outcomes	High risk	7 participants in intervention and 1 in control group lost to follow-up (25% attrition rate).
Selective reporting (reporting bias)	High risk	All outcomes mentioned in the study protocol were not reported.
Baseline comparability/imbalance	Low risk	Intervention and control group were comparable for age, sex and BMI at baseline.
Validity of outcome measure	Low risk	activPal accelerometer is a valid instrument for assessing physical activity and sedentary behaviour

MacEwen 2017

Methods	Random allocation Single-blind Study duration: 3 months Dropout: 11% **Location:** Australia **Recruitment:** through posters and word-of-mouth
Participants	**Population:** full-time desk-based employees in the Charlottetown area. **Intervention group:** 16 participants

MacEwen 2017 *(Continued)*

	Control group: 12 participants **Demographics:** Mean age in years: intervention 43.2 (SD 9.7), control 48.9 (SD 11.4) BMI: intervention group 36.5 (SD 9) kg/m^2, control group 34.6 (SD 7) kg/m^2
Interventions	**Duration:** 3 months **Intervention:** sit-stand desk **Control:** no sit-stand desk
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting/standing/stepping time (minutes/8-hour workday) measured at 12 weeks. Transitions in positions measured by activPAL3 accelerometer-inclinometer • Weight (kg), waist circumference (cm), BMI, body fat %, estimated $V0_2$max (ml/min/kg), systolic and diastolic BP (mmHg), fasting blood lipids (Total cholesterol/HDL/LDL/Triglycerides) (mmol/L), glucose (mmol/L), HbA1c (%), aortic augmentation Index (%), subendocardial variability (%) at 12 weeks
Notes	The project was supported by StepsCount, Inc

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were randomly assigned via coin flip to intervention and control group.
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	Four participants were excluded from analysis (14% attrition).
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the study protocol were reported.
Baseline comparability/imbalance	High risk	Participants in the control group were older (48.9 years, SD 11.4) than the intervention group (43.2 years, SD 9.7) and the intervention group had higher BMI (36.5 kg/m^2, SD 9) than the control group (34.6 kg/m^2 SD 7).
Validity of outcome measure	Low risk	activPal accelerometer is a valid instrument for assessing physical activity and sedentary behaviour

Mailey 2016

Methods	Random allocation Single-blind Study duration: 9 weeks Dropout: 22% **Location:** United States **Recruitment:** university email lists and flyers distributed at local businesses.
Participants	**Population:** university employees in office settings with set hours (8:00 a.m.-5:00 p.m.) but not set break schedules **Long break group:** 25 participants **Short break group:** 24 participants **Demographics:** Mean age in years: long break: 38.92 (SD 7.88), short break: 38.50 (SD8.67) All participants were females and 60% of them were obese
Interventions	**Duration:** 8 weeks Long break (LB) vs. short break (SB)
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting behaviour/light activity/moderate activity (minutes/ workday) measured at 8 weeks, assessed by Actigraph GT3X accelerometer • Weight (kg), waist circumference (cm), systolic and diastolic blood pressure, fasting blood lipids (Total cholesterol/Triglycerides) (mmol/L) and glucose (mmol/L) at 8 weeks
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Participants were randomised to the SB or LB group using a random digit generation Microsoft Excel.
Allocation concealment (selection bias)	Low risk	Participants were randomised to the SB or LB group, by an investigator not involved with testing.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants were not blinded to their treatment group assignment.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	Total 11 employees (22.4%) dropped out over 8 weeks. No ITT analysis

Mailey 2016 *(Continued)*

Selective reporting (reporting bias)	Low risk	All the outcomes mentioned in the protocol were reported.
Baseline comparability/imbalance	High risk	Participants assigned to the LB group had higher total cholesterol (P = 0.02) and fewer minutes of sedentary time per workday (P = 0.05) at baseline than participants assigned to the SB group
Validity of outcome measure	Low risk	Actigraph GT3X accelerometer is a valid instrument for assessing physical activity and sedentary behaviour.

Neuhaus 2014a

Methods	Allocation by clusters, 2 groups randomly and 2 group non-randomly: CBA Unblinded Study duration: 3 months Dropout: 13.6% **Location:** University of Queensland, Brisbane, Australia **Recruitment:** a recruitment email explaining the study's purpose and procedures was sent to all staff from consenting units. Interested employees emailed the project manager and were interviewed via telephone to assess eligibility.
Participants	**Population:** desk-based office workers located on the same office floor, aged between 20–65 years from 3 different campuses **Intervention group:** • multi component: 12 participants; • workstation only: 13 participants. **Control group:** 13 participants **Demographics:** mean age in the multi component group was 37.3 (SD 10.7) years, 43 (SD 10.2) years in the workstation only group, and 48 (SD 11.6) years in the control group. There were no men in the multi component group, 3 in the workstation only group, and 4 in the control group.
Interventions	**Duration of intervention:** 3 months **Interventions:** • multi-component intervention consisted of the installation of height-adjustable workstations and organisational-level (management consultation, staff education, manager emails to staff) and individual-level (face-to-face coaching, telephone support) elements; • workstation-only intervention consisted of the installation of height-adjustable workstations and occupational health and safety instructions from the project manager. **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** All outcomes were assessed at 3-month follow-up • Changes in sitting, standing, and moving at work (minutes/8-h workday) assessed with an accelerometer-inclinometer • Musculoskeletal symptoms by anatomical regions

Neuhaus 2014a *(Continued)*

	• Work related outcomes: work performance, ≥ 1 sick day (in the last month), > 1 day worked while suffering health problems (in the last month) • Study feasibility and acceptability • Adverse events
Notes	Funding source: Australian Postgraduate Award Scholarship, UQ School of Population Health Top-Up Scholarship and research student funding, Queensland Health Core Infrastructure Funding, and UQ Major Equipment and Infrastructure and NHMRC Equipment Grant. Height-adjustable workstations were provided by Ergotron. No other financial disclosures were reported by the authors.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	The 2 units that were located closer to the research centre were randomised to the intervention arms and the more distant unit was allocated to the control arm. No further information provided on the method used to generate the random sequence.
Allocation concealment (selection bias)	High risk	The faculty staff were allocated to the multi component group, department staff were allocated to the workstation only group and campus staff were allocated to the control group.
Blinding of participants and personnel (performance bias) All outcomes	High risk	The participants and personnel knew the group to which they had been allocated.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	25% of participants were lost in the sit-stand desk plus counselling group, and one participant, i.e. 7% each, in of the other two groups. The high attrition of participants from the sit-stand desk plus counselling group will have affected the outcome.
Selective reporting (reporting bias)	High risk	Not all the outcomes mentioned in the study protocol were reported.
Baseline comparability/imbalance	Low risk	All the participants had desk-based jobs at the University of Queensland in Brisbane, Australia. The mean age in the multi component group was 37.3 (SD 10.7) years, in the workstation only group it was 43 (SD 10.2) years, and 48 (SD 11.6) years in the control group. There were no men in the multi component group, 3 in the workstation only group, and 4 in the control group.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Pedersen 2013

Methods	Random allocation Unblinded

Pedersen 2013 *(Continued)*

	Study duration: 13 weeks No dropouts **Location:** Tasmania, Australia
Participants	**Population:** chosen from 460 desk-based Tasmania Police employees across several metropolitan sectors **Intervention group:** 17 participants **Control group:** 17 participants **Demographics:** mean age: intervention group 41.5 (SD 12.39) years, control group 43.88 (SD 9.65) years
Interventions	**Duration of intervention**:13 weeks **Intervention:** computer prompts **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Published: daily workplace energy expenditure (calories/workday) for different activities estimated from occupational physical activity questionnaire at 13 weeks vs. baseline Unpublished: self-reported time spent sitting at work (minutes/day) at 13 weeks
Notes	This research was launched through a research partnership between the Tasmania State Police Department and the University of Tasmania; funded by the Tasmanian government's Healthy@Work grant scheme. The authors report no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Following correspondence with the authors, they replied: "We used a random numbers generation software through the web".
Allocation concealment (selection bias)	High risk	Following correspondence with the authors, they replied: "The researchers did randomisation, so we did not blind to the allocation".
Blinding of participants and personnel (performance bias) All outcomes	High risk	Following correspondence with the authors, they replied: "Since it was field based, participants were not blind to the treatment groups".
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	There were no drop outs or exclusion of data.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. A study protocol was not available.

Pedersen 2013 *(Continued)*

Baseline comparability/imbalance	Low risk	All participants were employees of the Tasmania police department. Age was not significantly different between groups: 41.5 (12.4) years in the intervention group, and 43.88 (9.6) years in the control group.
Validity of outcome measure	Low risk	Occupational Sedentary and Physical Activity Questionnaire (OSPAQ) which had moderate validity was used for assessing time spent sitting at work.

Pickens 2016

Methods	Non-random allocation: CBA Study duration: 6 months Dropout: 45% **Location:** United States **Recruitment:** email from human resource department of company
Participants	**Population:** employees of a call centre company in the Eastern United States. **Intervention group:** sit-to-stand (45 participants) and standing (46 participants) **Control group:** seated (47 participants) **Demographics:** Mean age in years: sit-stand group: 34.8 (SD 11.5), stand group: 28.9 (SD 6.8), seated group: 35.0 (SD 13.2) % of females: sit-stand group 71.1%, stand group 58.7%, seated group 70.2% BMI: sit-stand group 29.0 (SD 9.13) kg/m^2, stand group 26.8 (SD 5.5) kg/m^2, seated group 27.8 (SD 5.7) kg/m^2
Interventions	**Duration:** 3 months Sit-to-stand vs. standing vs. seated workstation
Outcomes	**Outcome name, measurement time (units of measurement)** • Proportion of monitored time in each activity level - sedentary, light, moderate and vigorous activity at 3 months and 6 months • Steps per minute at 3 months and 6 months
Notes	Authors have not reported post intervention values for seated control group

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	While not completely random, management did their best to randomise employees between the workstation conditions. The call centre layout and team make-ups consisted of groups of four to eight workstations. Because of this, and the arrangement within the facility, management kept the type of workstation within each group constant.

Pickens 2016 *(Continued)*

Allocation concealment (selection bias)	High risk	Not reported but based on above quote, unlikely the allocation was concealed
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	High dropout rate at three months (30%) and six months (45%) follow-up times. No ITT analysis.
Selective reporting (reporting bias)	Low risk	All the outcomes mentioned in the methods section were reported
Baseline comparability/ imbalance	High risk	Age and sex is significantly different where persons using a standing workstation were 5 years younger and had more men. Also many more in this group were 'health coaches' and fewer were in customer services.
Validity of outcome measure	Low risk	The questionnaire used to assess activity outcomes in this study were based on the International Physical Activity Questionnaire (IPAQ), and the Modified Occupational Sitting and Physical Activity Questionnaire (OSPAQ)

Priebe 2015

Methods	Random allocation Study duration: 13 days Dropout: 32% **Location:** Canada **Recruitment:** email sent by human resource personnel on the researchers' behalf to potential participants.
Participants	**Population:** office workers employed in the head office of one large private company in Canada High personal/high contextual norm (n = 35), high personal/low contextual norm (n = 36), low personal/high contextual norm (n = 35) and low personal/low contextual norm (n = 36) **Demographics:** Mean age in years: 40.30 (SD 12.02) 66% of participants were females
Interventions	**Duration:** 10 days High personal/high contextual norm vs. high personal/ ow contextual norm vs. low personal/high contextual norm vs. low personal/low contextual norm
Outcomes	**Outcome name, measurement time (units of measurement)** • Prolonged sitting time (minutes/workday) assessed by self report

Priebe 2015 *(Continued)*

	• Standing, walking, and stair use were reported as number of times during the workday assessed by self report
Notes	This work was supported by a Vanier Canada Graduate Scholarship (first author) from the Social Sciences and Humanities Research Council of Canada.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were manually randomly assigned using random number tables to one of four conditions.
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	Very high dropout (32% attrition)
Selective reporting (reporting bias)	Low risk	No protocol. All the outcomes mentioned in the method section were reported.
Baseline comparability/imbalance	Unclear risk	Not reported
Validity of outcome measure	Unclear risk	Not reported

Puig-Ribera 2015

Methods	Random allocation by cluster Single blind Study duration: 27 weeks Dropouts: 28% **Location:** Spain **Recruitment:** office workers were first invited to participate in an on-line survey to identify those with low and moderate PA levels. Then they were invited to participate in the intervention by email or phone calls.
Participants	**Population:** administrative and academic staff working at six campuses in four Spanish Universities in Galicia, the Basque Country and Catalonia **Intervention group:** 135 participants (3 clusters)

Puig-Ribera 2015 *(Continued)*

	Control group: 129 participants (3 clusters)
Interventions	**Duration of intervention:** 8 weeks **Intervention:** automated web-based intervention (W@WS) to encourage incidental walking and short walks during the workday. The walking strategies focused on breaking occupational sitting time by incidental walking into work tasks such as moving rather than sitting during lectures and seminars, not sitting to take phone calls, short walks (5–10 minutes) within University campuses, active transport (e.g. walking to work whenever possible) or active lunch breaks. **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Self-reported occupational sitting time (minutes/day) measured by paper dairy log Daily step counts measured by Pedometer, Yamax-200 Physical risk factors (waist circumference, BMI, blood pressure)
Notes	The study was funded by the Spanish Ministry of Science and Innovation (MICCIN) (project reference DEP 2009-1147). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Campuses were randomly assigned by worksite to an intervention (n = 3; deployed W@WS) or comparative group (n = 3; maintained normal behaviour). In each region, one university campus was randomly assigned to the program (intervention group; IG) and another campus acted as a comparison group (CG). Authors replied to our request for further information but their reasoning was unclear.
Allocation concealment (selection bias)	Unclear risk	Authors replied to our request for further information but their reasoning was unclear.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Following correspondence with authors, they replied: “In the "big universities": the comparison and the intervention campuses were located in different cities and therefore, participants from each campus were not aware that another campus was doing the intervention. In the "small universities": Each university was located in a different city (Barcelona and Vic). Thus, participants did not know there was another university doing the intervention.” However because of the self-evident nature of the intervention awareness of their own exposure to a certain changed environment or intervention might have changed their behaviour.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	Number of withdrawals was unbalanced in two groups, with more in the intervention group. There were 33 (24%) in the intervention and 41 (32%) in the control group.
Selective reporting (reporting bias)	Low risk	All the outcomes mentioned in the protocol were reported.

Puig-Ribera 2015 *(Continued)*

Baseline comparability/ imbalance	Unclear risk	Not reported
Validity of outcome measure	Low risk	Paper-based diary was used to report sitting time at work.

Sandy 2016

Methods	Random allocation Single-blind Study duration: 14 weeks Dropouts: 14% **Location:** Australia **Recruitment:** participants were recruited via an email
Participants	**Population:** employees of Lockheed Martin Mission System and Training business unit: primarily develops software solutions and training/simulation technologies for both civil and commercial markets. 2500 full-time employees of whom 90% in sedentary computer work for a large percentage of their workday **Intervention group:** ergonomic training (16 participants), adjustable desks (23 participants), training and desks (20 participants) **Control group:** 13 participants **Demographics:** mean age in years: 37.2 (SD 9.4) BMI: 26.9 (SD 4.4) kg/m^2
Interventions	**Duration of intervention:** 14 weeks **Intervention:** Training vs. adjustable desks vs. training and desks **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting/standing/walking time (minutes/9-hour workday) assessed by self report at week 1, 2, 3, 4, 6, 10, 14 • Discomfort level, musculoskeletal pain, fatigue
Notes	No conflict of interest reported

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were listed out in Excel and randomly placed into one of the four groups.
Allocation concealment (selection bias)	Unclear risk	Not reported

Sandy 2016 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not reported
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	< 10% attrition rate
Selective reporting (reporting bias)	Low risk	No protocol; all the outcomes mentioned in the methods section are reported.
Baseline comparability/ imbalance	Unclear risk	Baseline characteristics of participants not reported
Validity of outcome measure	High risk	Only mentioned self report. No information on validity of questionnaires used.

