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Exploring the feasibility of a 6-week electric-bike intervention with behavioural support in Australia.

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ABSTRACT

Background: Physical inactivity increases the risk of non-communicable disease development and healthcare-associated burden. Research suggests electric bikes (e-bikes) can support individuals in meeting recommended physical activity (PA) guidelines. This study assessed the feasibility of an e-bike plus a tailored behavioural support intervention for physically inactive overweight or obese adults.
Methods: This non-randomized single-group pre-post study saw participants provided with an e-bike free of charge for six weeks. Feasibility was assessed across five domains: 1) feasibility of recruitment, 2) participant retention, 3) intervention adherence, 4) acceptability of questionnaires and lab-based outcome measures and 5) intervention acceptability. Participants completed self-reported measures of PA and self-efficacy for exercise. Lab-based measurements were completed pre-and post-intervention, this included blood pressure, body composition [anthropometrics and dual-energy X-ray absorptiometry (DEXA)], venous blood glucose, insulin, cholesterol, triglycerides, and cardiorespiratory fitness.
Results: Our recruitment strategy saw a total of eight participants (three males and five females) complete the intervention (88.9% retention rate). Participants utilised the e-bike for the intervention duration and rode a mean distance of 299.8 km (SD ± 172.2) over the 6-week intervention period. Participants completed all outcomes with minimal data points missing. Participants' moderate PA levels and self-efficacy for exercise increased post intervention. Lab-based measures showed a downward trend in body fat percentage, fasting blood glucose and brachial diastolic blood pressure.
Conclusion: The recruitment strategy, retention, adherence and acceptability of this study support future research. E-bikes are an acceptable way to help people who are physically inactive increase their PA levels. Furthermore, sustained use may contribute to health benefits and improve overall self-efficacy for exercise.

1. Introduction

Physical inactivity increases the risk of non-communicable disease development and imposes a considerable burden on society and

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healthcare systems (Lee et al., 2012). In 2013, it was estimated that physical inactivity-related healthcare costs reached INT$ 53.8 billion worldwide (Ding et al., 2016). Participation in regular moderate-to-vigorous intensity physical activity (PA) is difficult for many people. Those who are inactive report various barriers, including lack of time and enjoyment (Hoare et al., 2017). As such, it is understood that 1 in 4 adults do not meet PA recommendations (F. C. Bull et al., 2020). People who are overweight or obese are less likely to be physically active compared to those of a healthy weight (Hansen et al., 2013). Furthermore, higher-weight individuals may experience weight stigma and stereotyping, reducing their intention to exercise and impacting their efficacious beliefs to exercise (Meadows and Bombak, 2019). Self-efficacy is the confidence an individual has in their ability to achieve a specific outcome and has been identified as a correlate of PA, predictor of future PA behaviour and important in the maintenance of PA (Tang et al., 2019). Therefore, finding ways to encourage self-efficacy and support people who are overweight and physically inactive to increase their PA levels is important for improving health.

Electric bikes (e-bikes) have emerged as a promising approach to increase PA levels within people who are physically inactive (Peterman et al., 2016). E-bike sales have steadily increased since 2018 worldwide with projections of market sales hitting US$ 77 million by 2030 (Statista, 2023). Their popularity has increased across many European countries with more e-bikes being sold compared to conventional bikes in the Netherlands in 2018 (de Haas et al., 2022). However, e-bike uptake in Australia is low with 18% of adults reporting they cycle weekly which includes e-cycling (Munro, 2021).

