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Sitting-time, physical activity and depressive symptoms in mid-aged women

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ABSTRACT

Background: Associations between sitting-time and physical activity (PA) with depression are unclear.

Purpose: To examine concurrent and prospective associations between both sitting-time and PA with prevalent depressive symptoms in mid-aged Australian women.

Methods: Data were from 8,950 women, aged 50-55 years in 2001, who completed mail surveys in 2001, 2004, 2007 and 2010. Depressive symptoms were assessed using the Center for Epidemiological Studies Depression questionnaire. Associations between sitting-time (≤4, >4-7, >7 hrs/day) and PA (none, some, meeting guidelines) with depressive symptoms (symptoms/no symptoms) were examined in 2011 in concurrent and lagged mixed effect logistic modeling. Both main effects and interaction models were developed.

Results: In main effects modeling, women who sat >7 hrs/day (OR 1.47, 95%CI 1.29-1.67) and women who did no PA (OR 1.99, 95%CI 1.75-2.27) were more likely to have depressive symptoms than women who sat ≤4 hrs/day and who met PA guidelines, respectively. In interaction modeling, the likelihood of depressive symptoms in women who sat >7 hrs/day *and* did no PA was triple that of women who sat ≤4 hrs/day *and* met PA guidelines (OR 2.96, 95%CI 2.37-3.69). In prospective main effects and interaction modeling, sitting-time was not associated with depressive symptoms, but women who did no PA were more likely than those who met PA guidelines to have future depressive symptoms (OR 1.26, 95%CI 1.08-1.47).

Conclusions: Increasing PA to a level commensurate with PA guidelines can alleviate current depression symptoms and prevent future symptoms in mid-aged women. Reducing sitting-time may ameliorate current symptoms.

BACKGROUND

Depression is an important public-health problem; approximately 6% of the population has major depression each year and the lifetime prevalence ranges from 11-15% across countries.[1] Major depression has increased from the 15th cause of adult disease burden in 2000, to the 11th cause in 2010.[2] Furthermore, depressive disorders are projected to be the second leading cause of burden of disease worldwide by 2030, and the leading cause in high income countries.[3] To reduce this burden, it is critical to identify factors associated with the prevention and management of depression.

Regular physical activity (PA) is associated with reduced risk of depression,[4;5] with prospective studies in adults in different age groups showing protective effects of PA against depression 2 to 26 years later.[6;6-14] Another lifestyle factor that may be important is sedentary behavior, which is typically defined as any waking activity characterized by an energy expenditure $\leq$ 1.5 metabolic equivalents and a sitting or reclining posture[15;16], and is often conceptualized as sitting-time in epidemiological studies.[17] Although there is increasing evidence suggesting that sitting-time is associated with poor cardiovascular and metabolic health outcomes[18-20] and decreased life expectancy,[21;22] less is known about the association between sitting-time and psychological outcomes such as depression.[23]

Cross-sectional studies show an inverse association between sedentary time and mental health in older adults,[24;25] disadvantaged women,[26] and overweight and obese adults.[27;28] Prospective studies have also demonstrated an inverse association for time spent watching television and/or using a computer after 1 year,[29] 6 years,[30] and 10 years.[29] However, no studies have examined sitting-time and PA over multiple time points, and only one examined their combined effects on depressive symptoms.

The aim of this study was therefore to examine the concurrent and prospective associations between sitting-time and PA, individually and in combination, with prevalent depressive symptoms in mid-aged Australian women over a 9-year period.

METHODS

Australian Longitudinal Study on Women's Health (ALSWH)

ALSWH (www.alswh.org.au) is a prospective study of factors affecting the health and well-being of three cohorts of Australian women born in 1973-1978, 1946-1951 and 1921-1926.[31] They were randomly selected from the national Medicare health insurance database, with oversampling of women from rural and remote areas.[32] Starting in 1996, mail surveys have been administered every 3 years on a rolling basis. The study was approved by Ethics Committees at The University of Queensland and the University of Newcastle, and informed consent was received from all respondents.