Schuna 2014

Methods	Random allocation Single-blind Study duration: 3 months Dropouts: 24% **Location:** USA **Recruitment:** in-house distribution of print and electronic media. Potential participants received an email providing a link to an online survey that included a series of screening questions designed to assess participant eligibility.
Participants	**Population:** pool of 728 overweight/obese and sedentary employees at a single office **Intervention group:** 15 participants **Control group:** 16 participants **Demographics:** mean age: intervention 40 (SD 9.5) years, control 40.3 (SD 10.9) years One male participant and 40 female participants BMI: intervention 36.1 (SD 8.7) kg/m², control 35.6 (SD 8.2) kg/m²
Interventions	**Duration of intervention:** 3 months **Intervention:** treadmill desk plus counselling **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)**

Schuna 2014 *(Continued)*

	Physical activity (minutes/hour) and sedentary behaviour (minutes/hour) measured by accelerometer-inclinometer. Body mass, body fat percentage, and BMI
Notes	This research was supported by Blue Cross and Blue Shield of Louisiana.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Following correspondence with authors, they replied: "Statisticians generated a random list".
Allocation concealment (selection bias)	Low risk	Following correspondence with authors, they replied: “The randomisation codes were sealed in envelopes with randomisation numbers”.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Following correspondence with authors, they replied: “Participants were not blinded. Intervention personnel and Project Manager were not blinded”.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Does not appear to have attrition bias
Selective reporting (reporting bias)	High risk	The trial registry mentions a follow-up of 6 months but the study reports only 3 months' follow-up.
Baseline comparability/ imbalance	Low risk	Age, sex and occupation were similar in both the intervention group and the control group at baseline.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Swartz 2014

Methods	Random allocation by cluster Unblinded Study duration: 6 days Dropouts: 23% **Location:** USA **Recruitment:** employees with clerical positions were identified through University directory.
Participants	**Population:** full-time employees (employed > 20 years) engaged in a sedentary occupation **Intervention:** stand group: 29 participants; step group: 31 participants **Demographics:** mean age: stand: 42.3 (SD 11.6) years, step: 46.1 (SD 10.5) years

Swartz 2014 *(Continued)*

	60% were females in stand group and 75% were females in step group BMI: stand: 29.3 (SD 7.3) kg/m², step: 27.7 (SD 7.4) kg/m²
Interventions	**Duration of intervention:** 3 days **Intervention:** computer-based versus wrist worn prompts
Outcomes	**Outcome name, measurement time/tool (units of measurement)** Total sitting time (minutes/workday), duration of longest sitting bout (minutes/workday), number of sitting bouts/workday of 30 min or more, standing time (minutes/workday), stepping time, sit/stand transitions measured by accelerometer-inclinometers.
Notes	The Clinical and Translational Science Institute of Southeastern Wisconsin supported this research.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Random number generation was used to assign participants to either the stand group or step group.
Allocation concealment (selection bias)	Low risk	Assignments were written out and placed in sealed numbered envelopes.
Blinding of participants and personnel (performance bias) All outcomes	High risk	The envelopes were opened sequentially by a researcher; participants were informed of group assignment.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	High risk	18 participants were excluded, 9 each from stand group and step group. Reasons were dropout, equipment malfunction and not wearing monitor properly. The authors did not conduct intention-to-treat analysis.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the methods section were reported. The study protocol was not available.
Baseline comparability/ imbalance	Low risk	No baseline differences were found between the two groups for age, body mass, height or BMI. There was however difference in gender with the Stand group having 60% females and the Step group having 75%.
Validity of outcome measure	Low risk	The accelerometer is a valid instrument for the measurement of sitting time.

Tobin 2016

Methods	Random allocation Single-blind Study duration: 5 weeks

Tobin 2016 *(Continued)*

	Dropouts: 29% **Location:** Australia **Recruitment:** participants were recruited via an email sent to all staff working in the study locations
Participants	**Population:** participants were recruited from four locations across two organisations. The organisations were a non-government organisation and a university. All locations were office-based environments. **Intervention group:** 26 participants **Control group:** 26 participants **Demographics: m**ean age in years: intervention 34.8 (SD 10.5), control 34.3 (SD 8.9) % female participants: intervention 89%, control 84%
Interventions	**Duration of intervention:** 5 weeks **Intervention:** sit-stand desk + instructions/ergonomic assessment **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting/standing/stepping time (minutes/8-hour workday) measured at 5 weeks. Transitions in positions measured by activPAL3 accelerometer-inclinometer • Self-reported mental health- and physical health outcomes
Notes	This study was funded by Healthway (File No: Healthway Promotion Research Agreement 24008). The sit-stand workstations were supplied by Ergotron (www.ergotron.com). Authors had no conflicts of interest to report

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Not reported (only use the word randomised, no protocol to check)
Allocation concealment (selection bias)	Unclear risk	Not reported
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants were probably aware of allocation because of self evident nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Similar proportions of participants were missing from final analysis in both groups.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported. Study protocol was not available.

Tobin 2016 *(Continued)*

Baseline comparability/ imbalance	Low risk	Participants in control and intervention groups were comparable in age, sex, BMI and education at baseline.
Validity of outcome measure	Low risk	activPAL is a valid instrument for assessment of physical activity and sedentary behaviour

Urda 2016

Methods	Random allocation Single-blind Study duration: 2 weeks Dropouts: 8% **Location:** United States **Recruitment:** not reported
Participants	**Population:** staff at a United States university in desk jobs **Intervention group:** 26 participants **Control group:** 22 participants **Demographics:** mean age in years: 48 (SD 10) All participants were females Mean BMI: 30.5 (SD 8.2) kg/m^2
Interventions	**Duration of intervention:** 1 week **Intervention:** audible alert and text message every hour and information on behavioural choices and health risks associated with prolonged sitting **Control:** no intervention
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Changes in sitting (hours/ workday) measured at 2 weeks. Transitions in positions measured by activPAL3 accelerometer-inclinometer • Perceived wellness score (scale 3 to 29)
Notes	No conflict of interest reported

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Random assignment included assigning participants by table of random numbers to 1 of 2 groups.
Allocation concealment (selection bias)	Unclear risk	Not reported

Urda 2016 *(Continued)*

Blinding of participants and personnel (performance bias) All outcomes	High risk	Group assignment was doubly blinded until the end of week 1, at which time both the participants and the investigator were aware of group assignment. However, Its not for the duration of intervention
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	Low attrition (8%)
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the method section were reported. Study protocol was not available.
Baseline comparability/ imbalance	Unclear risk	Participants characteristics at baseline not reported
Validity of outcome measure	Low risk	activPAL is a valid instrument for assessing physical activity and sedentary behaviour.

van Berkel 2014

Methods	Random allocation Unblinded Study duration: 12 months Dropout: 11% **Location:** Amsterdam, the Netherlands
Participants	**Population:** all employees from 2 Dutch research institutes were invited to participate, between April and November 2010 **Intervention group:** 129 participants **Control group:** 128 participants **Demographics:** mean age of the study population was 46 years 67% of participants were women About 60% of the study population had a healthy weight (BMI 18.5-25).
Interventions	**Duration of intervention:** 6 months but the participants were followed up for 12 months. **Intervention**: the Mindful VIP intervention consists of 8 weeks of in-company mindfulness training with homework exercises, followed by 8 sessions of e–coaching. The homework exercises comprised a variety of formal ("body scan" meditation, sitting meditation) and informal exercises (small exercises, such as breathing exercises when starting up the computer, and grocery shopping mindfully). Additionally, free fruit and snack vegetables were provided during the 6 months. In addition, lunch walking routes, and a buddy-system were offered as supportive tools. **Control:** received information on existing lifestyle behaviour-related facilities that were already available at the worksite.

van Berkel 2014 *(Continued)*

Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Vigorous physical activity in leisure time (minutes/week) assessed with questionnaire and accelerometer-inclinometer • Sitting at work (minutes/week) assessed with questionnaires • Fruit intake (servings/day) • Determinants of lifestyle behaviours
Notes	The authors report no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Participants were individually randomised to either the intervention or control group, using a computer-generated randomisation sequence.
Allocation concealment (selection bias)	High risk	After randomisation, the research assistant notified each participant by email about the group to which he or she was allocated.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Blinding of the participants and the trainers was not possible.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not reported
Incomplete outcome data (attrition bias) All outcomes	Low risk	8 participants were lost to follow-up from the intervention group and 17 from the control group. The authors conducted intention-to-treat analysis by linear mixed-effect models.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the study protocol were reported.
Baseline comparability/imbalance	Low risk	Mean age was similar between the intervention group and control group. There were 63.6% women in the intervention group and 71% in the control group. All participants were from two Dutch research institutes.
Validity of outcome measure	High risk	Validity of the questionnaire used in the study has not been tested.

Verweij 2012

Methods	Allocation randomly by cluster Double-blind Study duration: 6 months Dropout: 43% in occupational physicians (OPs) and 10% in employees **Location:** Amsterdam, the Netherlands **Recruitment:** OPs were recruited by the Netherlands Society of Occupational Medicine via a direct mailing to their members' registry (> 2100 OPs). OPs were asked to recruit 1 or more companies of

Verweij 2012 *(Continued)*

	medium or large size (> 100 workers). Next, OPs recruited employees via a health risk appraisal consisting of anthropometric measurements and subsequent health advice.
Participants	**Population:** OPs from the Netherlands Society of Occupational Medicine and employees from medium or large sized companies in the Netherlands **Intervention group:** OPs (n = 7), employees (n = 274) **Control group:** OPs (n = 9), employees (n = 249) **Demographics:** mean age of employees in the intervention group was 46 (SD 8) years, mean age in the control group was 48 (SD 9) years. Percentages of men were 62% and 65% in the intervention and control groups respectively. 33% of employees in the intervention group and 27% of employees in the control group had a normal BMI. **Type of worker** Intervention group: blue collar (manual labour) 15%; white collar 70%; client contact 15% Control group: blue collar 17%; white collar 73%; client contact 10%
Interventions	**Duration of intervention:** 6 months **Intervention:** guideline-based counselling by OP providing advice to employers on how to assess and intervene on the obesogenic work environment. Conducted by OPs as 5 face-to-face behavioural change counselling sessions for employees to improve their lifestyle to prevent weight gain. **Control:** usual care by physician
Outcomes	**Outcome name, measurement time/tool (units of measurement)** • Sitting at work and leisure (minutes/day) assessed by a questionnaire • Physical activity assessed by Short questionnaire to assess health enhancing physical activity (SQUASH) • Dietary behaviour (daily servings/week): fruit intake assessed by Short Fruit and Vegetable questionnaire, consumption of energy-dense snacks was assessed by using the fat list • Weight-related measures: waist circumference (cm), body weight (kg) and body height (cm)
Notes	This study was funded by the Netherlands Organisation for Health Research and Development. The authors report no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	OPs who consented to participate were randomly assigned to the intervention or control group by an independent researcher using Random Allocation Software (V.1.0; Isfahan University of Medical Sciences)
Allocation concealment (selection bias)	High risk	After randomisation, the principal researcher notified OPs of the group to which they had been allocated.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	As OPs themselves were the intervention providers, they could not be blinded for allocation. OPs were asked not to reveal their group to participating employees or assistants performing measurements.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Waist circumference, body weight and height were measured by unblinded OPs or by blinded clinic employees. However blinding for assessment of sitting was not reported

Verweij 2012 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	High risk	28 OPs were randomised, but 12 (43%) did not participate in the study at all. However, the remaining OPs recruited employees well, matching the number of planned employees. During the 6-month intervention period, employees from both groups were lost to follow-up (7 from the intervention group and 16 from the control group). These subjects (n = 53) were significantly younger, women, and had a lower income than study completers.
Selective reporting (reporting bias)	Low risk	All outcomes mentioned in the study protocol were reported.
Baseline comparability/ imbalance	Low risk	Age, sex and occupation were similar in both the intervention group and the control group at baseline.
Validity of outcome measure	High risk	Validity of the questionnaire used in the study has not been tested.

Abbreviations
BMI: body-mass index
CBA: controlled before-and-after study
h: hour(s)
OP: occupational physician
CP: computer prompts
RCT: randomised controlled trial
SD: standard deviation

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Aadahl 2015	Not conducted in a workplace setting. Did not report workplace sitting, only total sitting.
Adams 2012	Not all the participants were working. Did not report workplace sitting as a separate outcome. Total sitting time reported.
Aittasalo 2004	Did not report workplace sitting as a separate outcome. Sitting time reported separately for working days and non-working days but the working days included both work and leisure time.
Alderman 2014	Not RCT or CBA. Did not report workplace sitting.
Arrogi 2017	Did not report workplace sitting
Audrey 2015	Not conducted in a workplace setting.
Barbieri 2017	Did not report workplace sitting
Ben-Ner 2014	Did not report data on sitting time at work separately. Daily sitting time (during waking hours) was measured with an accelerometer but it included both work and leisure time.
Berberien 2016	Not RCT or CBA.
Biddle 2015	Not conducted in a workplace setting.

Study	Reason for exclusion
Bird 2014	Not RCT or CBA.
Bjorklund 2015	Did not report workplace sitting
Boreham 2005	This was a stair-climbing training study that took place during working hours, but sitting time was not assessed.
Bouchard 2015	Not RCT or CBA.
Brown 2012	Did not report workplace sitting.
Buchholz 2016	Not RCT or CBA.
Carr 2013	No data reported for sitting time at work. Daily sedentary time (criterion: 0 steps/minute) was measured with StepWatch (accelerometer attached on ankle), but it included both work and leisure time (the monitor was kept during all wakeful hours for 7 consecutive days). Correspondence with the author was unclear regarding the distinction between work and leisure in sitting time. It is also not clear what the StepWatch measures as an accelerometer.
Carter 2015	Not RCT or CBA. Does not describe a full working day.
Chae 2015	Not RCT or CBA (pre-post design). All the participants did not complete the program.
Cheema 2013	Did not report workplace sitting.
Chia 2015	Did not report workplace sitting. Following correspondence with authors they replied: "We did not specifically measure sitting time but had an indication of the time spent in the office (these are desk bound participants- when they filled in the questionnaire of alertness by the hour (0900-1700hrs)".
Cifuentes 2015	Not RCT or CBA.
Clemes 2014	Not RCT or CBA. Pedometers were used to record sitting time and step counts.
DeCocker 2015	Not RCT or CBA.
Dewa 2009	Did not report workplace sitting. Sitting time was assessed (IPAQ) but it included both work and leisure time.
Elmer 2014	Not RCT or CBA. Outcome is energy expenditure not time spent sitting at work.
Engelen 2017	Not RCT or CBA.
Fennell 2017	Did not report workplace sitting
Foley 2016	Not RCT or CBA.
Freak-Poli 2011	Not an RCT or CBA.

Study	Reason for exclusion
	Workplace sitting not reported. Sitting time was questioned separately for weekdays and weekend days but it included both work and leisure.
Ganesan 2016	Did not report workplace sitting
Gardner 2015	Not conducted in a workplace setting.
Gilson 2012	Not an RCT or CBA. Did not report workplace sitting.
Gilson 2015	Not RCT or CBA.
Gilson ND 2012	Not an RCT or CBA.
Gorman 2013	Not an RCT or CBA.
Green 2016	Not RCT or CBA.
Grunseit 2012	Not an RCT or CBA.
Hadgraft 2017	Did not report workplace sitting
Hedge 2004	Sitting time was not reported in hours (only %). The length of intervention was not the same for everybody (no detailed information, stated “4-6 wks”).
Irvine 2011	Not an RCT or CBA. No quantitative data on sitting time at work.
Jancey 2016	Not RCT or CBA.
John 2011	Not an RCT or CBA. Did not report workplace sitting. Daily sitting time (waking hours) was measured with an accelerometer, but it included both work and leisure time.
Jones 2017	Did not report workplace sitting
Júdice 2015	Did not report workplace sitting, only total sitting time.
Kennedy 2007	Did not report workplace sitting.
Kerr 2016	Not conducted in a workplace setting.
Koepp 2013	Not an RCT or CBA.
Lara 2008	Not an RCT or CBA. Did not report workplace sitting.
Liu 2016	Not RCT or CBA.
Maeda 2014	Not RCT or CBA.