E-bikes have battery-powered pedal assistance that supports forward motion when the rider pedals. Assistance level can be changed throughout the ride independent of cadence or speed. The pedal assistance allows riders to overcome barriers such as cardiovascular fitness concerns and apprehension regarding long distances or topography. Compared with conventional bikes, e-bikes help individuals cycle further for more extended periods of time (Bourne et al., 2020), potentially increasing the number of journeys completed as active travel (Sundfør et al., 2020). Furthermore, people reported increased levels of enjoyment during e-cycling compared with conventional cycling and walking (Langford et al., 2017) demonstrating that they may be good for encouraging PA. E-cycling has been shown to increase heart rate, produce an energy expenditure equivalent to moderate-intensity activity (Bourne et al., 2018; McVicar et al., 2022), and increase glucose sensitivity and fitness levels after four weeks of regular use (Peterman et al., 2016). To our knowledge, previous e-cycling interventions have not implemented tailored behavioural interventions to support e-bike use. Although e-cycling helps overcome barriers associated with conventional cycling, e-bikes and e-cycling possess their own barriers. A scoping review of the impact of e-cycling on travel behaviour (Bourne et al., 2020) found theft concerns, social stigma (e-bikes viewed as 'cheating') and battery concerns (e.g., range anxiety, charging issues) as barriers to e-cycling uptake. To help overcome such barriers and increase PA levels, we co-previously designed a tailored behavioural support intervention to assist day-to-day e-bike use with people who were physically inactive and either overweight or obese (McVicar et al., 2022).

In this study we assessed the feasibility of delivering the behavioural intervention and to understand its potential impact on physical activity and physiological variables in adults who were physically inactive and overweight or obese. Feasibility work provides an essential level of understanding, which is required prior to conducting larger trials, such as randomized controlled trials, or transferability for real-world practice (Haines, 2020).

The main aim of this study was to determine the feasibility of delivering our tailored behavioural intervention across five domains: 1) feasibility of recruitment, 2) participant retention, 3) intervention adherence, 4) acceptability of questionnaires and lab-based outcome measures and 5) intervention acceptability. Secondary aims were to determine the potential impact of the e-bike plus tailored behavioural support on self-reported PA and self-efficacy for exercise. Furthermore, various physiological parameters (cardiorespiratory fitness [VO_2peak], vascular stiffness, brachial and central blood pressures, body composition, body weight, blood lipids, insulin, HbA_{1c} and glucose levels) were assessed to help guide sample size calculations for a future randomized controlled trial.

2. Methods

2.1. Design

A non-randomized single group study was conducted. The intervention duration was 6-weeks and outcomes were assessed at baseline and post-intervention.

2.2. Participants and screening

This study was conducted in accordance with the Declaration of Helsinki and was approved by Deakin University Human Research Ethics Committee (project ID, 2019–275). Participants were recruited via promoted social media posts advertised on the Institute of Physical Activity and Nutrition - Deakin University Facebook and Instagram profiles. Funding was provided (AU$450.00 total) to the communications office and posts were advertised intermittently until recruitment ceased, approximately 5 months. Interested participants emailed researchers who provided the plain language statement. Those with continued interest set a time with researchers to complete the pre-screening questionnaire to determine eligibility. Participants were asked to self-report their height and weight, physical activity status, and answer questions regarding their general health status. Our eligibility criteria included people who were physically inactive (i.e., not currently partaking in 150 min of moderate to vigorous PA/week (F. C. Bull et al., 2020)), had a body mass index (BMI) between 28 and 38 kg/m^2, and could ride a bicycle. Participants were excluded if they were currently smoking, had a history of chronic illness, cardiovascular disease, diabetes, were pregnant or breastfeeding, had recently started a weight loss diet, were on BP medication, statins, or were diagnosed with a terminal illness. Furthermore, those who were currently regularly cycling were excluded from the study, as we did not want to displace traditional cycling with e-cycling. Females were recruited independent of menopausal status. Participants completed a physical activity readiness questionnaire before being invited to the laboratory for baseline measurements.

2.3. Procedures

Participants arrived fasted at Deakin University, Burwood campus, for baseline measurements and were given time to ask questions before providing informed consent. Once consented, participants completed self-reported measures of PA (Craig et al., 2003) and self-efficacy (Resnick and Jenkins, 2000) (details below). Blood pressure (BP) measurements, anthropometrics (height, weight and waist and hip circumferences), body composition via dual-energy X-ray absorptiometry (DEXA) and fasted venous blood samples were collected. Following baseline measures, participants completed a familiarisation of the VO_2 protocol. Participants then consumed a light breakfast, completed an e-bike training session and were familiarised with the e-bike for approximately 10 min. After adequate rest (approximately 1 h), participants completed the cardiorespiratory test to calculate VO_2 peak. Participants were asked to use the e-bike three times per week over the 6-week intervention period with no set duration or intensity prescribed. This recommendation was provided as our participants were previously physically inactive and we hoped providing the e-bike could be used as a steppingstone to meet PA guidelines. The second visit to the university mirrored the baseline measurements.