Participants and surveys

Data were from women born in 1946-1951 who responded to the surveys in 2001 (n=11,226), 2004 (n=10,905), 2007 (n=10,638) and 2010 (n=10,011). Data were included from 8,962 women who had complete data on depressive symptoms, sitting-time and PA in 2001 and at least one other survey. Twelve women who reported across all surveys that their health limited their ability to walk100 meters "a lot" were excluded, leaving data from 8,950 women for analyses, with a total of 35,800 observations. Notable differences between women included and women excluded from the analysis were that excluded women generally had lower education levels, were less likely to be employed or worked fewer paid hours, and had more difficulty managing on their income (Table 1).

Measures

Depressive symptoms were assessed with the 10-item version of the Center for Epidemiological Studies Depression questionnaire (CES-D 10).[33] Respondents rated the extent to which they experienced cognitive, affective and behavioral symptoms in the last week (e.g., guilt, worthlessness, helplessness, psychomotor retardation, loss of appetite, sleep difficulties), using a 4-point ordinal scale ranging from *rarely or none of the time* (no points) to *most or all of the time* (3 points). Scale scores range from 0-30 points, with a score of ≥10 indicative of mild-moderate levels of depressive symptoms.[33] For this study, scores were dichotomized as 'depressive symptoms' (score ≥10) or 'no depressive symptoms' (score <10). The one to four week (average 22 days) test-retest reliability of the CES-D10 is satisfactory (r =.71), as is convergent validity with health status scores (r =.37) and positive affect (r =-.63).[33] Furthermore, the CES-D10 has good predictive accuracy compared with the 20-item version (kappa = .97),[33] which has good concurrent validity with a range of self-report and clinical criteria.[34]

Sitting-time was assessed by the following questions: *How many hours each day do you typically spend sitting down while doing things like visiting friends, driving, reading, watching television or working at a desk or computer on a usual a) weekday; b) weekend day*?. This item is similar to the one used in the International PA Questionnaire, which, in women, has good test–retest reliability with Spearman correlations of 0.77 and 0.85 for week-day and weekend-day sitting-time, respectively.[35] Details about the management of sitting-time data have been reported elsewhere.[36;37] Mean sitting-time (hours/day) was calculated as [(weekday sitting x 5) + (weekend day sitting x 2)]/7, and categorized using tertiles (rounded to whole hours) of ≤4 hrs/day, >4-7 hrs/day or >7 hrs/day.

Items to assess PA were adapted from the Active Australia questionnaire.[38] These items assess the duration of time spent in the previous week walking briskly, in moderate-intensity leisure-time PA and in vigorous-intensity leisure-time PA. The questionnaire has acceptable test–retest reliability (PA minutes/week: Spearman's rho=0.64) and acceptable validity (correlation pedometer steps and total PA, r=0.43; correlation accelerometer counts and PA≥3 metabolic equivalents, r=0.52) in mid-aged women.[39] A PA score was calculated as the sum of the products of time in each of the three activities and a metabolic equivalent value (MET)[40] assigned to each activity: (walking minutes*3.0 METs) + (moderate PA*4.0 METs) + (vigorous PA*7.5 METs). The PA score was then categorized as no PA (<40 MET.minutes), some PA (40-600 MET.minutes), or meeting PA guidelines (>600 MET.minutes). The category 'meeting guidelines' is comparable with recommendations to do at least 150 minutes of moderate-intensity PA per week.[4]

For the composite sitting-time and PA variable, the three levels of sitting-time and the three levels of PA were combined to provide nine categories (Tables 2, 3, 4). Covariates were identified from relevant previous studies,[12;26;29;30;41] and included socio-demographic variables, health-related variables, health behaviors and social variables, as shown in Table 1.