Study	Reason for exclusion
	Participants were university students.
Mahmud 2015	Did not report workplace sitting
Mainsbridge 2014	Did not report workplace sitting.
Mair 2014	Did not report workplace sitting.
Marshall 2003	Did not report workplace sitting. Sitting time was assessed (IPAQ, short version) but it included both work and leisure time (reported as 'weekday sitting time').
McAlpine 2007	Not a normal working day, but an experimental office facility. Not an RCT or CBA.
Miyachi 2015	Did not report workplace sitting.
NCT01221363	Following correspondence with the authors, they replied: "Ours is not a work place intervention study, but a 'total sitting time' community-based intervention study where the individual behavioural intervention addresses all domains of life, i.e. leisure time, work, transportation etc. Approximately 1/3 of participants are not working (retired or unemployed) and those who do work, do not necessarily have sedentary work, since our main inclusion criterion was minimum 3.5 hours of leisure time sitting/day. Consequently our primary outcome measure is objectively measured total daily sitting time (activPAL), and we only have rather crude self-report measures on sitting time at work."
Ognibene 2016	Did not report workplace sitting
Opdenacker 2008	Did not report workplace sitting. Sitting time was assessed (IPAQ) but it included both work and leisure time.
Ouyang 2015	Not conducted in a workplace setting. Participants were sedentary overweight females.
Parry S 2013	Did not report workplace sitting. Reported sedentary time measured by accelerometer. Sedentary time was defined as an activity having less than 100 counts on an accelerometer.
Pilcher 2017	Did not report workplace sitting
Poirier 2016	Did not report workplace sitting
Pronk 2012	Not an RCT or CBA.
Roossien 2017	Not RCT or CBA.
Schwartz 2016	Did not report workplace sitting
Slootmaker 2009	Did not report workplace sitting. Daily sitting time (waking hours) was measured with an accelerometer, but it included both work and leisure time.
Sternfeld 2009	Did not report workplace sitting. Sedentary time assessed during leisure.
Straker 2013	Not an RCT or CBA.

Study	Reason for exclusion
Taylor 2016	Did not report workplace sitting
Thogersen-Ntoumani 2013	Did not report workplace sitting.
Thompson 2014	Did not report workplace sitting. The authors used accelerometers, but converted their results into energy expenditure/day (no separation between work and leisure time).
Thorp 2015	Outcome is energy expenditure not time spent sitting at work.
Torbeyns 2016	Did not report workplace sitting
Torbeyns 2017	Not RCT or CBA.
Tucker 2016	Did not report workplace sitting
vanNassau 2015	Not RCT or CBA.
Wirick 2016	Not conducted in a workplace setting.
Yancey 2004	Did not report workplace sitting.
Østerås 2005	Not an RCT or CBA.

Abbreviations
CBA: controlled before-and-after study
IPAQ: International physical activity questionnaire
RCT: randomised controlled trial

Characteristics of studies awaiting assessment *[ordered by study ID]*

Carpenter 2015

Methods	Randomised controlled trial
Participants	Sedentary office workers (n = 127; ages 22-64; BMI = 28.5±6.1 kg/m^2) were recruited from three Minnesota employers.
Interventions	The intervention consisted of 4 groups for 6 months: 1) Control, 2) Move (30 minutes of light activity during the workday), 3) Stand (standing 50% of the workday using a sit-stand workstation), or 4) Stand + Move (combined Stand and Move).
Outcomes	Outcomes were assessed at baseline and at 6 months' follow-up using the following cardiometabolic risk factors: blood pressure, fasting blood glucose, log of fasting triglycerides, and HDL-cholesterol.
Notes	We could not find the full-text article.

Dutta 2013

Methods	No information available
Participants	No information available

Dutta 2013 *(Continued)*

Interventions	No information available
Outcomes	No information available
Notes	We could not find the full-text article.

Kirk 2012

Methods	Pre-post design
Participants	Scottish working adults
Interventions	A 30-minute individual discussion incorporating cognitive behavioural strategies (e.g. decisional balance, goal setting) to encourage individuals to think about their current sedentary behaviour and strategies to change. Duration of intervention: 2 weeks
Outcomes	Time spent sitting/lying, standing, stepping, step counts and sit-to-stand transitions.
Notes	We could not find the full-text article.

NCT02932787

Methods	Random allocation
Participants	Desk-based employees
Interventions	Intervention: height-adjustable workstation Control: no intervention
Outcomes	Change in workplace sedentary time assessed at 4 weeks after installation of height-adjustable workstations, and 4 weeks after removal of height-adjustable workstations Change in workplace absenteeism using the World Health Organization Health and Work Performance Questionnaire Change in workplace presenteeism using the World Health Organization Health and Work Performance Questionnaire
Notes	Principal Investigator: Simon H Till, Sheffield Hallam University

Characteristics of ongoing studies *[ordered by study ID]*

ACTRN12612001290886

Trial name or title	
Methods	Random allocation in clusters **Location:** Australia

ACTRN12612001290886 *(Continued)*

	Recruitment: not yet recruiting
Participants	**Population:** male and female employees of Rockhampton Regional Council working either full-time or part-time, aged 18-65 years
Interventions	Participants will be asked to wear a pedometer during the 6-week challenge and to record the number of steps they have taken each day on the Central Queensland University 10,000 Steps website. **Control:** no intervention
Outcomes	**Primary outcome:** total steps of physical activity measured using the Yamax Digiwalker DW-150 pedometer **Secondary outcomes** • BMI (kg/m^2) • Health-related quality of life, measured using the Australian quality of life scale: AQoL-15 • Mood, measured using Depression Anxiety Stress Scales (DASS-21) • Physical activity, measured using self-reported Active Australia Questionnaire • Total minutes of sitting at work, measured using the adapted workforce sitting questionnaire and occupational physical activity questionnaire
Starting date	It is unclear whether the study has started at all. The study was promised to take place in 2013 and the study registration has not been updated.
Contact information	Mitch Duncan, email: m.duncan@cqu.edu.au
Notes	**Primary sponsor:** Government funding body Central Queensland Hospital and Health Service

ACTRN12614000252617

Trial name or title	
Methods	Random allocation **Recruitment:** not yet recruiting
Participants	**Population:** office-based workers aged 18 years and over, working at least 0.6 full-time equivalent
Interventions	The organisational plus technology support intervention lasts for 8 weeks and consists of the following components: • a participant information session (30-45 minutes); • an electronic information booklet; • a unit representatives' consultation workshop (2-4 hours); • the training of team managers; • PLUS technology support: participants will wear a LUMOback posture sensor device around their waists for 8 weeks. **Control:** will receive all the elements of the intervention except PLUS technology support.
Outcomes	**Primary outcome** • Daily sitting time and workplace sitting time assessed objectively using an activPAL accelerometer-inclinometers

ACTRN12614000252617 *(Continued)*

	Secondary outcomes • Mediators and moderators of any change • Reliability and validity of the LUMOback • Standing and moving time (a) at the workplace and (b) across the day
Starting date	It is unclear whether the study has started despite mentioning anticipated date of first participant enrolment 17/03/2014. The study registration has not been updated.
Contact information	Genevieve Healy, email: g.healy@uq.edu.au
Notes	**Primary sponsor:** University Cancer Prevention Research Centre, The University of Queensland, Australia

Bergman 2015

Trial name or title	The Inphact treadmill study
Methods	Random allocation **Location:** Sweden **Recruitment:** recruitment and screening of participants has been completed.
Participants	**Population description:** healthy overweight and obese office workers (n = 80) with mainly sedentary tasks will be recruited from office workplaces in Umeå, Sweden.
Interventions	The intervention group will receive a health consultation and a treadmill desk, which they will use for at least one hour per day for 13 months. **Control:** the control group will receive the same health consultation, but continue to work at their regular workstations.
Outcomes	**Primary outcome:** Physical activity and sedentary time during workdays and non-workdays as well as during working and non-working hours on workdays will be measured objectively using accelerometers (Actigraph and activPAL) at baseline and after 2, 6, 10, and 13 months of follow-up. **Secondary outcome:** Food intake will be recorded and metabolic and anthropometric variables, body composition, stress, pain, depression, anxiety, cognitive function, and functional magnetic resonance imaging will be measured at 3–5 time points during the study period.
Starting date	November 2013
Contact information	Tommy Olsson, email: tommy.g.olsson@umu.se
Notes	**Sponsors:** Not reported

Buman 2017

Trial name or title	Stand & Move at Work

Buman 2017 *(Continued)*

Methods	Random allocation by clusters **Location:** United States **Recruitment:** not yet recruiting
Participants	**Population description:** worksites will be enrolled in the greater Phoenix, AZ, USA and Minneapolis, MN, USA metropolitan regions. Selected worksites will be drawn from three distinct work sectors: higher education, industry/healthcare (e.g., law firms, health insurance providers), and government (e.g. state departments).
Interventions	Multicomponent interventions comprising of sit-stand workstation, e-newsletter, individualised coaching, prompts and engagement of worksite administrators and managers to enact policy-level workplace modifications
Outcomes	**Primary outcomes:** time spent sitting and LPA at work, will be assessed with the activPAL3 accelerometer-inclinometer **Secondary outcomes:** cardiometabolic risk, workplace productivity, work engagement, and workplace satisfaction
Starting date	
Contact information	Matthew P. Buman, email address: matthew.buman@asu.edu
Notes	Study supported by the National Institutes of Health [R01CA198971].

Finkelstein 2015

Trial name or title	TRial of Economic Incentives to Promote Physical Activity (TRIPPA)
Methods	Random allocation **Location:** Singapore **Recruitment:** on a rolling basis, and in two steps. In the first step, companies were engaged through existing contacts and “cold calls”. If companies responded positively, a study briefing was conducted to apprise the management of study details. Once we received confirmation of participation from the management team, we proceeded to step two of the recruitment process. Recruitment materials (e.g., electronic direct mails, posters, and newsletters) communicating the nature of the research study were disseminated to employees through internal channels unique to each company. The materials directed potential participants to the study website for additional information. Employees were also invited to attend a presentation conducted by the study team at each participating worksite.
Participants	**Population description:** employees from 13 companies spanning 15 worksites in Singapore
Interventions	4 arms: “basic package” comprising two educational booklets, Fitbit arm, two incentive arms (cash or charity)
Outcomes	Primary outcome: MVPA bout minutes/week as measured via accelerometry Secondary outcomes: • daily and weekly steps, total minutes of sedentary/light, moderate and vigorous physical activity per week (counts all moderate and vigorous minutes, including those that do not meet the criteria for MVPA bouts); • adherence to the commonly cited 10,000 steps/day target;

Finkelstein 2015 *(Continued)*

	• changes in body mass index (BMI) and systolic blood pressure; • quality of life as measured by the EuroQoL's EQ-5D-5L instrument, productivity losses as measured by the Work Productivity and Activity Impairment (WPAI) scale; • cardiorespiratory fitness assessed by Non-Exercise Fitness Test (NEFT;) • cost-effectiveness outcomes.
Starting date	
Contact information	Eric A. Finkelstein, e-mail address: eric.finkelstein@duke-nus.edu.sg
Notes	This study is supported by the Singapore Ministry of Health's Health Services Research Competitive Research Grant (HSRG/022/2012).

Finni 2011

Trial name or title	
Methods	Random allocation **Location:** Finland **Recruitment:** recruitment is performed in the city of Jyväskylä, Finland, by delivering advertisements to parents via kindergartens and primary schools that have been pre-randomised to control and intervention groups after balancing different environmental and socioeconomic regions within the city.
Participants	**Population description:** families from Jyväskylä region, Finland
Interventions	Tailored counselling targeted to decrease sitting time by focusing on commuting and work time. **Control:** no intervention
Outcomes	Changes in physical activity, health-related indices and maintenance of the behavioural change
Starting date	December 2011
Contact information	Taija Juutinen, email: taija.m.juutinen@jyu.fi
Notes	**Study sponsors:** Ministry of Education and Culture, Finland

Hall 2015

Trial name or title	Take A Stand for Workplace Health: A Sit-stand Workstation Project Evaluation
Methods	Random allocation **Recruitment:** active, not recruiting
Participants	**Population:** office employees primarily engaged in desk-based work at one of the two worksites involved in the study (Macmillan Cancer Support, Public Health England)
Interventions	**Duration of intervention:** 12 months Three-arm trial

Hall 2015 *(Continued)*

	Intervention: a sit-stand workstation only and a multi-component sit-stand workstation intervention including individual and organisation-level approaches **Control:** usual practice (seated workstation)
Outcomes	• Objective measures of sitting, standing, and physical activity using ActivPAL3™ and ActiGraph (GT3X+) • Understanding of the influence of organisational culture on sitting, standing and physical activity behaviour in the workplace using qualitative methods
Starting date	May 2014
Contact information	Jenifer Hall, email: Jennifer.Hall@brunel.ac.uk
Notes	**Sponsors and collaborators:** Brunel University, Macmillan Cancer Support, Ergotron, Public Health England

ISRCTN25767399

Trial name or title	Booster breaks: health promoting work breaks
Methods	Random allocation
Participants	**Population:** employees with sedentary office jobs from four workplaces in a large, urban southwestern U.S. city.
Interventions	Three-arm trial **Intervention:** Computer Prompt (individualized PA work breaks) group and Booster Break group **Control:** usual break group
Outcomes	**Primary outcomes:** lipid profile, blood pressure, height, weight, International Physical Activity Questionnaire (IPAQ), pedometer readings **Secondary outcomes:** physical activity mediators and employee and organisational psychosocial constructs: self-report assessments.
Starting date	January 2009
Contact information	Wendell Taylor, email: Wendell.C.Taylor@uth.tmc.edu
Notes	**Sponsor:** National Institutes of Health (USA)

Mackey 2011

Trial name or title	
Methods	Random allocation **Location:** Australia

Mackey 2011 *(Continued)*

Participants	**Population:** employees of 1 of 3 of the university's campuses located in Sydney and Melbourne, working on a part-time or full-time basis in either a job with an academic or administrative designation.
Interventions	**Duration of intervention:** 12 weeks The intervention will comprise 2 distinct treatment phases targeting behaviour adoption (weeks 1-4) and adherence (weeks 5-12) using 'stages of behaviour change' principles • Adoption phase of the walking intervention will consist of individually targeted, supervised, 60-minute education/information group sessions of 5-6 participants held once a week • The adherence phase of the walking intervention will be self-directed and remotely monitored to encourage participant compliance and progression. Participants will select their own preferred walking option(s) from 3 alternatives, walking routes, walking within tasks (walk and talk seminars or meetings) or walking for transport. Participants will be encouraged to select a mix of the options from day-to-day depending on their preferences. **Control:** no intervention

Outcomes	**Primary outcome:**
	
	Average workday step count: measured by pedometer (Yamax SW-200) and averaged over 5 workdays at each time point
	
	Secondary outcomes
	
	• Mental health status: the psychological well-being of participants will be measured by a validated self-administered questionnaire; Kessler-10
	• Physical activity participation will be measured by the validated Active Australia Survey
	• Physical health status will be measured by 3 standard measures of cardiovascular and metabolic health
	  * Blood pressure
	  * Waist circumference
	  * Body fat percentage
	  * Work ability