2.4. Outcomes

2.4.1. Feasibility

Feasibility was measured across five domains: 1) feasibility of recruitment 2) participant retention 3) intervention adherence, 4) acceptability of questionnaires and lab-based outcome measures, and 5) intervention acceptability (Haines, 2020). Those who indicated interest by emailing the research team were invited to complete pre-screening. Recruitment was deemed feasible if >30% of those screened met our inclusion criteria. Retention was defined as the number of participants who completed the 6-week intervention. Retention was deemed feasible if >80% of participants completed the intervention. Intervention adherence was deemed feasible if participants used the e-bike regularly during the 6-week intervention (Haines, 2020). This was measured by the inbuilt e-bike odometer, we considered the intervention feasible if participants cycled an average of ≥21 km/week. This amount was chosen as previous e-cycling feasibility studies found their participants rode this distance over the intervention duration (Cooper et al., 2018). Acceptability of questionnaires and lab-based measures was deemed acceptable if participants completed the measures pre-and post-intervention. Intervention acceptability was measured during the exit interview where participants were asked if they would continue to use an e-bike if they had the opportunity, and their views on the training session and the Facebook group. Furthermore, intervention fidelity was assessed by case record form checklists, which ensured all aspects of the intervention were delivered to participants.

As mentioned above, additional self-reported and lab-based outcomes were collected to explore preliminary effects of e-cycling and provide data to inform potential larger, future trials.

2.4.2. Self-reported physical activity and self-efficacy

Self-reported PA was assessed using the International Physical Activity Questionnaire (IPA-Q) short form (Craig et al., 2003) which provides information on types of PA, intensity, and sitting time over the previous 7-days. Perceived self-efficacy was assessed using the Self-Efficacy for Exercise Scale (Resnick and Jenkins, 2000). The nine questions in the self-efficacy for exercise scale explored participant's confidence to complete the exercise in various conditions with 0 indicating not confident and 10 indicating very confident.

2.4.3. Blood pressure (brachial and central) and Aortic stiffness

Participants rested in a seated position for at least 10 min before BP measures were taken. Brachial blood pressure, central blood pressure and vascular stiffness were recorded non-invasively with a validated Mobil-O-Graph device (I.E.M.; www.iem.de/en/products/mobil-o-graph.html) as described previously (Russell et al., 2017). All measures were taken with an appropriately sized cuff, and the average of the three measurements was reported. Blood pressure was measured to the nearest 1 mmHg.

2.4.4. Anthropometrics

Anthropometric outcomes were assessed with calibrated measurement tools. Participants' height was measured to the nearest 0.1 cm using a standardised stadiometer. Body mass was measured to the nearest 0.1 kg using a calibrated electronic weigh scale; after that, BMI was calculated. Participants' waist and hip circumferences were measured three times via measuring tape, or until there was less than 0.5 cm of error between the three measures. The average of the three measures with less than 0.5 cm error between was reported. Body composition metrics, including fat-freee mass, body fat mass, body fat percentage and trunk fat percentage were assessed via a whole-body dual-energy x-ray absorptiometry scan (DEXA) (Lunar iDXA, GE Healthcare, Australia/New Zealand).

2.4.5. Blood clinical chemistries assessed using venous blood sampling

Fasted venous blood samples were analysed for glucose, HbA1c, insulin, cholesterol, high density lipoprotein (HDL), low density lipoprotein (LDL) and triglycerides via Dorevitch Pathology using standardised pathology protocols.

2.4.6. Cardiorespiratory fitness - VO_2peak

Participants completed a short familiarisation session which consisted of fitting the metabolic cart face mask, adjusting seat and handlebar height. Participants then completed two stages of the test protocol (I.e., 2 min at 40 W, 2 min at 60 W) allowing them the opportunity to understand how the test would run and to feel the resistance increase. After adequate rest (approximately 1 h), participants completed the cardiorespiratory test to calculate VO_2 peak. The main test required participants to cycle at a pre-determined pedalling frequency (approximately 60 RPM) on an Excalibur Lode bike (www.lode.nl). Resistance started at 40 W and was increased by 20 W every 2 min until volitional exhaustion (i.e., could not maintain 60 ± 3 RPM). Gas samples were analysed by a Quark metabolic cart (Quark RMR Gas Analyzer, Cosmed, Italy).