Analyses

Analyses were conducted in 2011 using STATA (Stata Corporation, Release 10.1, College Station, TX), with statistical significance set at $p \leq 0.05$. Concurrent and prospective associations between sitting-time and PA with depressive symptoms were examined in concurrent and lagged mixed effect logistic models (Stata function xtlogit) with random intercepts for respondents. Concurrent (i.e. sequential cross-sectional) models were used to

examine associations between sitting-time and PA with depressive symptoms at four survey points (2001, 2004, 2007 and 2010). These models do have a longitudinal element, as they take into account that repeated observations from the same person are not independent of each other, and the overall estimates take within-subject correlations into account. Lagged models were used to examine prospective associations between sitting-time and PA in 2001, 2004, and 2007 with depressive symptoms in 2004, 2007, and 2010 respectively. Thus, sitting-time and PA preceded depressive symptoms by 3 years in the lagged models. Furthermore, to examine potential reverse causation, lagged mixed effect ordered logit models (Stata user written function GLLAMM) were used to examine the associations between depressive symptoms in 2001, 2004 and 2007 with sitting-time and PA in 2004, 2007 and 2010, respectively.

Associations were examined in unadjusted and adjusted main effects models, including both sitting-time and PA variables, and interaction models including the composite variable. The variables in the unadjusted models included sitting-time and PA, survey time period, and area of residence. CES-D10 status (symptoms/no symptoms) at baseline in 2001 was also included as a confounder in lagged unadjusted models. The adjusted models also included all covariates (Table 1). Reverse causation models examining the association between depression status and future sitting-time and PA included sitting-time and PA in 2001 as covariates and were adjusted for the same covariates as the main effects and interaction models.

RESULTS

Characteristics of the analysis sample are presented in Table 1. In 2001, when the women were aged 50-55 years, one in five (20.8%) had depressive symptoms; this proportion

decreased slightly over time (Table 2). Overall, 63.0% of the women did not have depressive symptoms at any time point and 5.1% reported symptoms at each of the four time points, or at one (17.3%), two (8.9%) or three time points (5.6%). Sitting-time and PA levels increased over time, with higher proportions of women sitting >4 hrs/day and meeting PA guidelines at the later surveys (Table 2). 8.5% of the women sat ≤4 hrs/day, and 24.0% met PA guidelines at all four time-points.

In concurrent main effects modeling, using data from four time points over nine years, sitting-time and PA were each significantly associated with depressive symptoms (Table 3). Women who sat >4-7 hrs/day or >7 hrs/day were up to 1.5 times more likely to have depressive symptoms than women who sat ≤4 hrs/day (OR 1.17, 95%CI 1.05-1.32 and OR 1.47, 95%CI 1.29-1.67, respectively). Current depressive symptoms were also more likely for women who did some PA (OR 1.24, 95%CI 1.12-1.38) and twice as likely for those who did no PA (OR 1.99, 95% CI 1.75-2.27) compared with those who met PA guidelines. In concurrent interaction modeling, there was a gradual increase in risk of depressive symptoms with higher levels of sitting-time and lower levels of PA, up to a tripled risk in women who sat >7 hrs/day *and* did no PA (OR 2.96, 95%CI 2.37-3.69, Table 3).

In prospective (time-lagged) main effects and interaction models, once again using data from four time points over nine years, PA was associated with future depressive symptoms, but sitting-time was not (Table 4). In main effects models, women who did no PA were more likely to have future depressive symptoms than women who met PA guidelines (OR 1.26, 95%CI 1.08-1.47). In interaction models, women who did no PA, regardless of their sitting-time, had a significantly increased risk of future depressive symptoms compared with women who sat ≤4 hrs/day and met PA guidelines (Table 4).

Depressive symptoms were associated with future sitting-time and PA in simple prospective models (Table 5), but only the association with PA remained significant in adjusted models. Compared with women without depressive symptoms, women with depressive symptoms were less likely to increase their PA from none to some, or from some to meeting guidelines (OR 0.80, 95%CI 0.72-0.88).

DISCUSSION

This study examined associations between sitting-time and PA, separately and in combination, with current and future depressive symptoms over 9 years, in Australian women aged 50 to 55 years in 2001. Higher sitting-time and lower PA were associated with increased risk of current symptoms, with the combination of high sitting-time *and* no PA being associated with a tripled risk. Sitting-time was not associated with future depressive symptoms. Doing no PA, regardless of the amount of sitting-time, was associated with increased risk of future symptoms.