Starting date	March 2010
Contact information	Martin Mackey, email: martin.mackey@sydney.edu.au
Notes	**Study sponsors:** Australian Research Council: ARC (Industry) Linkage Grant Professor Philip Taylor

Mantzari 2016

Trial name or title	
Methods	Random allocation **Location:** United Kingdom **Recruitment:** will be recruited through: 1) employment databases and invited via letter/email, and 2) adverts in local newsletters and flyers posted within the buildings of target organisations.
Participants	**Population description:** office-based employees from two companies in Cambridge, UK

Mantzari 2016 *(Continued)*

Interventions	Intervention: sit-stand desks Control: no intervention
Outcomes	• Physical activity energy expenditure estimated via Actiheart monitors • Sedentary behaviour measured using activPAL inclinometers: sitting time during a) working hours (workplace sitting time) and b) all waking hours (total sitting time); sitting patterns (number of sit-to-stand transitions; sitting time accrued in prolonged bouts (≥ 30 min)) during a) working hours (workplace sitting patterns) and b) all waking hours (total sitting patterns) • Cardio-metabolic related outcomes: BMI calculated from weight and height; weight measured using a scale; height measured using a stadiometer; fat mass and fat-free mass measured via a spectroscopy device; blood pressure, measured via an electronic monitor; waist-hip circumference measured using a tape measure; plasma total cholesterol, HDL, triglycerides and HbA1C, measured via non-fasting blood tests • Musculoskeletal discomfort measured using the Nordic Musculoskeletal Questionnaire [80] • Ability to work, work productivity, presenteeism, absenteeism and job satisfaction measured using the Work ability index
Starting date	
Contact information	Correspondence: tm388@medschl.cam.ac.uk
Notes	The study is supported by a grant from the Department of Health Policy Research Program (Policy Research Unit in Behaviour and Health [PR-UN-0409-10109]), the Medical Research Council (Unit Programme number MC_UU_12015/3) and the British Heart Foundation (Intermediate Basic Science Research Fellowship grant FS/12/58/29709 to KW)

Martin-Borras 2014

Trial name or title	SedestActiv Project
Methods	Random allocation **Location:** Spain **Recruitment:** a total of 232 subjects will be randomly allocated to an intervention and control group (116 individuals each group). In addition, 50 subjects with fibromyalgia will be included.
Participants	**Population description:** professionals from 13 primary health care centres will randomly invite mildly obese or overweight patients of both genders, aged 25-65 years, to participate.
Interventions	6-month primary care intervention **Control:** no intervention
Outcomes	**Duration of intervention:** 6 months **Primary outcome:** to assess the effectiveness of a 6-month primary care intervention to reduce diary hours of sitting time in overweight and obese patients, as well as to increase their weekly energy expenditure **Secondary outcomes** • Number of steps walked • Subjective level of physical activity • Quality of life related to health • Blood pressure

Martin-Borras 2014 *(Continued)*

	• Skin folds and waist circumference • Triglycerides, total cholesterol and glucose
Starting date	June 2012
Contact information	Carme Martín-Borràs Email: sedestactiv@gmail.com
Notes	**Study sponsor:** Jordi Gol i Gurina Foundation

NCT01787643

Trial name or title	
Methods	Random allocation **Recruitment:** active, not recruiting
Participants	**Population:** sedentary office employees
Interventions	Height-adjustable desk installation in office
Outcomes	**Primary outcome:** workplace sitting time **Secondary outcomes** • Total sitting time • Energy expenditure • Body weight, BMI, fat mass reduction • Changes in musculoskeletal symptoms • Increase in standing behaviour
Starting date	January 2013
Contact information	
Notes	**Study sponsor:** USDA (United States Department of Agriculture) Grand Forks Human Nutrition Research Center

NCT01846013

Trial name or title	
Methods	Random allocation **Recruitment:** active, not recruiting
Participants	**Population:** sedentary employees who use a single computer workstation for the majority of their workday
Interventions	Sit-stand workstation with three arms • Stand: standing for at least half of the workday at work (4 hours)

NCT01846013 *(Continued)*

	• Move: increase movement time at work. Move more by making small changes (walking meetings, take stairs, etc.) • Stand and Move: increase standing time to half of workday (4h) and increase movement time at work.
Outcomes	• Total physical activity • Fasting blood glucose • Total cholesterol • Body composition
Starting date	November 2013
Contact information	
Notes	**Study sponsor:** University of Minnesota - Clinical and Translational Science Institute

NCT02376504

Trial name or title	Modifying the workplace to decrease sedentary behaviour and improve health
Methods	Random allocation
Participants	Healthy volunteers employed in a full-time sedentary job
Interventions	**Duration of intervention:** 12 months Three-arm trial **Intervention:** treadmill workstation and sit-stand workstation **Control:** participants will be asked to engage in three 10 min walking bouts each workday
Outcomes	Change in weight
Starting date	April 2014
Contact information	Anne Thorndike, email: ATHORNDIKE@mgh.harvard.edu
Notes	**Study sponsor:** Northeastern University

NCT02609282

Trial name or title	
Methods	Random allocation
Participants	Employees from 10 organisations involved with the Healthy Working Lives initiative
Interventions	**Duration of intervention:** 12 weeks **Intervention:** hourly prompts to stand for a period of 10 weeks plus education on why and how to reduce prolonged sitting **Control:** education on why and how to reduce prolonged sitting

NCT02609282 *(Continued)*

Outcomes	Total time spent sitting at work, accessed by 7 day ActivPal and diary measurement Time spent sitting in prolonged sedentary bouts at work Number of sitting events at work Number of prolonged sitting events at work
Starting date	1 February 2015
Contact information	
Notes	Pricinpal Investigator: Philippa Dall, PhD

NCT02785640

Trial name or title	
Methods	Random allocation
Participants	Desk-based office employees
Interventions	**Duration:** 12 weeks **Intervention:** an education session on the health benefits of breaking prolonged sitting and feedback on baseline sitting behaviour followed by hourly prompts to stand delivered by Microsoft Outlook for a period of 10 weeks. The messages will be short in length, varied and centre around the key message of breaking prolonged sitting by standing. **Control:** same education session as the prompt group, as well as feedback on their baseline sitting behaviour.
Outcomes	Total time spent sitting at work will be objectively measured using a tri-axial accelerometer Total time spent sitting at work in continuous bouts of at least 30 minutes Number of sitting events at work Number of prolonged sitting events at work Time after prompt to stand
Starting date	March 2016
Contact information	Philippa Dall, PhD
Notes	

NCT03236597

Trial name or title	
Methods	Random allocation
Participants	Desk-based employees

NCT03236597 *(Continued)*

Interventions	Treadmill workstation versus sit-stand workstation
Outcomes	• Time spent sitting, standing, and moving measured by the ActivPAL at 7 days follow-up • Cardiometabolic risk profile measured via a composite score of fasting glucose, insulin, triglycerides, HDL-cholesterol and blood pressure
Starting date	August 2017
Contact information	Mark Pereira, perei004@umn.edu
Notes	

O'Connell 2015

Trial name or title	SMArT Work: Stand More AT Work
Methods	Random allocation in clusters **Location:** UK **Recruitment:** participant recruitment will be coordinated via the research team at the Leicester Diabetes Centre. The study team currently hold a database of office units within the University Hospitals of Leicester NHS Trust and will promote this study to them initially through the use of the Trust's intranet and emails to department managers. This will be followed up with a face-to-face presentation/meeting if necessary.
Participants	Desk-based office workers (n = 238) from a stratified sample of NHS staff (e.g. employees, managers, gender, job role)
Interventions	Height-adjustable workstations at the environmental, organisational and individual level that support less occupational sitting.
Outcomes	• Primary outcome is a reduction in sitting time, measured by the activPALTM micro at 12 months. • Secondary outcomes include objectively measured physical activity and a variety of work-related health and psycho-social measures.
Starting date	October 2014
Contact information	Dr Ben Jackson, email: b.r.jackson@lboro.ac.uk
Notes	

Radas 2013

Trial name or title	The Healthier Office Study
Methods	Quasi-random allocation **Location:** Australia **Recruitment:** "Posters will be placed in staff tearooms and common areas, inviting staff to participate. The advertisements will contain general information informing participants that we are testing simple occupational health interventions and that participants will be provided with an er-

Radas 2013 *(Continued)*

	gonomic device or advice about improving healthy work practices. The study will also be advertised at Faculty staff meetings to improve potential participants' awareness of the study"
Participants	**Population description:** participants will be recruited from academic and administrative staff of The University of Sydney, Sydney, Australia
Interventions	**Intervention:** 3 groups (1 control group and 2 intervention groups) will be conducted in an office workplace setting. The education intervention group will receive an education package that encourages reduction in sitting behaviours. The sit-stand desk intervention group will receive the same education package along with an adjustable sit-stand desk. The control group will receive no information or advice about postural change and no modification to their office desk set-up.
Outcomes	Average daily sedentary time during work hours, measured by an accelerometer
Starting date	March 2013
Contact information	
Notes	**Study sponsors:** this research is supported by funding from the Heart Foundation, Sydney, NSW, Australia, and by Australian National Health and Medical Research Council Program Grant (number: 569940; AB). Sit-stand workstations were donated by Sit Back and Relax, Alexandria, NSW, Australia.

Van Hoye 2012

Trial name or title	
Methods	Random allocation **Location:** Belgium **Recruitment:** all participants were recruited from working places in Flanders (Belgium) through flyers, emails, pharmacists, and word of mouth
Participants	**Population:** employees (male and female) aged 19-67 years who mentioned not being physically active during the last year
Interventions	**Interventions:** Participants were randomised into one of the following four intervention groups. • A minimal intervention group received no feedback • A pedometer group was provided only with information on their daily step count • A display group received feedback on calories burned, steps taken, and minutes of physical activity by means of the sense wear armband (SWA) display • A coaching group also received the SWA display and had weekly meetings with a personal coach
Outcomes	**Primary outcome:** physical activity level **Secondary outcomes** • Step count, minutes of physical (in)activity (sedentary, light, moderate, vigorous, and very vigorous intensity physical activity) • Daily energy expenditure in physical activity • Percent of participants losing fat • Stages of motivational readiness for physical activity

Van Hoye 2012 *(Continued)*

Starting date	
Contact information	
Notes	No conflict of interest

Abbreviation
BMI: body mass index

DATA AND ANALYSES

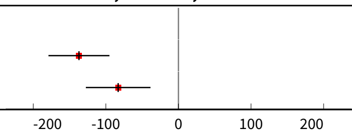
Comparison 1. Sit-stand desk with or without information and counselling versus sit-desk

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work follow-up short-term	10	323	Mean Difference (Random, 95% CI)	-100.16 [-115.83, -84.48]
1.1 Sit-stand desk only	5	145	Mean Difference (Random, 95% CI)	-96.72 [-126.05, -67.39]
1.2 Sit-stand desk + information and counselling	6	178	Mean Difference (Random, 95% CI)	-104.38 [-122.81, -85.96]
2 Mean difference in time spent sitting at work, follow-up short-term - sensitivity analysis	10	323	Mean Difference (Random, 95% CI)	-100.16 [-115.83, -84.48]
2.1 Randomised control trials	4	132	Mean Difference (Random, 95% CI)	-105.19 [-128.13, -82.24]
2.2 Cross-over RCT	2	70	Mean Difference (Random, 95% CI)	-99.11 [-112.82, -85.41]
2.3 Control before after studies	4	121	Mean Difference (Random, 95% CI)	-92.80 [-133.13, -52.47]
3 Mean difference in time spent sitting at work. follow-up medium-term (CBA)	2	60	Mean Difference (Fixed, 95% CI)	-57.08 [-98.76, -15.41]
4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term (CBA)	2	74	Mean Difference (Fixed, 95% CI)	-52.57 [-78.79, -26.35]
4.1 Sit-stand desk only	1	20	Mean Difference (Fixed, 95% CI)	-13.00 [-70.80, 40.80]
4.2 Sit-stand desk + information and counselling	2	54	Mean Difference (Fixed, 95% CI)	-63.22 [-92.92, -33.51]
5 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term	2	56	Mean Difference (Fixed, 95% CI)	-81.67 [-123.99, -39.36]
6 Mean difference in time spent standing at work, follow-up short-term	9	295	Mean Difference (Fixed, 95% CI)	89.38 [76.44, 102.32]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
6.1 Sit-stand desk only	4	117	Mean Difference (Fixed, 95% CI)	75.78 [57.56, 94.01]
6.2 Sit-stand desk + information and counselling	6	178	Mean Difference (Fixed, 95% CI)	103.20 [84.83, 121.58]
7 Mean difference in time spent standing at work, follow-up short-term (RCT only)	4	132	Mean Difference (Fixed, 95% CI)	98.65 [74.94, 122.36]
8 Mean difference in time spent stepping at work follow-up short-term	8	270	Mean Difference (Random, 95% CI)	-0.52 [-3.88, 2.85]
9 Mean difference in time spent standing at work, follow-up medium-term (CBA)	2	60	Mean Difference (IV, Fixed, 95% CI)	53.36 [16.59, 90.14]
10 Work performance (1-10 scale), follow-up short-term (CBA)	3	109	Mean Difference (Fixed, 95% CI)	0.35 [-0.10, 0.79]
10.1 Sit-stand desk only	2	52	Mean Difference (Fixed, 95% CI)	0.82 [0.00, 1.63]
10.2 Sit-stand desk + information and counselling	2	57	Mean Difference (Fixed, 95% CI)	0.15 [-0.38, 0.68]
11 Proportion with ≥ 1 sick days in the last three months (CBA)	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected
12 Proportion with ≥ 1 sick days in the last month (CBA)	2	78	Risk Ratio (M-H, Fixed, 95% CI)	0.77 [0.49, 1.21]
12.1 Sit-stand desk only	1	20	Risk Ratio (M-H, Fixed, 95% CI)	0.94 [0.42, 2.13]
12.2 Sit-stand desk + information and counselling	2	58	Risk Ratio (M-H, Fixed, 95% CI)	0.72 [0.41, 1.24]
13 Mean difference in musculoskeletal symptoms, follow-up short-term	1	46	Mean Difference (Fixed, 95% CI)	-0.51 [-1.03, -0.00]
14 Mean difference in musculoskeletal symptoms, follow-up Medium-term	1	45	Mean Difference (Fixed, 95% CI)	-0.54 [-0.89, -0.19]

Analysis 1.1. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 1 Mean difference in time spent sitting at work follow-up short-term.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Random, 95% CI	Weight	Mean Difference IV, Random, 95% CI
1.1.1 Sit-stand desk only						
Alkhajah 2012	18	13	-137 (21.429)		9.34%	-137[-179,-95]
Chau 2014	21	21	-83 (22.714)		8.63%	-83[-127.52,-38.48]



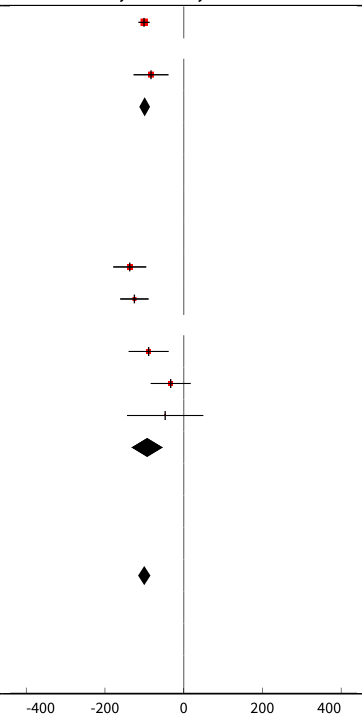
Favours sit-stand desk only or with information | Favours sit-desk