2.4.7. Behavioural support intervention

Tailored behavioural support was provided to participants of the study. Our previously published manuscript (McVicar et al., 2022b) details the development of the tailored behavioural support intervention. Our intervention utilises the capability, opportunity, motivation – behaviour (COM-B) model of behaviour change (Michie S and West, 2014). The COM-B model has been utilised in many PA promotion interventions, however to our knowledge has yet to be utilised to promote e-cycling. The COM-B model includes three conditions which influence behaviour change: one's capability (physical and psychological), opportunity (social and physical) and motivation (reflective and automatic) interact to produce or change behaviour (Michie S and West, 2014). We increased participants' physical capability by ensuring all participants had the physical skill to operate and maintain the e-bike (training provided) and increased psychological capability by educating the participants on the benefits associated with e-cycling and ensuring they understood how to operate the e-bike. Physical opportunity was supported by providing e-bikes to the participants along with resources to enable them to ride (e.g., pumps, helmets, cycling ponchos). Participants were provided with a Gazelle Vento C7 2019 e-bike (www.gazellebikes.com) for 6-weeks. The e-bikes offer five ride options: no assistance, 'eco', which provides approximately 40% power, 'tour' providing 100% additional power, 'sport' around 150% power and 'turbo' around 225% additional power. The maximum assistance which can be provided on this e-bike is 250%. A short training session was provided by a trained researcher, which included showing participants how to use the odometer, lock the e-bike, battery removal, battery charging and seat adjustment. Advice was provided on how to use Google Maps (Google. Inc) to find the best cycle routes for them. Social opportunity was increased by restructuring their social environment and providing a closed Facebook group to interact with participants of the study. One participant did not have Facebook therefore researchers communicated more frequently via email. The group was moderated by members of the research team. The Facebook group aimed to create a sense of comradery between the participants as research showed people would prefer to start e-cycling with a buddy (McVicar et al., 2022). Reflective motivation was encouraged by prompting participants to set e-cycling goals for their week ahead and we encouraged automatic motivation by promoting use of the Facebook group to log their activity and the experience they had. Health benefits associated with e-cycling (Bourne et al., 2018; McVicar et al., 2022; Peterman et al., 2016) were communicated to participants by researchers via conversation. Participants were advised e-cycling was equivalent to moderate intensity PA and that health benefits could be observed from regular e-cycling. They were advised that research has shown that people who e-cycle regularly see an increase in cardiorespiratory fitness, improved glucose control and an increase in overall wellbeing due to the enjoyment individuals find from e-cycling.

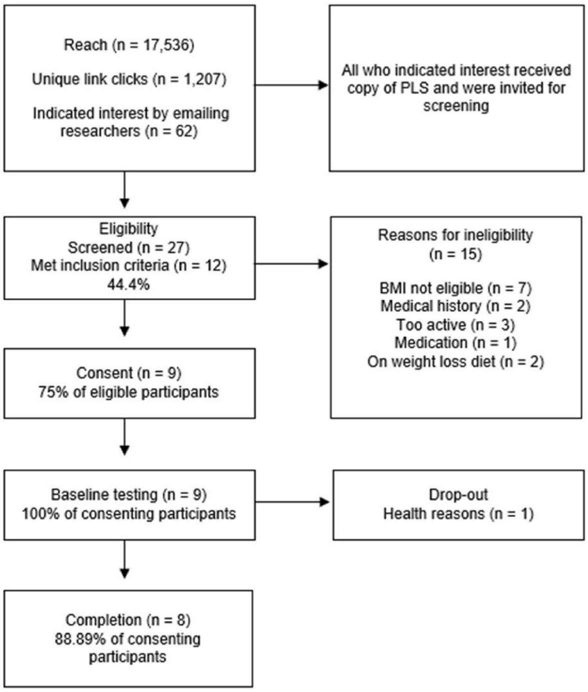

Fig. 1. Flow of participants in the feasibility study. PLS; plain language statement.