These results are consistent with other cross-sectional studies demonstrating that PA is inversely associated with risk of depression[23] and that high sitting-time is associated with poor mental health.[24-28] The current study adds that the link between sedentary behavior and depressive symptoms is not limited to younger, [26] older[24;25] or overweight population groups[27;28] or to sedentary behavior associated with screen time only.[25-27] This study extends previous cross-sectional work by considering the combined effects of sitting-time and PA, and is consistent with other research demonstrating that combinations of high sedentary behavior (screen-time) and no PA are associated with the lowest health related quality of life in adults.[42]

The inverse association between PA and future depressive symptoms is consistent with other prospective studies.[43-45] In contrast to the current study however, three previous prospective studies have shown significant positive associations between sedentary behavior and depression.[29;30;46] In the US Nurses' Health Study, there was an increased risk of depression over 10 years among women aged 63+ years who watched TV >21 hrs/week compared with those who watched TV <1 hour/week.[29] Spanish university graduates (mean age 42 years), who spent >42 hrs/week watching television and using a computer were more likely to develop a mental disorder over 6 years than those who did this for <10.5 hrs/week.[30] A Swedish study of adults aged 18-25 years found a positive association between computer and internet time with depressive symptoms over 1 year.[46]

The differences between these previous findings and the current study may be explained in part by the diversity of sedentary behavior and depression measures. Previous studies have typically assessed sedentary behavior as time spent watching television and/or using a computer,[29;30;46] whereas the current study used a more comprehensive measure. Some results suggest that the association between sedentary behavior and mental health may differ by domain (e.g. leisure, transport, or work)[47] in the same way that associations between PA and depression can differ by domain.[48;49] The measure of depression could also affect the association, with studies using as measures self-completed screening tools,[46] use of prescribed antidepressants,[29] measures of depression only,[29] or measures that combine depression, anxiety and stress.[30] As a result, participants classified as 'depressed' can vary widely among studies. The length of follow up and the different categorizations of sedentary behavior could further explain the different findings.

There are several potential explanations for why sitting-time was cross-sectionally associated with depressive symptoms, but not prospectively. One explanation could be that sitting-time is not associated with future depression. Other potential explanations are that a prospective relationship may be evident only over a shorter time frame than the three year time lag used in this study, or that the strength of the association varies over time as a result of the episodic nature of depression, making it difficult to establish causality. Reverse causation could also explain the findings. As anhedonia, psychomotor retardation, fatigue, and loss of energy are common depressive symptoms, depression could precipitate sedentary behavior.[41] However, although significant in unadjusted analyses, depressive symptoms were not associated with future sitting-time after adjusting the analyses. In contrast, women with depressive symptoms were significantly less likely to increase their PA over time, indicating a bi-directional relationship between PA and depressive symptoms. This is consistent with previous findings that depression leads to a less active lifestyle.[50;51]

Prospective analyses of the *combination* of sitting-time and PA indicated that women who reported no PA, and any amount of sitting-time, had an increased risk of future depressive symptoms. Only one other study has examined the combined effects of sedentary time and PA with future depression. In their study of Spanish University graduates, Sanchez et al. observed a 25% lower risk of mental disorders after 6 years among those with high PA and low sedentary time compared with those with low PA and high sedentary time.[30] As in the current study, the decreased risk associated with higher PA levels was irrespective of sedentary time.

Potential physiological mechanisms underpinning the inverse association between PA and depression include changes in endorphins, core body temperature, central serotonergic

systems, availability of neurotransmitters, and blood flow to brain regions involved in emotional regulation, as well as disruption of the hypothalamic-pituitary-adrenocortical axis that regulates endocrine response to stress, and improved sleep.[43;52-55] Psychosocial mechanisms include distraction, enhanced feelings of control and mastery, improved self-esteem and physical worth, behavioral activation, and social interactions.[43;52-55] Much less work has examined the mechanisms that underpin relationships between sedentary behavior and depression, although they may be similar to those proposed for PA. Behavioral theory posits that insufficient environmental reinforcement contributes to depression. A key component of treatment is therefore to reduce behavioral inactivity (e.g. sedentary behavior) so as to increase opportunities for reinforcement, for example via mastery and pleasurable experiences.[56] This also enables the person to develop an understanding between actions and emotions, so that they can identify what actions increase or relieve symptoms. Empirical evidence indicates that behavioral activation is an effective treatment for depression.