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Random, 95% CI	Weight	Mean Difference IV, Random, 95% CI
Dutta 2014	14	14	-100.8 (7.347)		22.88%	-100.8[-115.2,-86.4]
MacEwen 2017	15	10	-130.6 (35.555)		4.29%	-130.56[-200.25,-60.87]
Neuhaus 2014a	13	6	-33 (26.021)		7.09%	-33[-84,18]
Subtotal (95% CI)					**52.23%**	**-96.72[-126.05,-67.39]**
Heterogeneity: Tau²=647.68; Chi²=10.92, df=4(P=0.03); I²=63.36%						
Test for overall effect: Z=6.46(P<0.0001)						
1.1.2 Sit-stand desk + information and counselling						
Chau 2016	6	10	-47 (49.491)		2.39%	-47[-144,50]
Graves 2015	23	21	-80.2 (24.898)		7.57%	-80.2[-129,-31.4]
Healy 2013	18	18	-125.2 (18.47)		11.29%	-125.2[-161.4,-89]
Li 2017	17	9	-127 (25.935)		7.12%	-127[-177.83,-76.17]
Neuhaus 2014a	12	7	-89 (26.021)		7.09%	-89[-140,-38]
Tobin 2016	18	19	-101.6 (17.141)		12.32%	-101.6[-135.2,-68]
Subtotal (95% CI)					**47.77%**	**-104.38[-122.81,-85.96]**
Heterogeneity: Tau²=0; Chi²=4.69, df=5(P=0.45); I²=0%						
Test for overall effect: Z=11.11(P<0.0001)						
Total (95% CI)					**100%**	**-100.16[-115.83,-84.48]**
Heterogeneity: Tau²=225.6; Chi²=15.8, df=10(P=0.11); I²=36.69%						
Test for overall effect: Z=12.52(P<0.0001)						
Test for subgroup differences: Chi²=0.19, df=1 (P=0.66), I²=0%						
		Favours sit-stand desk only or with information		-200 -100 0 100 200	Favours sit-desk	

Analysis 1.2. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 2 Mean difference in time spent sitting at work, follow-up short-term - sensitivity analysis.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Random, 95% CI	Weight	Mean Difference IV, Random, 95% CI
1.2.1 Randomised control trials						
Graves 2015	23	21	-80.2 (24.898)		7.57%	-80.2[-129,-31.4]
Tobin 2016	18	19	-101.6 (17.141)		12.32%	-101.6[-135.2,-68]
MacEwen 2017	15	10	-130.6 (35.555)		4.29%	-130.56[-200.25,-60.87]
Li 2017	17	9	-127 (25.935)		7.12%	-127[-177.83,-76.17]
Subtotal (95% CI)					**31.3%**	**-105.19[-128.13,-82.24]**
Heterogeneity: Tau²=0; Chi²=2.27, df=3(P=0.52); I²=0%						
Test for overall effect: Z=8.98(P<0.0001)						
1.2.2 Cross-over RCT						
		Favours sit-stand desk only or with information		-400 -200 0 200 400	Favours sit-desk	

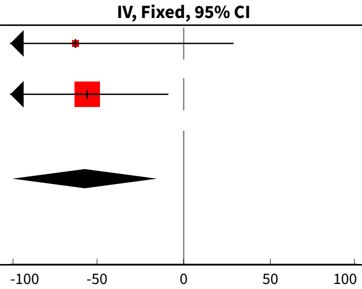
Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Random, 95% CI	Weight	Mean Difference IV, Random, 95% CI
Dutta 2014	14	14	-100.8 (7.347)		22.88%	-100.8[-115.2,-86.4]
Chau 2014	21	21	-83 (22.714)		8.63%	-83[-127.52,-38.48]
Subtotal (95% CI)					**31.51%**	**-99.11[-112.82,-85.41]**
Heterogeneity: Tau²=0; Chi²=0.56, df=1(P=0.46); I²=0%						
Test for overall effect: Z=14.18(P<0.0001)						
1.2.3 Control before after studies						
Alkhajah 2012	18	13	-137 (21.429)		9.34%	-137[-179,-95]
Healy 2013	18	18	-125.2 (18.47)		11.29%	-125.2[-161.4,-89]
Neuhaus 2014a	12	7	-89 (26.021)		7.09%	-89[-140,-38]
Neuhaus 2014a	13	6	-33 (26.021)		7.09%	-33[-84,18]
Chau 2016	6	10	-47 (49.491)		2.39%	-47[-144,50]
Subtotal (95% CI)					**37.19%**	**-92.8[-133.13,-52.47]**
Heterogeneity: Tau²=1377.11; Chi²=12.76, df=4(P=0.01); I²=68.66%						
Test for overall effect: Z=4.51(P<0.0001)						
Total (95% CI)					**100%**	**-100.16[-115.83,-84.48]**
Heterogeneity: Tau²=225.6; Chi²=15.8, df=10(P=0.11); I²=36.69%						
Test for overall effect: Z=12.52(P<0.0001)						
Test for subgroup differences: Chi²=0.33, df=1 (P=0.85), I²=0%						



Favours sit-stand desk only or with information | Favours sit-desk

Analysis 1.3. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 3 Mean difference in time spent sitting at work. follow-up medium-term (CBA).

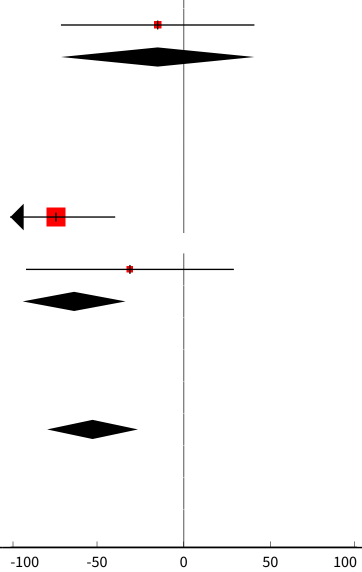
Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Chau 2016	7	8	-62.4 (46.532)		20.88%	-62.4[-153.6,28.8]
Gao 2015	24	21	-55.7 (23.903)		79.12%	-55.68[-102.53,-8.83]
Total (95% CI)					**100%**	**-57.08[-98.76,-15.41]**
Heterogeneity: Tau²=0; Chi²=0.02, df=1(P=0.9); I²=0%						
Test for overall effect: Z=2.68(P=0.01)						



Favours sit-stand desk only or with information | Favours sit-desk

Analysis 1.4. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term (CBA).

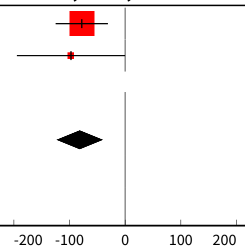
Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
1.4.1 Sit-stand desk only						
Neuhaus 2014a	13	7	-15 (28.47)		22.08%	-15[-70.8,40.8]
Subtotal (95% CI)					**22.08%**	**-15[-70.8,40.8]**
Heterogeneity: Tau²=0; Chi²=0, df=0(P<0.0001); I²=100%						
Test for overall effect: Z=0.53(P=0.6)						
1.4.2 Sit-stand desk + information and counselling						
Healy 2013	18	18	-73.7 (17.449)		58.79%	-73.7[-107.9,-39.5]
Neuhaus 2014a	12	6	-31 (30.59)		19.13%	-31[-90.96,28.96]
Subtotal (95% CI)					**77.92%**	**-63.22[-92.92,-33.51]**
Heterogeneity: Tau²=0; Chi²=1.47, df=1(P=0.23); I²=31.98%						
Test for overall effect: Z=4.17(P<0.0001)						
Total (95% CI)					**100%**	**-52.57[-78.79,-26.35]**
Heterogeneity: Tau²=0; Chi²=3.71, df=2(P=0.16); I²=46.02%						
Test for overall effect: Z=3.93(P<0.0001)						
Test for subgroup differences: Chi²=2.23, df=1 (P=0.13), I²=55.26%						



Favours sit-stand desk only or with information | Favours sit-desk

Analysis 1.5. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 5 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Alkhajah 2012	18	13	-78 (23.98)		81.06%	-78[-125,-31]
MacEwen 2017	15	10	-97.4 (49.603)		18.94%	-97.39[-194.61,-0.17]
Total (95% CI)					**100%**	**-81.67[-123.99,-39.36]**
Heterogeneity: Tau²=0; Chi²=0.12, df=1(P=0.72); I²=0%						
Test for overall effect: Z=3.78(P=0)						



Favours sit-stand desk only or with information | Favours sit-desk

Analysis 1.6. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 6 Mean difference in time spent standing at work, follow-up short-term.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
1.6.1 Sit-stand desk only						
Alkhajah 2012	18	13	131 (20.919)		9.96%	131[90,172]
Chau 2014	21	21	61 (12.203)		29.27%	61[37.08,84.92]
MacEwen 2017	15	10	129 (34.789)		3.6%	129.02[60.84,197.21]
Neuhaus 2014a	13	6	35 (23.98)		7.58%	35[-12,82]
Subtotal (95% CI)					**50.42%**	**75.78[57.56,94.01]**
Heterogeneity: Tau²=0; Chi²=13.67, df=3(P=0); I²=78.05%						
Test for overall effect: Z=8.15(P<0.0001)						
1.6.2 Sit-stand desk + information and counselling						
Chau 2016	10	6	95 (40.817)		2.62%	95[15,175]
Graves 2015	23	21	72.9 (26.378)		6.27%	72.9[21.2,124.6]
Healy 2013	18	18	127.2 (17.96)		13.52%	127.2[92,162.4]
Li 2017	17	9	106 (22.091)		8.93%	106[62.7,149.3]
Neuhaus 2014a	12	7	93 (24.49)		7.27%	93[45,141]
Tobin 2016	18	19	97.4 (19.922)		10.98%	97.4[58.35,136.45]
Subtotal (95% CI)					**49.58%**	**103.2[84.83,121.58]**
Heterogeneity: Tau²=0; Chi²=3.42, df=5(P=0.64); I²=0%						
Test for overall effect: Z=11.01(P<0.0001)						
Total (95% CI)					**100%**	**89.38[76.44,102.32]**
Heterogeneity: Tau²=0; Chi²=21.4, df=9(P=0.01); I²=57.95%						
Test for overall effect: Z=13.54(P<0.0001)						
Test for subgroup differences: Chi²=4.31, df=1 (P=0.04), I²=76.81%						
			Favours sit-desk	-100 -50 0 50 100	Favours sit-stand desk only or with information	

Analysis 1.7. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 7 Mean difference in time spent standing at work, follow-up short-term (RCT only).

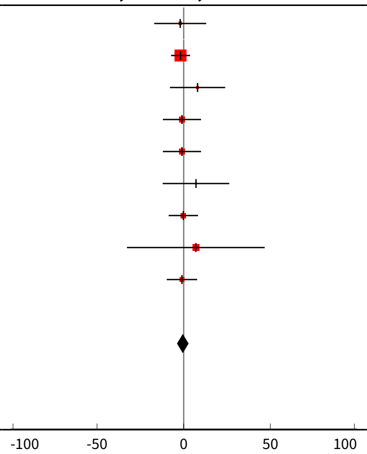
Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Graves 2015	23	21	72.9 (26.378)		21.04%	72.9[21.2,124.6]
Tobin 2016	18	19	97.4 (19.922)		36.88%	97.4[58.35,136.45]
MacEwen 2017	15	10	129 (34.789)		12.09%	129.02[60.84,197.21]
Li 2017	17	9	106 (22.091)		29.99%	106[62.7,149.3]
Total (95% CI)					**100%**	**98.65[74.94,122.36]**
Heterogeneity: Tau²=0; Chi²=1.83, df=3(P=0.61); I²=0%						
Test for overall effect: Z=8.15(P<0.0001)						
			Favours sit-desk	-200 -100 0 100 200	Favours sit-stand desk only or with information	

Analysis 1.8. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 8 Mean difference in time spent stepping at work follow-up short-term.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Random, 95% CI	Weight	Mean Difference IV, Random, 95% CI
Alkhajah 2012	18	13	-2 (7.653)		5.03%	-2[-17,13]
Healy 2013	18	18	-1.8 (2.806)		37.44%	-1.8[-7.3,3.7]
Chau 2014	21	21	8 (8.136)		4.45%	8[-7.95,23.95]
Neuhaus 2014a	13	6	-1 (5.612)		9.36%	-1[-12,10]
Neuhaus 2014a	12	7	-1 (5.612)		9.36%	-1[-12,10]
Graves 2015	23	21	7.1 (9.796)		3.07%	7.1[-12.1,26.3]
Tobin 2016	18	19	-0.2 (4.314)		15.85%	-0.2[-8.65,8.25]
Chau 2016	10	6	7 (20.276)		0.72%	7[-32.74,46.74]
Li 2017	17	9	-1 (4.477)		14.71%	-1[-9.78,7.78]
Total (95% CI)					**100%**	**-0.52[-3.88,2.85]**

Heterogeneity: Tau²=0; Chi²=2.12, df=8(P=0.98); I²=0%

Test for overall effect: Z=0.3(P=0.76)



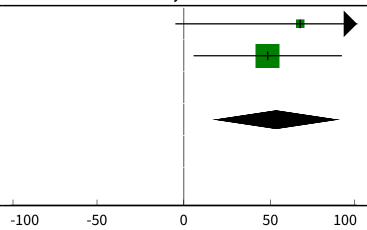
Favours sit-desk | Favours sit-stand desk only or with information

Analysis 1.9. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 9 Mean difference in time spent standing at work, follow-up medium-term (CBA).

Study or subgroup	Sit-stand desk with or without information N	Sit-stand desk with or without information Mean(SD)	Sit-desk N	Sit-desk Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Chau 2016	7	62.4 (72.7)	8	-4.8 (69)		26.09%	67.2[-4.8,139.2]
Gao 2015	24	31.2 (73)	21	-17.3 (73)		73.91%	48.48[5.7,91.26]
Total ***	**31**		**29**			**100%**	**53.36[16.59,90.14]**

Heterogeneity: Tau²=0; Chi²=0.19, df=1(P=0.66); I²=0%

Test for overall effect: Z=2.84(P=0)

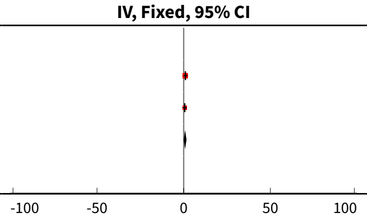


Favours sit-desk | Favours sit-stand desk only or with information

Analysis 1.10. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 10 Work performance (1-10 scale), follow-up short-term (CBA).

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
1.10.1 Sit-stand desk only						
Alkhajah 2012	18	14	1 (0.565)		15.94%	1[-0.11,2.11]
Neuhaus 2014a	13	7	0.6 (0.613)		13.57%	0.6[-0.6,1.8]
Subtotal (95% CI)					**29.51%**	**0.82[0,1.63]**

Heterogeneity: Tau²=0; Chi²=0.23, df=1(P=0.63); I²=0%



Favours sit-stand desk only or with information | Favours sit-desk

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Test for overall effect: Z=1.96(P=0.05)						
1.10.2 Sit-stand desk + information and counselling						
Healy 2013	18	19	0.2 (0.291)		60.25%	0.21[-0.36,0.78]
Neuhaus 2014a	13	7	-0.2 (0.705)		10.24%	-0.2[-1.58,1.18]
Subtotal (95% CI)					**70.49%**	**0.15[-0.38,0.68]**
Heterogeneity: Tau²=0; Chi²=0.29, df=1(P=0.59); I²=0%						
Test for overall effect: Z=0.56(P=0.58)						
Total (95% CI)					**100%**	**0.35[-0.1,0.79]**
Heterogeneity: Tau²=0; Chi²=2.33, df=3(P=0.51); I²=0%						
Test for overall effect: Z=1.54(P=0.12)						
Test for subgroup differences: Chi²=1.81, df=1 (P=0.18), I²=44.71%						

Favours sit-stand desk only or with information -100 -50 0 50 100 Favours sit-desk

Analysis 1.11. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 11 Proportion with ≥ 1 sick days in the last three months (CBA).