2.4.8. Analysis

Data are presented as means ± standard deviations (SD) and medians, interquartile ranges. Mean change and confidence intervals (CI) are reported. Interviews were analysed by reflective thematic analysis (V. Braun and Clarke, 2006) and coded via NVivo (QSR International) by JM. Codes identified conceptualised themes associated with the interview data (V. Braun, Clarke, V., Hayfield, N., Terry, G., 2018).

3. Results

In total, 62 people indicated interest in the study, 35 did not respond to invitation to complete pre-screening and 27 people were screened for eligibility. Twelve people met the inclusion criteria, three were unable to commit to the study and one person withdrew after starting due to health reasons (Fig. 1). Data analysis was completed on the eight participants who completed the intervention. All measurements were completed pre- and post-intervention with minimal data points missing (one participant's pre-LDL cholesterol, one participant's pre-pulse wave velocity (PWV) and augmentation index normalised for a heart rate of 75 beats per minute (AIx@75), one participant's e-bike odometer data).

Participant demographics and characteristics are presented in Tables 1 and 3.

3.1. Participant demographics

Participant's age ranged from 31 to 57 years (mean 50, SD 8.3) with 62.5% identified as female, 100% were married or living with a partner. The participant group were well educated, 75% reported having a bachelor's degree and 25% reported having a degree higher than bachelor. Furthermore, all participants reported high income with 87% reporting over AU$100,000 and 12.5% reporting AU $90,001-$100,000.

3.2. Feasibility

3.2.1. Recruitment and retention

Promoted social media posts provided significant reach with 17,536 people viewing the post. The posts were targeted to those 18+ and living in the suburbs surrounding the university. The posts saw 1207 unique link clicks, which resulted in 62 people emailing for further information. Of those screened (27), 12 met the inclusion criteria (44%) which was higher than our target of 30%. The consent rate was 75% (9 out of 12 eligible participants). One participant was unable to start the study due to COVID-19 lab closures, one sustained an injury before consenting to participate and another was unable to find time to attend the university for baseline measurements. Nine participants started the study with eight participants completing the intervention (88.9% retention rate), which was higher than our target of >80%. One participant withdrew 5-weeks into the intervention.

3.2.2. Intervention adherence

Adherence to the study was determined by assessing if the e-bikes were consistently used throughout the intervention duration. We

Table 1
Participant demographics. Data are count (percentage within-group).

Variable	Participants n (%) (n = 8)
Age	
30–40	1 (12.5)
41–50	3 (37.5)
51–60	4 (50.0)
Sex	
Female	5 (62.5)
Male	3 (37.5)
Ethnicity	
Australian	5 (62.5)
New Zealander	1 (12.5)
Portuguese	1 (12.5)
Serbian	1 (12.5)
Employment	
Self-employed	1 (12.5)
Full-time salary or wage earner	6 (75.0)
Casual part-time hours	1 (12.5)
Living status	
Married/living with a partner	8 (100.0)
Education	
Degree higher than Bachelor *(Bachelor with honours, Master, PhD)*	2 (25.0)
Bachelor's degree	6 (75.0)
Household income	
$90,001-$100,000	1 (12.5)
Over $100,000	7 (87.5)

Table 2
Average odometer travel date for participants over the 6-week period. Data are expressed as mean ± SD and median (IQR) for total values and absolute (kms).

Mode	Total (N = 7) distance (km)
Total	299.8 ± 172.2 295.5 (169.9–416.5)
Turbo	46.4 ± 40.9 43.2 (11.4–75.1)
Sport	31.6 ± 49.5 11.7 (4.6–30.9)
Tour	36.2 ± 48.2 19.0 (11.4–34.8)
Eco	36.6 ± 24.5 32.7 (19.5–49.9)
No assistance	138.4 ± 99.9 98.3 (74.0–186.7)

deemed adherence as acceptable if participants rode ≥21 km/week. Participants reported using the e-bikes consistently, Table 2 shows the average total distance travelled (odometer) and the average distance travelled in each assistance mode over the 6-week intervention period. The odometers showed that seven of the eight participants rode on average (mean ± SD) 299.8 km ± 172.2 over the 6-week period, an average of 49.9 km/week which is greater than our target of 21 km/week. One participant's data was removed as the odometer total was inaccurate, therefore averages will be artificially low.