Strengths of the current study include a large population-based sample, 9-year follow up and the inclusion of measures of sedentary behavior and PA at multiple time-points. Limitations are that sedentary behavior and PA were assessed using self-report measures, and that detailed information about the domains of sedentary behavior was not available. While self-report measures are appropriate for large scale surveillance,[57] the strength of the associations may have been underestimated, as recall of unstructured behaviors like sitting-time can be difficult. Although ALSWH participants were representative of mid-aged Australian women in 1996,[32] women with lower socioeconomic status and worse health were more likely to drop out from the study,[58] which may affect the generalizability of results.

Conclusion

Both high sitting-time and low PA were associated with increased risk of current depressive symptoms, and in combination, the risk further increased. However, only lack of PA was associated with increased risk of future depressive symptoms, irrespective of sitting-time. Women with depressive symptoms were less likely to increase PA levels over time, suggesting a vicious circle whereby inactive women are more likely to become depressed and those who are depressed are less likely to increase PA.

Based on these findings, lifestyle interventions for depression in mid-aged women should include strategies to increase PA, to a level commensurate with meeting PA guidelines, to both alleviate current depressive symptoms and prevent future symptoms. There may be some justification for strategies to reduce sitting-time to alleviate current symptoms. More prospective and intervention studies are needed to clarify these associations, and their direction. Furthermore, future studies should clarify the role of domain specific sitting-time.

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Table 1: Characteristics of analysis sample (n=8,950 women, aged 50-55 years in 2001)[a]

	Analysis sample n=8,950		Excluded from analysis n=2,276		p-value[b]
Sociodemographic variables	n	%[c]	n	%[c]	
Country of birth[d]					<0.001
Australia	6,880	(76.9)	1,712	(75.6)	
Other English speaking	1,270	(14.2)	226	(10.0)	
Other non-English speaking	715	(8.0)	281	(12.4)	
Missing	85	(1.0)	45	(2.0)	
Area of residence[e]					0.004
Urban	3,049	(34.1)	749	(33.1)	
Large rural town	3,669	(41.0)	869	(38.4)	
Small rural town/remote area	2,173	(24.3)	632	(27.9)	
Missing	59	(0.7)	14	(0.6)	
Education[d]					<0.001
No formal education or school certificate	4,079	(45.9)	1,325	(58.5)	
Higher school or leaving certificate	1,512	(17.0)	350	(15.5)	
Trade/apprenticeship/certificate/diploma	1,873	(21.1)	344	(15.2)	
University	1,417	(16.0)	225	(9.9)	
Missing	69	(0.8)	20	(0.9)	
Employment status					<0.001
Not in labor force/unemployed	1,880	(21.1)	664	(29.3)	
1-34 hrs/week	3,228	(36.2)	748	(33.0)	
35+ hrs/week	3,808	(42.7)	808	(35.7)	
Missing	34	(0.4)	44	(1.9)	
Income management					<0.001
Impossible/difficult all of the time	896	(10.1)	352	(15.6)	
Difficult some of the time	2,374	(26.7)	643	(28.4)	
Not too bad	3,908	(44.0)	908	(40.1)	
Easy	1,707	(19.2)	284	(12.5)	
Missing	65	(0.7)	77	(3.4)	
Health-related variables					
Body mass index[f]					<0.001
Underweight	120	(1.4)	33	(1.5)	
Normal weight	3,663	(43.3)	805	(35.6)	
Overweight	2,757	(32.6)	643	(28.4)	
Obese	1,912	(22.6)	513	(22.7)	