Study or subgroup	Sit-stand desk with or without information n/N	Sit-desk n/N	Risk Ratio M-H, Fixed, 95% CI	Risk Ratio M-H, Fixed, 95% CI
Alkhajah 2012	12/18	4/13		2.17[0.9,5.22]

Favours sit-stand desk only or with information 0.01 0.1 1 10 100 Favours sit-desk

Analysis 1.12. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 12 Proportion with ≥ 1 sick days in the last month (CBA).

Study or subgroup	Sit-stand desk with or without information n/N	Sit-desk n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
1.12.1 Sit-stand desk only					
Neuhaus 2014a	7/13	4/7		24.3%	0.94[0.42,2.13]
Subtotal (95% CI)	**13**	**7**		**24.3%**	**0.94[0.42,2.13]**
Total events: 7 (Sit-stand desk with or without information), 4 (Sit-desk)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.14(P=0.89)					
1.12.2 Sit-stand desk + information and counselling					
Healy 2013	6/19	11/19		51.4%	0.55[0.25,1.17]
Neuhaus 2014a	8/13	4/7		24.3%	1.08[0.5,2.33]
Subtotal (95% CI)	**32**	**26**		**75.7%**	**0.72[0.41,1.24]**
Total events: 14 (Sit-stand desk with or without information), 15 (Sit-desk)					
Heterogeneity: Tau²=0; Chi²=1.56, df=1(P=0.21); I²=35.87%					
Test for overall effect: Z=1.2(P=0.23)					

Favours sit-stand desk only or with information 0.01 0.1 1 10 100 Favours sit-desk

Study or subgroup	Sit-stand desk with or without information n/N	Sit-desk n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Total (95% CI)	**45**	**33**		**100%**	**0.77[0.49,1.21]**
Total events: 21 (Sit-stand desk with or without information), 19 (Sit-desk)					
Heterogeneity: Tau²=0; Chi²=1.74, df=2(P=0.42); I²=0%					
Test for overall effect: Z=1.12(P=0.26)					
Test for subgroup differences: Chi²=0.3, df=1 (P=0.58), I²=0%					

Favours sit-stand desk only or with information 0.01 0.1 1 10 100 Favours sit-desk

Analysis 1.13. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 13 Mean difference in musculoskeletal symptoms, follow-up short-term.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Graves 2015	8	7	-0.9 (0.51)		26.34%	-0.9[-1.9,0.1]
Graves 2015	8	7	-0.6 (0.459)		32.51%	-0.6[-1.5,0.3]
Graves 2015	9	7	-0.2 (0.408)		41.15%	-0.2[-1,0.6]
Total (95% CI)					**100%**	**-0.51[-1.03,-0]**
Heterogeneity: Tau²=0; Chi²=1.2, df=2(P=0.55); I²=0%						
Test for overall effect: Z=1.96(P=0.05)						

Favours sit-stand desk only or with information -100 -50 0 50 100 Favours sit-desk

Analysis 1.14. Comparison 1 Sit-stand desk with or without information and counselling versus sit-desk, Outcome 14 Mean difference in musculoskeletal symptoms, follow-up Medium-term.

Study or subgroup	Sit-stand desk with or without information N	Sit-desk N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Gao 2015	12	11	-0.6 (0.269)		44.13%	-0.6[-1.13,-0.07]
Gao 2015	12	10	-0.5 (0.239)		55.87%	-0.5[-0.97,-0.03]
Total (95% CI)					**100%**	**-0.54[-0.89,-0.19]**
Heterogeneity: Tau²=0; Chi²=0.08, df=1(P=0.78); I²=0%						
Test for overall effect: Z=3.05(P=0)						

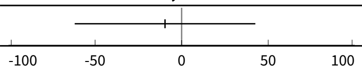
Favours sit-stand desk only or with information -100 -50 0 50 100 Favours sit-desk

Comparison 2. Standing desk versus sit-stand desk

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Mean difference in time spent sitting at work, follow-up medium-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

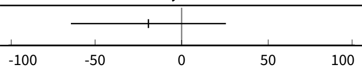
Analysis 2.1. Comparison 2 Standing desk versus sit-stand desk, Outcome 1 Mean difference in time spent sitting at work, follow-up short-term.

Study or subgroup	Standing desk		Sit-stand desk		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Kress 2014	23	-9.6 (95.3)	29	0 (95.3)		-9.6[-61.77,42.57]



Analysis 2.2. Comparison 2 Standing desk versus sit-stand desk, Outcome 2 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Standing desk		Sit-stand desk		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Kress 2014	33	-19.2 (92.1)	32	0 (92.1)		-19.2[-63.97,25.57]

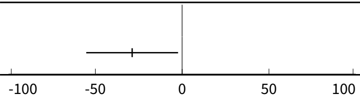


Comparison 3. Active workstation versus sit desk

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
1.1 Treadmill desk plus counselling versus sit desk	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
2 Mean difference in time spent in inactive sitting at work, follow-up medium term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2.1 Cycling desk + information and counselling versus information and counselling only	1		Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]

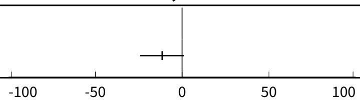
Analysis 3.1. Comparison 3 Active workstation versus sit desk, Outcome 1 Mean difference in time spent sitting at work, follow-up short-term.

Study or subgroup	Treadmill desk + counselling N	Treadmill desk + counselling Mean(SD)	Sit-desk N	Sit-desk Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
3.1.1 Treadmill desk plus counselling versus sit desk						
Schuna 2014	15	-19.2 (37.6)	16	9.6 (37.5)		-28.8[-55.25,-2.35]



Analysis 3.2. Comparison 3 Active workstation versus sit desk, Outcome 2 Mean difference in time spent in inactive sitting at work, follow-up medium term.

Study or subgroup	Cycling desk + information N	Cycling desk + information Mean(SD)	Information only N	Information only Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
3.2.1 Cycling desk + information and counselling versus information and counselling only						
Carr 2015	27	-9.6 (29.1)	27	1.9 (17)		-11.52[-24.24,1.2]

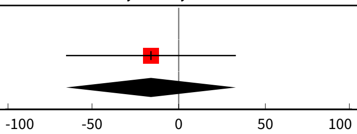


Comparison 4. Walking strategies versus no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short term	1	179	Mean Difference (Fixed, 95% CI)	-15.49 [-49.65, 18.67]
1.1 Route versus no intervention	1	90	Mean Difference (Fixed, 95% CI)	-16.0 [-64.98, 32.98]
1.2 Incidental versus no intervention	1	89	Mean Difference (Fixed, 95% CI)	-15.0 [-62.66, 32.66]
2 Mean difference in time spent sitting at work, follow-up medium-term	1	264	Mean Difference (IV, Fixed, 95% CI)	-16.50 [-60.55, 27.55]
3 Percentage of lost work productivity (WLQ Index Score) follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected

Analysis 4.1. Comparison 4 Walking strategies versus no intervention, Outcome 1 Mean difference in time spent sitting at work, follow-up short term.

Study or subgroup	Walking strategies N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
4.1.1 Route versus no intervention						
Gilson 2009	60	30	-16 (24.992)		48.63%	-16[-64.98,32.98]
Subtotal (95% CI)					**48.63%**	**-16[-64.98,32.98]**



Study or subgroup	Walking strategies N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Heterogeneity: Not applicable						
Test for overall effect: Z=0.64(P=0.52)						
4.1.2 Incidental versus no intervention						
Gilson 2009	59	30	-15 (24.318)		51.37%	-15[-62.66,32.66]
Subtotal (95% CI)					**51.37%**	**-15[-62.66,32.66]**
Heterogeneity: Not applicable						
Test for overall effect: Z=0.62(P=0.54)						
Total (95% CI)					**100%**	**-15.49[-49.65,18.67]**
Heterogeneity: Tau²=0; Chi²=0, df=1(P=0.98); I²=0%						
Test for overall effect: Z=0.89(P=0.37)						
Test for subgroup differences: Chi²=0, df=1 (P=0.98), I²=0%						
			Favours walking strategies	-100 -50 0 50 100	Favours no intervention	

Analysis 4.2. Comparison 4 Walking strategies versus no intervention, Outcome 2 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Walking strategies N	Walking strategies Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Puig-Ribera 2015	135	-32.2 (136.6)	129	-15.7 (217.6)		100%	-16.5[-60.55,27.55]
Total ***	**135**		**129**			**100%**	**-16.5[-60.55,27.55]**
Heterogeneity: Not applicable							
Test for overall effect: Z=0.73(P=0.46)							
				Favours walking strategies	-100 -50 0 50 100	Favours no intervention	

Analysis 4.3. Comparison 4 Walking strategies versus no intervention, Outcome 3 Percentage of lost work productivity (WLQ Index Score) follow-up medium-term.

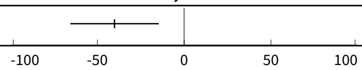
Study or subgroup	Walking strategies N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Puig-Ribera 2015	88	102	-2.6 (0.678)		-2.59[-3.92,-1.26]
			Favours walking strategies	-100 -50 0 50 100	Favours no intervention

Comparison 5. Short break versus long break

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 5.1. Comparison 5 Short break versus long break, Outcome 1 Mean difference in time spent sitting at work, follow-up short-term.

Study or subgroup	Short break N	Short break Mean(SD)	Long break N	Long break Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Mailey 2016	24	-35.6 (45.5)	25	4.5 (45.5)		-40.1[-65.57,-14.63]



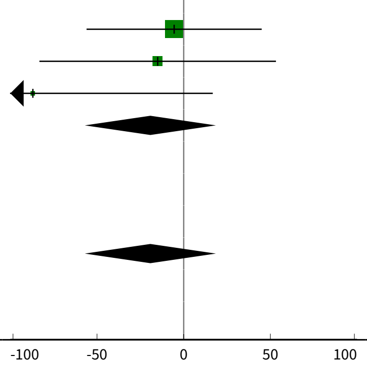
Favours short break | Favours long break

Comparison 6. Information, feedback and/or reminder versus information only or no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short term	2	63	Mean Difference (IV, Fixed, 95% CI)	-19.23 [-57.05, 18.58]
1.1 Information and feedback versus no intervention	2	63	Mean Difference (IV, Fixed, 95% CI)	-19.23 [-57.05, 18.58]
2 Mean difference in time spent sitting at work, follow-up medium-term	2	747	Mean Difference (Fixed, 95% CI)	-28.38 [-51.49, -5.26]
2.1 Counselling versus no intervention	2	747	Mean Difference (Fixed, 95% CI)	-28.38 [-51.49, -5.26]
3 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Subtotals only
3.1 Information and feedback versus no intervention	1	37	Mean Difference (Fixed, 95% CI)	-16.40 [-96.85, 64.06]
4 Mean difference in total time spent sitting (including sitting at and outside work), follow-up medium term	1		Mean Difference (Fixed, 95% CI)	Subtotals only
4.1 Counselling versus no intervention	1	416	Mean Difference (Fixed, 95% CI)	-20.0 [-85.00, 45.00]
5 Mean difference in time spent standing at work follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Subtotals only
5.1 Information and feedback	1	93	Mean Difference (Fixed, 95% CI)	10.24 [-17.17, 37.65]
6 Work engagement (0-6 scale), follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Subtotals only
6.1 Counseling versus no intervention	1	224	Mean Difference (Fixed, 95% CI)	0.1 [-0.10, 0.30]

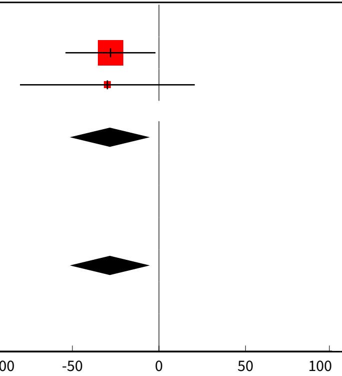
Analysis 6.1. Comparison 6 Information, feedback and/or reminder versus information only or no intervention, Outcome 1 Mean difference in time spent sitting at work, follow-up short term.

Study or subgroup	Information and reminder N	Information and reminder Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
6.1.1 Information and feedback versus no intervention							
Gordon 2013	12	-14.7 (60.2)	10	-9.2 (60.2)		56.02%	-5.5[-56.02,45.02]
De Cocker 2016	21	-8 (63.8)	4	7 (63.8)		30.71%	-15[-83.23,53.23]
De Cocker 2016	12	-80 (91.7)	4	7 (91.7)		13.27%	-87[-190.79,16.79]
Subtotal ***	**45**		**18**			**100%**	**-19.23[-57.05,18.58]**
Heterogeneity: Tau²=0; Chi²=1.94, df=2(P=0.38); I²=0%							
Test for overall effect: Z=1(P=0.32)							
Total ***	**45**		**18**			**100%**	**-19.23[-57.05,18.58]**
Heterogeneity: Tau²=0; Chi²=1.94, df=2(P=0.38); I²=0%							
Test for overall effect: Z=1(P=0.32)							



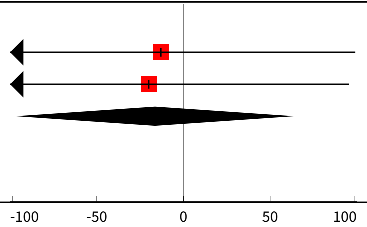
Analysis 6.2. Comparison 6 Information, feedback and/or reminder versus information only or no intervention, Outcome 2 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Counselling N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
6.2.1 Counselling versus no intervention						
Verweij 2012	274	249	-28 (13.266)		79.05%	-28[-54,-2]
Coffeng 2014	118	106	-29.8 (25.766)		20.95%	-29.8[-80.3,20.7]
Subtotal (95% CI)					**100%**	**-28.38[-51.49,-5.26]**
Heterogeneity: Tau²=0; Chi²=0, df=1(P=0.95); I²=0%						
Test for overall effect: Z=2.41(P=0.02)						
Total (95% CI)					**100%**	**-28.38[-51.49,-5.26]**
Heterogeneity: Tau²=0; Chi²=0, df=1(P=0.95); I²=0%						
Test for overall effect: Z=2.41(P=0.02)						



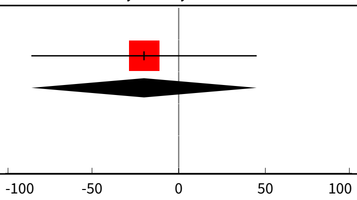
Analysis 6.3. Comparison 6 Information, feedback and/or reminder versus information only or no intervention, Outcome 3 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term.

Study or subgroup	Information and reminder N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
6.3.1 Information and feedback versus no intervention						
De Cocker 2016	14	5	-13 (57.223)		51.46%	-13[-125.16,99.16]
De Cocker 2016	14	4	-20 (58.918)		48.54%	-20[-135.48,95.48]
Subtotal (95% CI)					**100%**	**-16.4[-96.85,64.06]**
Heterogeneity: Tau²=0; Chi²=0.01, df=1(P=0.93); I²=0%						
Test for overall effect: Z=0.4(P=0.69)						



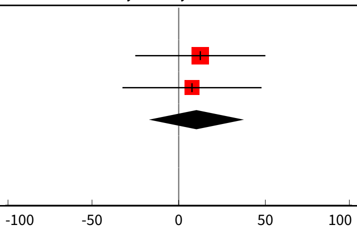
Analysis 6.4. Comparison 6 Information, feedback and/or reminder versus information only or no intervention, Outcome 4 Mean difference in total time spent sitting (including sitting at and outside work), follow-up medium term.