Missing	498	(5.6)	270	(11.9)	
Menopausal status					<0.001
Premenopausal	1,638	(18.3)	357	(15.8)	
Perimenopausal	2,185	(24.4)	576	(25.4)	
Postmenopausal	49	(0.5)	27	(1.2)	
Surgical menopause	2,547	(28.5)	706	(31.2)	
Other	2,531	(28.3)	595	(26.3)	
Missing	0	(0)	3	(0.1)	
Number of chronic conditions[g]					<0.001
None	4,286	(47.9)	997	(44.0)	
One	2,890	(32.3)	722	(31.9)	
Two	1,204	(13.5)	350	(15.5)	
Three or more	570	(6.4)	195	(8.6)	
Missing	0	(0)	0	(0)	
Diagnosed or treated anxiety/other psychiatric condition[h]					0.024
No	8,355	(93.4)	2,083	(92.0)	
Yes	595	(6.6)	181	(8.0)	
Missing	0	(0)	0	(0)	
Health behaviors					
Smoking status					<0.001
Never smoked	4,828	(54.1)	1,184	(52.3)	
Ex-smoker	2,890	(32.4)	667	(29.5)	
Current smoker	1,207	(13.5)	385	(17.0)	
Missing	25	(0.3)	28	(1.2)	
Alcohol intake					<0.001
Low risk drinker (1-14 drinks/week)	4,989	(55.8)	796	(35.2)	
Non-drinker	1,272	(14.2)	372	(16.4)	
Rarely drinker (<1 drink/week)	2,071	(23.2)	458	(20.2)	
Risky drinker (≥15 drinks/week)	604	(6.8)	89	(3.9)	
Missing	14	(0.2)	549	(24.3)	
Social variables					
Marital status					<0.001
Married/ partnered	7,324	(82.1)	1,765	(78.0)	
Single/ separated/ divorced/ widow	1,600	(17.9)	466	(20.6)	
Missing	26	(0.3)	33	(1.5)	
Life events[i]					0.001

None	2,273	(25.4)	656	(29.0)	
One	2,153	(24.1)	568	(25.1)	
Two	1,882	(21.0)	430	(19.0)	
Three or more	2,642	(29.5)	610	(26.9)	
Missing	0	(0)	0	(0)	
Providing care for others[j]					0.070
No	6,698	(74.8)	1,736	(76.7)	
Yes	2,252	(25.2)	528	(23.3)	
Missing	0	(0)	0	(0)	
	Mean	SD			
Social support[k]	3.8	(1.0)	3.6	(1.2)	<0.001
Missing (182 [1.6%])					

[a] Data collected in 2001 unless indicated otherwise; [b] Chi-square test for categorical variables, independent T-test for continuous variables; [c] Percentage may not add up to 100% due to rounding; [d] Assessed in 1996; [e] Derived from postal code; [f] Based on self-reported weight and height (kg/m^2), categorized in accordance with the World Health Organization classification; [g] From a list of health conditions, including diabetes, cancer, and heart disease, reported as diagnosed by a doctor, or treated for, in the previous 3 years; [h] Diagnosed or received treatment for anxiety or other psychiatric conditions in the past 3 years. [i] From a list of life events, in the past year; [j] Caring duties for people with a long-term illness, disability, or frailty; [k] Duke Social Support Index, range 4-12 points, higher score indicates more support; SD = standard deviation.

Table 2: Depressive symptoms, sitting-time and physical activity in 2001, 2004, 2007 and 2010[a]