Study or subgroup	Counselling N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
6.4.1 Counselling versus no intervention						
Verweij 2012	210	206	-20 (33.164)		100%	-20[-85,45]
Subtotal (95% CI)					**100%**	**-20[-85,45]**
Heterogeneity: Not applicable						
Test for overall effect: Z=0.6(P=0.55)						



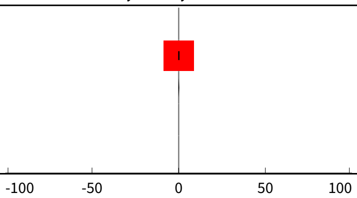
Analysis 6.5. Comparison 6 Information, feedback and/or reminder versus information only or no intervention, Outcome 5 Mean difference in time spent standing at work follow-up short-term.

Study or subgroup	Info + feedback + reminder N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
6.5.1 Information and feedback						
De Cocker 2016	35	12	12.5 (19.152)		53.32%	12.48[-25.06,50.02]
De Cocker 2016	35	11	7.7 (20.47)		46.68%	7.68[-32.44,47.8]
Subtotal (95% CI)					**100%**	**10.24[-17.17,37.65]**
Heterogeneity: Tau^2=0; Chi^2=0.03, df=1(P=0.86); I^2=0%						
Test for overall effect: Z=0.73(P=0.46)						



Analysis 6.6. Comparison 6 Information, feedback and/or reminder versus information only or no intervention, Outcome 6 Work engagement (0-6 scale), follow-up medium-term.

Study or subgroup	Counselling N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
6.6.1 Counseling versus no intervention						
Coffeng 2014	118	106	0.1 (0.102)		100%	0.1[-0.1,0.3]
Subtotal (95% CI)					**100%**	**0.1[-0.1,0.3]**
Heterogeneity: Not applicable						
Test for overall effect: Z=0.98(P=0.33)						



Comparison 7. Prompts plus information versus information alone

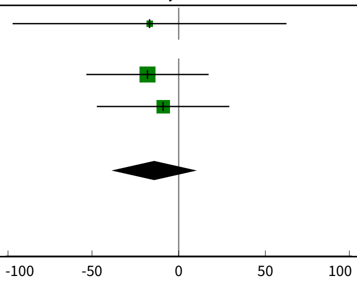
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short term	3	103	Mean Difference (IV, Fixed, 95% CI)	-14.14 [-38.77, 10.48]
2 Mean difference in time spent sitting at work, follow-up medium-term	1	34	Mean Difference (Fixed, 95% CI)	-54.92 [-95.82, -14.02]
3 Mean difference in number of sitting bouts lasting 30 minutes or more, follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term	1	28	Mean Difference (Fixed, 95% CI)	-73.92 [-123.78, -24.06]
5 Mean difference in time spent standing at work follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
6 Mean difference in energy expenditure, follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected

Analysis 7.1. Comparison 7 Prompts plus information versus information alone, Outcome 1 Mean difference in time spent sitting at work, follow-up short term.

Study or subgroup	Prompts + information N	Prompts + information Mean(SD)	Information alone N	Information alone Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Donath 2015	15	-19.2 (112.2)	16	-2.4 (112.2)		9.72%	-16.8[-95.8,62.2]
Evans 2012	14	-12 (47.6)	14	6 (47.6)		48.73%	-18[-53.28,17.28]
Urda 2016	22	-7.2 (64.7)	22	1.8 (64.7)		41.55%	-9[-47.21,29.21]
Total ***	**51**		**52**			**100%**	**-14.14[-38.77,10.48]**

Heterogeneity: Tau²=0; Chi²=0.12, df=2(P=0.94); I²=0%

Test for overall effect: Z=1.13(P=0.26)

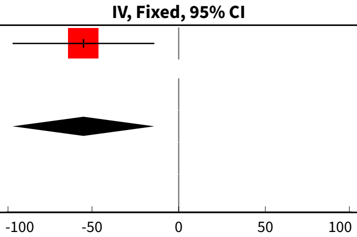


Analysis 7.2. Comparison 7 Prompts plus information versus information alone, Outcome 2 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Prompts + information N	Information alone N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Pedersen 2013	17	17	-54.9 (20.866)		100%	-54.92[-95.82,-14.02]
Total (95% CI)					**100%**	**-54.92[-95.82,-14.02]**

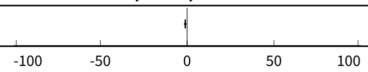
Heterogeneity: Not applicable

Test for overall effect: Z=2.63(P=0.01)



Analysis 7.3. Comparison 7 Prompts plus information versus information alone, Outcome 3 Mean difference in number of sitting bouts lasting 30 minutes or more, follow-up short-term.

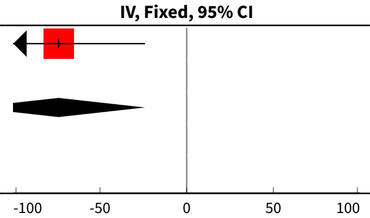
Study or subgroup	Prompts + information N	Information alone N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Evans 2012	14	14	-1.1 (0.4)		-1.1[-1.88,-0.32]



Favours prompts + information | Favours information alone

Analysis 7.4. Comparison 7 Prompts plus information versus information alone, Outcome 4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term.

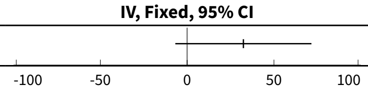
Study or subgroup	Prompts + information N	Information alone N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Evans 2012	14	14	-73.9 (25.44)		100%	-73.92[-123.78,-24.06]
Total (95% CI)					**100%**	**-73.92[-123.78,-24.06]**
Heterogeneity: Not applicable						
Test for overall effect: Z=2.91(P=0)						



Favours prompts + information | Favours information alone

Analysis 7.5. Comparison 7 Prompts plus information versus information alone, Outcome 5 Mean difference in time spent standing at work follow-up short-term.

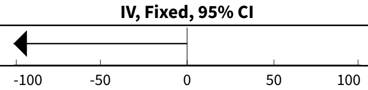
Study or subgroup	Prompts + information N	Information alone N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Donath 2015	15	16	32.4 (20.004)		32.4[-6.81,71.61]



Favours information alone | Favours prompts + information

Analysis 7.6. Comparison 7 Prompts plus information versus information alone, Outcome 6 Mean difference in energy expenditure, follow-up medium-term.

Study or subgroup	Prompts + information N	Information alone N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Pedersen 2013	17	17	-278.1 (141.92)		-278.15[-556.31,0.01]



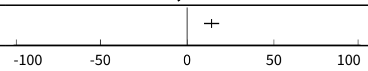
Favours prompts + information | Favours information alone

Comparison 8. Computer prompts to step versus computer prompts to stand

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Mean difference in number of sitting bouts lasting 30 minutes or more, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Mean difference in time spent standing at work, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Mean difference in time spent stepping at work, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Analysis 8.1. Comparison 8 Computer prompts to step versus computer prompts to stand, Outcome 1 Mean difference in time spent sitting at work, follow-up short-term.

Study or subgroup	Step group		Stand group		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Swartz 2014	31	-10.9 (7.8)	29	-25 (9.6)		14.1[9.66,18.54]

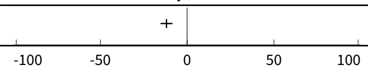


Analysis 8.2. Comparison 8 Computer prompts to step versus computer prompts to stand, Outcome 2 Mean difference in number of sitting bouts lasting 30 minutes or more, follow-up short-term.

Study or subgroup	Step group		Stand group		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Swartz 2014	31	-0.1 (0.2)	29	-0.5 (0.2)		0.4[0.3,0.5]

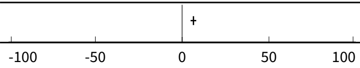
Analysis 8.3. Comparison 8 Computer prompts to step versus computer prompts to stand, Outcome 3 Mean difference in time spent standing at work, follow-up short-term.

Study or subgroup	Step group		Stand group		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Swartz 2014	31	4.3 (5.9)	29	16.2 (7.5)		-11.9[-15.33,-8.47]



Analysis 8.4. Comparison 8 Computer prompts to step versus computer prompts to stand, Outcome 4 Mean difference in time spent stepping at work, follow-up short-term.

Study or subgroup	Step group		Stand group		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Swartz 2014	31	12 (3.8)	29	5.5 (2.6)	+	6.5[4.86,8.14]
				Favours step group	-100 -50 0 50 100	Favours stand group

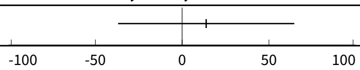


Comparison 9. High personalised or contextualised information versus less personalised or contextualised information

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected

Analysis 9.1. Comparison 9 High personalised or contextualised information versus less personalised or contextualised information, Outcome 1 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term.

Study or subgroup	High personalised/context	Less personalised/context	Mean Difference	Mean Difference	Mean Difference
	N	N	(SE)	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Priebe 2015	23	27	13.9 (25.895)		13.85[-36.9,64.6]
			Favours high personalised/context	-100 -50 0 50 100	Favours less personalised/context

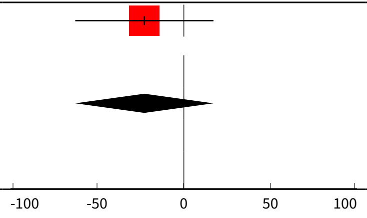


Comparison 10. Mindfulness training versus no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up medium-term	1	257	Mean Difference (Fixed, 95% CI)	-22.69 [-62.55, 17.17]
2 Work engagement (0-6 scale), follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected

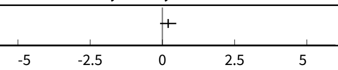
Analysis 10.1. Comparison 10 Mindfulness training versus no intervention, Outcome 1 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Mindfulness training N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
van Berkel 2014	129	128	-22.7 (20.339)		100%	-22.69[-62.55,17.17]
Total (95% CI)					**100%**	**-22.69[-62.55,17.17]**
Heterogeneity: Not applicable						
Test for overall effect: Z=1.12(P=0.26)						



Analysis 10.2. Comparison 10 Mindfulness training versus no intervention, Outcome 2 Work engagement (0-6 scale), follow-up medium-term.

Study or subgroup	Mindfulness training N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
van Berkel 2014	129	128	0.2 (0.143)		0.2[-0.08,0.48]



Comparison 11. Activity tracker combined with organisational support versus organisational support only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
2 Mean difference in time spent sitting at work, follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
3 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up medium-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
5 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
6 Mean difference in total time spent sitting (including sitting at and outside work), follow-up medium-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
7 Mean difference in time spent standing at work follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
8 Mean difference in time spent stepping at work, follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
9 Mean difference in time spent standing at work follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
10 Mean difference in time spent stepping at work, follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected

Analysis 11.1. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 1 Mean difference in time spent sitting at work, follow-up short-term.

Study or subgroup	Tracker + org. support N	Org. support only N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Brakenridge 2016	87	66	-6.6 (14.49)		-6.6[-35,21.8]
			Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.2. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 2 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Tracker + org. support N	Org. support only N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Brakenridge 2016	87	66	4.4 (19.133)		4.4[-33.1,41.9]
			Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.3. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 3 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term.

Study or subgroup	Tracker + org. support N	Tracker + org. support Mean(SD)	Org. support only N	Org. support only Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Brakenridge 2016	87	-6 (120.6)	66	-17.1 (120.6)		11.1[-27.5,49.7]
				Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.4. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up medium-term.

Study or subgroup	Tracker + org. support N	Tracker + org. support Mean(SD)	Org. support only N	Org. support only Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Brakenridge 2016	87	-45.7 (155.7)	66	-44.3 (155.7)		-1.4[-51.2,48.4]
				Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.5. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 5 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term.

Study or subgroup	Tracker + org. support		Org. support only		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Brakenridge 2016	87	-7.4 (136.6)	66	-9.2 (136.6)		1.8[-41.9,45.5]
				Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.6. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 6 Mean difference in total time spent sitting (including sitting at and outside work), follow-up medium-term.

Study or subgroup	Tracker + org. support		Org. support only		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Fixed, 95% CI	Fixed, 95% CI
Brakenridge 2016	87	-35 (151.9)	66	-26.6 (151.9)		-8.4[-57,40.2]
				Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.7. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 7 Mean difference in time spent standing at work follow-up short-term.

Study or subgroup	Tracker + org. support	Org. support only	Mean Difference	Mean Difference	Mean Difference
	N	N	(SE)	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Brakenridge 2016	87	66	3.4 (11.837)		3.4[-19.8,26.6]
			Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.8. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 8 Mean difference in time spent stepping at work, follow-up short-term.

Study or subgroup	Tracker + org. support	Org. support only	Mean Difference	Mean Difference	Mean Difference
	N	N	(SE)	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Brakenridge 2016	87	66	4.2 (5.204)		4.2[-6,14.4]
			Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.9. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 9 Mean difference in time spent standing at work follow-up medium-term.

Study or subgroup	Tracker + org. support	Org. support only	Mean Difference	Mean Difference	Mean Difference
	N	N	(SE)	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Brakenridge 2016	87	66	-12.4 (16.429)		-12.4[-44.6,19.8]
			Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

Analysis 11.10. Comparison 11 Activity tracker combined with organisational support versus organisational support only, Outcome 10 Mean difference in time spent stepping at work, follow-up medium-term.

Study or subgroup	Tracker + org. support N	Org. support only N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Brakenridge 2016	87	66	7.7 (5.868)		7.7[-3.8,19.2]
			Favours tracker + org. support	-100 -50 0 50 100	Favours org. support only

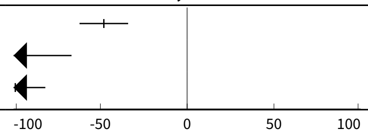
Comparison 12. Multi-component intervention versus no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Mean difference in time spent sitting at work, follow-up short-term	3		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Mean difference in time spent sitting at work, follow-up medium-term	2	562	Mean Difference (IV, Fixed, 95% CI)	-45.60 [-62.54, -28.66]
3 Mean difference in number of sitting bouts lasting 30 minutes or more, follow-up short-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term	2		Mean Difference (Fixed, 95% CI)	Totals not selected
5 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up medium-term	1		Mean Difference (Fixed, 95% CI)	Totals not selected
6 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term	2	227	Mean Difference (Fixed, 95% CI)	-72.73 [-91.87, -53.59]
7 Mean difference in total time spent sitting (including sitting at and outside work), follow-up medium-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
8 Mean difference in time spent standing at work follow-up short-term	2		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
9 Mean difference in time spent stepping at work follow-up short-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
10 Mean difference in time spent standing at work follow-up medium-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
11 Mean difference in time spent stepping at work follow-up medium-term	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
12 Work engagement (0-6 scale), follow-up short-term	1		Mean Difference (Fixed, 95% CI)	0.0 [-0.14, 0.14]
12.1 Environmental interventions only	1		Mean Difference (Fixed, 95% CI)	0.1 [-0.10, 0.30]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
12.2 Environmental interventions + counselling	1		Mean Difference (Fixed, 95% CI)	-0.1 [-0.30, 0.10]
13 Mean difference in musculoskeletal symptoms all sites (score 0–6) at short-term follow-up	1		Mean Difference (Fixed, 95% CI)	Totals not selected

Analysis 12.1. Comparison 12 Multi-component intervention versus no intervention, Outcome 1 Mean difference in time spent sitting at work, follow-up short-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Danquah 2017	173	-35 (63.3)	144	13 (63.3)		-48[-62,-34]
Ellegast 2012	13	249.6 (76.3)	12	366.7 (50.9)		-117.12[-167.62,-66.62]
Healy 2016	136	-107.8 (86.1)	95	-8.8 (47.2)		-99[-116.3,-81.7]



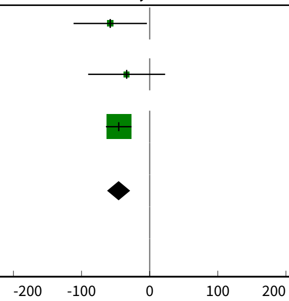
Favours multifaceted intervention | Favours no intervention

Analysis 12.2. Comparison 12 Multi-component intervention versus no intervention, Outcome 2 Mean difference in time spent sitting at work, follow-up medium-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Coffeng 2014	76	-67.5 (178.8)	96	-9.6 (178.8)		9.92%	-57.9[-111.7,-4.1]
Coffeng 2014	63	-101.3 (177.8)	96	-67.5 (177.8)		8.99%	-33.8[-90.3,22.7]
Healy 2016	136	-58.4 (85.5)	95	-13 (60.4)		81.09%	-45.4[-64.21,-26.59]
Total ***	**275**		**287**			**100%**	**-45.6[-62.54,-28.66]**

Heterogeneity: Tau²=0; Chi²=0.37, df=2(P=0.83); I²=0%

Test for overall effect: Z=5.28(P<0.0001)



Favours multifaceted intervention | Favours no intervention

Analysis 12.3. Comparison 12 Multi-component intervention versus no intervention, Outcome 3 Mean difference in number of sitting bouts lasting 30 minutes or more, follow-up short-term.