	2001		2004		2007		2010	
	n	**%**[b]	**n**	**%**[b]	**n**	**%**[b]	**n**	**%**[b]
Depressive symptoms								
No	7,086	(79.2)	6,791	(80.3)	6,603	(81.4)	6,432	(82.3)
Yes	1,864	(20.8)	1,663	(19.7)	1,505	(18.6)	1,383	(17.7)
Sitting-time								
≤4 hrs/day	3,104	(34.7)	2,368	(29.7)	2,053	(26.3)	2,093	(28.0)
>4-7 hrs/day	3,562	(39.8)	3,394	(42.6)	3,483	(44.6)	3,279	(43.9)
>7 hrs/day	2,284	(25.5)	2,208	(27.7)	2,274	(29.1)	2,100	(28.1)
Physical activity								
Meeting guidelines (>600 MET.minutes)	4,094	(45.7)	4,513	(54.9)	4,677	(58.3)	4,335	(57.0)
Some (40-600 MET.minutes)	3,351	(37.4)	2,461	(29.9)	2,160	(26.9)	2,077	(27.3)
None (<40 MET.minutes)	1,505	(16.8)	1,245	(15.2)	1,186	(14.8)	1,194	(15.7)
Combinations								
≤4 hrs/day ST & meeting PA guidelines	1,548	(17.3)	1,308	(17.0)	1,210	(16.1)	1,197	(16.7)
>4-7 hrs/day ST & meeting PA guidelines	1,651	(18.5)	1,864	(24.2)	2,026	(26.9)	1,871	(26.1)
>7 hrs/day ST & meeting PA guidelines	895	(10.0)	1,066	(13.9)	1,151	(15.3)	1,031	(14.4)
≤4 hrs/day ST & some PA	1,088	(12.2)	630	(8.2)	475	(6.3)	504	(7.0)
>4-7 hrs/day ST & some PA	1,334	(14.9)	961	(12.5)	890	(11.8)	858	(12.0)
>7 hrs/day ST & some PA	929	(10.4)	707	(9.2)	672	(8.9)	608	(8.5)
≤4 hrs/day ST & no PA	468	(5.2)	320	(4.2)	264	(3.5)	271	(3.8)
>4-7 hrs/day ST & no PA	577	(6.5)	458	(6.0)	439	(5.8)	428	(6.0)
>7 hrs/day ST & no PA	460	(5.1)	378	(4.9)	396	(5.3)	403	(5.6)

[a] n=8,950 women, aged 50-55 years in 2001; [b] Percentage may not add up to 100% due to rounding; PA = physical activity; ST = sitting-time.

Table 3: Concurrent associations between sitting-time and physical activity with depressive symptoms[a]

	Simple model[b]	Fully adjusted model[c]
Main effects model: Sitting-time and PA	OR (95%CI)	OR (95%CI)
Sitting-time		
≤4 hrs/day	Reference	Reference
> 4-7 hrs/day	1.06 (0.95 - 1.18)	**1.17 (1.05 - 1.32)**
> 7 hrs/day	**1.38 (1.21 - 1.57)**	**1.47 (1.29 - 1.67)**
Physical activity		
Meeting guidelines (>600 MET.minutes)	Reference	Reference
Some (40-600 MET.minutes)	**1.40 (1.26 - 1.55)**	**1.24 (1.12 - 1.38)**
None (<40 MET.minutes)	**2.56 (2.25 - 2.90)**	**1.99 (1.75 - 2.27)**
Interaction model: Combined effect		
Sitting-time and PA composite variable		
≤4 hrs/day ST & meeting PA guidelines	Reference	Reference
>4-7 hrs/day ST & meeting PA guidelines	1.08 (0.93 – 1.25)	**1.22 (1.04 - 1.43)**
>7 hrs/day ST & meeting PA guidelines	**1.39 (1.16 - 1.65)**	**1.48 (1.24 - 1.77)**
≤4 hrs/day ST & some PA	**1.52 (1.26 - 1.83)**	**1.35 (1.11 - 1.64)**
>4-7 hrs/day ST & some PA	**1.45 (1.22 - 1.72)**	**1.40 (1.18 - 1.67)**
>7 hrs/day ST & some PA	**1.89 (1.57 - 2.29)**	**1.89 (1.56 - 2.29)**
≤4 hrs/day ST & no PA	**2.33 (1.85 - 2.93)**	**1.92 (1.51 - 2.44)**
>4-7 hrs/day ST & no PA	**2.80 (2.29 - 3.43)**	**2.49 (2.02 - 3.08)**
>7 hrs/day ST & no PA	**3.75 (3.02 - 4.65)**	**2.96 (2.37 - 3.69)**

[a] n=8,950 women, aged 50-55 years in 2001; [b] Model adjusted for: survey, PA *or* ST (main effects model), area of residence; [c] Model additionally adjusted for: country of birth, education, hours worked, income management, smoking, BMI, number of chronic conditions, diagnosed or treated anxiety/other psychiatric condition, menopausal status, marital status, providing care for others, life events, social support; PA = physical activity; ST = sitting-time; **Boldface** indicates significant association ($p<0.05$).