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Danquah 2017	173	144	-0.4 (0.148)		-0.41[-0.7,-0.12]

Favours multifaceted intervention | Favours no intervention

Analysis 12.4. Comparison 12 Multi-component intervention versus no intervention, Outcome 4 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up short-term.

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Danquah 2017	173	144	-16 (7.653)		-16[-31,-1]
Healy 2016	117	84	-72.6 (10.817)		-72.6[-93.8,-51.4]

Favours multifaceted intervention -100 -50 0 50 100 Favours no intervention

Analysis 12.5. Comparison 12 Multi-component intervention versus no intervention, Outcome 5 Mean difference in time in sitting bouts lasting 30 minutes or more, follow-up medium-term.

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Healy 2016	96	65	-17.7 (14.337)		-17.7[-45.8,10.4]

Favours multifaceted intervention -100 -50 0 50 100 Favours no intervention

Analysis 12.6. Comparison 12 Multi-component intervention versus no intervention, Outcome 6 Mean difference in total time spent sitting (including sitting at and outside work), follow-up short-term.

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Ellegast 2012	13	12	-58.3 (19.3)		25.61%	-58.3[-96.13,-20.47]
Healy 2016	119	83	-77.7 (11.325)		74.39%	-77.7[-99.9,-55.5]
Total (95% CI)					**100%**	**-72.73[-91.87,-53.59]**
Heterogeneity: Tau²=0; Chi²=0.75, df=1(P=0.39); I²=0%						
Test for overall effect: Z=7.45(P<0.0001)						

Favours multifaceted intervention -100 -50 0 50 100 Favours no intervention

Analysis 12.7. Comparison 12 Multi-component intervention versus no intervention, Outcome 7 Mean difference in total time spent sitting (including sitting at and outside work), follow-up medium-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Healy 2016	97	-40.1 (83.4)	65	-3.8 (81.1)		-36.3[-62.07,-10.53]

Favours multifaceted intervention -100 -50 0 50 100 Favours no intervention

Analysis 12.8. Comparison 12 Multi-component intervention versus no intervention, Outcome 8 Mean difference in time spent standing at work follow-up short-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Danquah 2017	173	31 (58.8)	144	-12 (58.8)		43[30,56]
Healy 2016	119	102.2 (80.8)	85	7 (36.1)		95.2[78.78,111.62]
				Favours multifaceted intervention	-100 -50 0 50 100	Favours no intervention

Analysis 12.9. Comparison 12 Multi-component intervention versus no intervention, Outcome 9 Mean difference in time spent stepping at work follow-up short-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Healy 2016	117	2.2 (16.4)	83	1.7 (15.1)		0.5[-3.9,4.9]
				Favours multifaceted intervention	-100 -50 0 50 100	Favours no intervention

Analysis 12.10. Comparison 12 Multi-component intervention versus no intervention, Outcome 10 Mean difference in time spent standing at work follow-up medium-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Healy 2016	97	55.2 (67)	67	12.4 (44.1)		42.8[25.8,59.8]
				Favours multifaceted intervention	-100 -50 0 50 100	Favours no intervention

Analysis 12.11. Comparison 12 Multi-component intervention versus no intervention, Outcome 11 Mean difference in time spent stepping at work follow-up medium-term.

Study or subgroup	Multifaceted intervention N	Multifaceted intervention Mean(SD)	No intervention N	No intervention Mean(SD)	Mean Difference Fixed, 95% CI	Mean Difference Fixed, 95% CI
Healy 2016	96	-0.3 (14.8)	65	-0.1 (14.5)		-0.2[-4.8,4.4]
				Favours multifaceted intervention	-100 -50 0 50 100	Favours no intervention

Analysis 12.12. Comparison 12 Multi-component intervention versus no intervention, Outcome 12 Work engagement (0-6 scale), follow-up short-term.

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
12.12.1 Environmental interventions only						
Coffeng 2014	0	0	0.1 (0.102)		50%	0.1[-0.1,0.3]
		Favours multifaceted intervention		-5 -2.5 0 2.5 5	Favours no intervention	

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Weight	Mean Difference IV, Fixed, 95% CI
Subtotal (95% CI)					**50%**	**0.1[-0.1,0.3]**
Heterogeneity: Not applicable						
Test for overall effect: Z=0.98(P=0.33)						
12.12.2 Environmental interventions + counselling						
Coffeng 2014	0	0	-0.1 (0.102)		50%	-0.1[-0.3,0.1]
Subtotal (95% CI)					**50%**	**-0.1[-0.3,0.1]**
Heterogeneity: Not applicable						
Test for overall effect: Z=0.98(P=0.33)						
Total (95% CI)					**100%**	**0[-0.14,0.14]**
Heterogeneity: Tau²=0; Chi²=1.92, df=1(P=0.17); I²=47.98%						
Test for overall effect: Not applicable						
Test for subgroup differences: Chi²=1.92, df=1 (P=0.17), I²=47.98%						
			Favours multifaceted intervention	-5 -2.5 0 2.5 5	Favours no intervention	

Analysis 12.13. Comparison 12 Multi-component intervention versus no intervention, Outcome 13 Mean difference in musculoskeletal symptoms all sites (score 0–6) at short-term follow-up.

Study or subgroup	Multifaceted intervention N	No intervention N	Mean Difference (SE)	Mean Difference IV, Fixed, 95% CI	Mean Difference IV, Fixed, 95% CI
Danquah 2017	153	126	-0.2 (0.077)		-0.17[-0.32,-0.02]
			Favours multifaceted intervention	-100 -50 0 50 100	Favours no intervention

APPENDICES

Appendix 1. CENTRAL search strategy

#1 work*

#2 sedentary

#3 sitting

#4 #2 or #3

#5 office

#6 inactiv*

#7 #5 and #6

#8 #4 or #7

#9 #1 and #8

#10 #9 AND trials

Appendix 2. MEDLINE search strategy

#1 (work[tw] OR works*[tw] OR work'*[tw] OR worka*[tw] OR worke*[tw] OR workg*[tw] OR worki*[tw] OR workl*[tw] OR workp*[tw] OR occupation*[tw] OR employe*[tw])

#2 (effect*[tw] OR control[tw] OR controls*[tw] OR controla*[tw] OR controle*[tw] OR controli*[tw] OR controll*[tw] OR evaluat*[tw] OR intervention*[tw] OR program*[tw] OR compare*[tw])

#3 (sedentary OR sitting) OR seated posture OR chair[tiab] OR desk[tiab] OR (office AND inactiv*)

#4 (animals [mh] NOT humans [mh])

#5 #1 AND #2 AND #3 NOT #4

Appendix 3. CINAHL search strategy

S10 S1 AND S2 AND S9 **Limiters** - Exclude MEDLINE records **Search modes** - Boolean/Phrase

S9 S3 OR S4 OR S5 OR S6 OR S7 OR S8

S8 (office AND inactive*) or TX (office AND inactive*) or MW (office AND inactive*)

S7 Desk or TX desk or MW desk

S6 Sedentary or TX sedentary or MW sedentary

S5 Seated posture or TX seated posture or MW seated posture

S4 Sitting or TX sitting or MW sitting

S3 Chair or TX chair or MW chair

S2 TX randomised controlled trial or TX controlled clinical trial or AB placebo or TX clinical trials or AB randomly or TI trial or TX intervent* or control* or evaluation* or program*

S1 work* OR (offic* OR busines*) OR occupat*

Appendix 4. OSH update search strategy

#1 DC{OUCISD OR OUHSEL OR OUNIOC OR OUNIOS OR OURILO}

#2 GW{office AND inactiv*}

#3 GW{sitting OR sedentary}

#4 TW{work*}

#5 #2 OR #3

#6 #4 AND #5

#7 #1 AND #6

Appendix 5. EMBASE search strategy

#1 sedentary

#2 'sitting'/de

#3 'seated posture'

#4 seated NEAR/1 posture

#5 chair:ab,ti OR desk:ab,ti

#6 chair:ab,ti

#7 desk:ab,ti

#8 office AND inactiv*

#9 #1 OR #2 OR #4 OR #6 OR #7 OR #8

#10 'work'/de OR work

#11 work*

#12 'occupation'/de OR occupation

#13 employe*

#14 #10 OR #12 OR #13

#15 effect

#16 control

#17 evaluat*

#18 intervention*

#19 program

#20 compare

#21 #15 OR #16 OR #17 OR #18 OR #19 OR #20

#22 #9 AND #14 AND #21

#23 #22 AND [embase]/lim

#24 #23 AND [humans]/lim AND [embase]/lim

Appendix 6. PsycINFO (ProQuest)

S25 S13 AND S17 AND S24

S24 S18 OR S19 OR S20 OR S21 OR S22 OR S23

S23 compare

S22 program

S21 intervention*

S20 evaluat*

S19 control

S18 effect

S17 S14 OR S15 OR S16

S16 employe*

S15 occupation

S14 work

S13 S1 OR S2 OR S4 OR S8 OR S11 OR S12

S12 office AND inactive*

S11 S9 OR S10

S10 ab(desk)

S9 ti(desk)

S8 S6 OR S7

S7 ti(chair)

S6 ab(chair)

S5 ab(chair) OR ti(chair)

S4 seated NEAR/1 posture

S3 seated posture

S2 sitting

S1 sedentary

Appendix 7. ClinicalTrials.gov

Sitting AND Workplace

Appendix 8. World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP) search portal

Sitting AND Workplace

WHAT'S NEW

Date	Event	Description
3 December 2018	Amended	Following feedback and further information from the authors we corrected our risk of bias assessment of Healy 2016 and added the data contributed by Evans 2012 to one meta-analysis. The latter increased the pooled effect of computer prompts combined with information compared to information only on time spent sitting at work by four minutes per eight-hour workday, and reduced the width of the confidence interval. We then corrected all instances where these results are mentioned in the text (Abstract, Plain language summary, Effects of interventions, Discussion), tables (Summary of findings 3), and graphs (Figure 1, Figure 3, and forest plot of Analysis 7.1) to reflect the changes. We also found out that the study by Dunstan et al. we had previously classified as ongoing was in fact a published protocol of Healy 2016 so it is now a secondary reference of the latter.
4 April 2018	New citation required and conclusions have changed	'Summary of findings' tables updated
4 April 2018	New search has been performed	New studies have been incorporated into review, and new analyses have been added.
9 August 2017	New search has been performed	Searches updated

CONTRIBUTIONS OF AUTHORS

Jos Verbeek, Sharea Ijaz, and Nipun Shrestha conceptualised the review.

Nipun Shrestha took the lead in writing the protocol.

Kaisa Neuvonen (Information Specialist, Cochrane Work Group) and Nipun Shrestha designed the systematic search strategies.

Nipun Shrestha and Katriina Kukkonen-Harjula conducted the study selection.

Nipun Shrestha, Suresh Kumar, Chukwudi Nwankwo, Veerle Hermans, and Soumyadeep Bhaumik did the data extraction and 'Risk of bias' assessment for the previous versions.

Nipun Shrestha, Veerle Hermans, and Sharea Ijaz did the data extraction and 'Risk of bias' assessment for the current update.

Nipun Shrestha, Jos Verbeek, and Zeljko Pedisic conducted the data analysis.

Nipun Shrestha wrote the manuscript collaborating with Jos Verbeek, Katriina Kukkonen-Harjula, Sharea Ijaz, Veerle Hermans, and Zeljko Pedisic.

DECLARATIONS OF INTEREST

Nipun Shrestha: None known.

Jos Verbeek: I am employed by the Finnish Institute of Occupational Health to co-ordinate the Cochrane Work Group.

Sharea Ijaz: None known.

Katriina T Kukkonen-Harjula: None known.

Veerle Hermans: None known.

Zeljko Pedisic: None known.

SOURCES OF SUPPORT

Internal sources

- Cochrane Work Review Group, Finland.

  Nipun Shrestha attended a three-month internship to learn about Cochrane systematic review methodology.

External sources

- NIHR CLAHRC West, UK.

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We added time spent in prolonged sitting bouts (e.g. 30 minutes or more) and number of such bouts, total time spent sitting, including sitting at and outside work, time spent standing and stepping at work as new outcomes in the review. We added the number and duration of prolonged sitting bouts as outcomes because research has suggested that breaking up sitting time may be beneficial to health (Dunstan 2011). We added the total time spent sitting, including sitting at and outside work, as an outcome because reducing occupational sitting time may lead to an increase of time spent sitting in non-occupational domains. The possibility of such compensatory effects has been described in previous papers (Gomersall 2013; Pedišić 2017). We added the amounts of time spent standing and stepping at work as outcomes because the amount of time in a 24-hour day is fixed and every reduction of time spent sitting has to necessarily result in a proportional increase of time spent in one or more other time-use components (Pedišić 2017). From the public health perspective it may be important to know whether time spent sitting is replaced with quiet standing, physical activity or some other movement or non-movement related behaviour.

In the protocol we stated that in cases where we would include more than one comparison from a trial with multiple arms in the same meta-analysis, we would halve the numbers of control group participants to prevent them from being included twice, however this does not work for the inverse variance input method. One study, Neuhaus 2014a, reported only the results from ANCOVA and could not provide us with the raw data. For this trial we modelled the means and standard deviations from the intervention and the control group in Review Manager as closely to the real data as possible to achieve the same MD and standard error. Then we halved the number of participants in the control group and entered the resulting standard errors into Review Manager.

We judged studies to be at low risk of selective outcome reporting if the final publications of the trial reported what had been planned and registered in international databases (trial registries), such as ClinicalTrials.gov, Australia New Zealand Clinical Trials Registry (ANZCTR.org.au), Netherland's Trial Registry (NTR). We judged the studies that were not registered in trial registries as being at low risk for selective outcome reporting if they reported all the outcomes mentioned in the methods section.

Initially, we planned to pool interventions that were categorised under broad headings like physical changes in workplace environment, workplace policy changes and information and counselling, but later we found that the interventions were quite different from one another and decided not to combine them under these broad headings. We also added a new category consisting of approaches that used multiple types of interventions at the same time. Due to the large number of outcomes it was not practical to incorporate a GRADE rating of the quality of the evidence of every single result. Hence we report time spent sitting at work and time spent in sitting bouts lasting 30 minutes or more for short-term follow-up in the 'Summary of findings' table. Where studies reporting effects at short-term follow-up for the above-mentioned outcomes were not available, we present medium-term follow-up. We only report the most relevant comparisons.

We also calculated a prediction interval for the outcome 'sitting time at work' for interventions comparing the effectiveness of sit-stand desks and sit-desks.

INDEX TERMS

Medical Subject Headings (MeSH)

*Ergonomics; *Sitting Position; Accelerometry; Controlled Before-After Studies; Energy Metabolism; Interior Design and Furnishings; Randomized Controlled Trials as Topic; Time Factors; Workplace [*statistics & numerical data]

MeSH check words

Humans