Table 4: Prospective associations between sitting-time and PA (2001, 2004, 2007) with depressive symptoms (2004, 2007, 2010)[a]

	Simple model[b]	Fully adjusted model[c]
Main effects model: Sitting-time and PA	OR (95%CI)	OR (95%CI)
Sitting-time		
≤4 hrs/day	Reference	Reference
> 4-7 hrs/day	0.96 (0.85 - 1.10)	1.00 (0.88 - 1.14)
> 7 hrs/day	1.06 (0.91 - 1.23)	1.10 (0.95 - 1.28)
Physical activity		
Meeting guidelines (>600 MET.minutes)	Reference	Reference
Some (40-600 MET.minutes)	1.09 (0.97 - 1.23)	1.04 (0.92 - 1.17)
None (<40 MET.minutes)	**1.54 (1.32 - 1.79)**	**1.26 (1.08 - 1.47)**
Interaction model: Combined effect		
Sitting-time and PA composite variable		
≤4 hrs/day ST & meeting PA guidelines	Reference	Reference
>4-7 hrs/day ST & meeting PA guidelines	1.01 (0.85 - 1.21)	1.07 (0.89 - 1.28)
>7 hrs/day ST & meeting PA guidelines	1.13 (0.92 - 1.39)	1.19 (0.97 - 1.47)
≤4 hrs/day ST & some PA	1.18 (0.95 - 1.47)	1.12 (0.89 - 1.40)
>4-7 hrs/day ST & some PA	1.08 (0.88 - 1.32)	1.08 (0.88 - 1.32)
>7 hrs/day ST & some PA	1.17 (0 .94 - 1.46)	1.18 (0.95 - 1.48)
≤4 hrs/day ST & no PA	**1.66 (1.27 - 2.18)**	**1.46 (1.10 - 1.92)**
>4-7 hrs/day ST & no PA	**1.54 (1.21 - 1.96)**	**1.30 (1.01 - 1.66)**
>7 hrs/day ST & no PA	**1.63 (1.26 - 2.12)**	**1.38 (1.06 - 1.80)**

[a] n=8,950 women, aged 50-55 years in 2001; [b] Model adjusted for: survey, PA *or* ST (main effects model), area of residence, depression status in 2001; [c] Model additionally adjusted for: country of birth, education, hours worked, income management, smoking, BMI, number of chronic conditions, diagnosed or treated anxiety/other psychiatric condition, menopausal status, marital status, providing care for others, life events, social support; PA = physical activity; ST = sitting-time; **Boldface** indicates significant association ($p<0.05$)

Table 5: Prospective associations between depressive symptoms (2001, 2004, 2007) with sitting-time and PA (2004, 2007, 2010)

	Simple model[a]	Fully adjusted model[b]
Sitting-time	OR (95%CI)[c]	OR (95%CI)[c]
Depressive symptoms		
No	Reference	Reference
Yes	**1.16 (1.05 – 1.28)**	1.10 (0.99 – 1.23)
Physical activity		
Depressive symptoms		
No	Reference	Reference
Yes	**0.65 (0.59 - 0.71)**	**0.80 (0.72 - 0.88)**

[a] Model adjusted for: survey, depressive symptoms, area of residence, sitting-time *or* PA in 2001; [b] Model additionally adjusted for: country of birth, education, hours worked, income management, smoking, BMI, number of chronic conditions, diagnosed or treated anxiety/other psychiatric condition, menopausal status, marital status, providing care for others, life events, social support; [c] OR in ordinal logistic regressions for increasing PA from none to some *or* from some to meeting guidelines or for increasing ST from ≤4 hrs/day to >4-7 hrs *or* from >4-7 to >7 hrs/day; PA = physical activity; **Boldface** indicates significant association ($p<0.05$)