3.2.3. Acceptability of questionnaires and lab-based outcome measures

Questionnaire and lab-based outcome measures were deemed acceptable by participants. All participants were provided with the plain language statement which detailed all outcome measures. Participants provided informed consent for the study with the understanding of the measurements. Participants completed all questionnaires and lab-based measures pre-and post-intervention with minimal data-points missing.

3.2.4. Intervention acceptability

Intervention acceptability was measured by asking participants if they would continue to e-cycle, all advised yes. All participants used the e-bike throughout the intervention period and advised they would keep using the e-bike if they had the opportunity or would be interested in purchasing their own. Furthermore, each participant advised they would recommend e-bikes to a friend, which reflected their liking for e-bikes and that they wanted to share their enjoyment. All participants advised the training was beneficial in helping them begin e-cycling. All participants reported that the e-bike was easy to use and charge, but concerns were raised with storage, as the e-bikes are relatively large and heavy. Without specific storage, e.g., a garage, participants were concerned regarding storing the e-bike outside their home and would therefore store it in their property. Two participants stated they felt calmer and had a clearer mind during the intervention and four commented on their perceived health benefits e.g., felt stronger, healthier and had lost weight. One participant was not included in the Facebook group as she did not have a Facebook profile, however, researchers engaged more frequently via email to determine if they had any questions regarding the e-bike. Six of the seven participants who used the Facebook group posted within the group with an average of 4.6 posts per participant over the intervention period. Researchers engaged with participant posts to facilitate discussion. Three participants advised that it would have been beneficial to have more people within the Facebook group. Seven participants utilised the group to record trips, upload photos that were taken during their rides, comment on local cycle paths, ask questions regarding the e-bikes and share their experiences.

3.2.5. Intervention fidelity

Participants completed each assessment aspect of the intervention pre- and post-intervention as reported by the case record forms. All participants competed the e-bike training session which was conducted with high fidelity. Researcher posts in the Facebook group were conducted with high fidelity however, due to participants entering and leaving the group at varying times, it is not understood if participants engaged with posts which were in the group before they entered.

3.3. Participant characteristics and study outcomes

The clinical characteristics of the participants are shown in Table 3. Participants had a mean age of 50 ± 8 years and were classified as overweight or obese at baseline 33.2 ± 3.1 kg/m^2, no change was observed post-intervention. The current study was not powered to determine significant changes in physiological parameters. Only one participant reported vigorous PA pre-intervention. Participants

Table 3
Participant characteristics. Data are expressed as mean ± SD and median (IQR). BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; PWV, pulse wave velocity; AI, augmentation index; HR, heart rate; HbA1c, glycated haemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; VO_2, oxygen uptake; MET, metabolic equivalent. CI = Confidence Interval.

Participant characteristics (n = 8)	Baseline	Post-intervention	Change and 95% CI
Physical activity and self-efficacy			
Vigorous PA (MET min/week)	320.0 320.0 (320.0–320.0)	1730.0 ± 1783.0 1120.0 (690.0–2160.0)	825 (−408.6–2058.6)
Moderate PA (MET min/week)	140.0 ± 141.0 140.0 (90.0–190.0)	1004.0 ± 1154.0 500.0 (390.0–960.0)	968.8 (67.4–1870.1)
Walking PA (MET min/week)	987.6 ± 619.2 891.0 (643.5–1089.0)	1083.5 ± 776.3 940.5 (544.5–1410.8)	−51.6 (−924.0–820.8)
Total PA (MET-min/week)	7513.5 ± 3818.4 320.0 (300.0–3616.8)	18181.0 ± 1145.4 6501.0 (5630.5–6710.5)	3555.8 (−5378.21–12489.9)
Sitting time (min/day)	457.5 ± 189.6 420.0 (300.0–585.0)	487.5 ± 279.0 465.0 (292.5–630.0)	30 (−145.3–205.3)
Self-Efficacy for Exercise (total)	41.1 ± 17.9 43.5 (29.5–56.3)	49.8 ± 14.4 50.5 (45.3–54.0)	8.6 (−1.2-18.4)
Anthropometrics			
Body mass (kg)	100.4 ± 16.6 104 (85–110.5)	99.5 ± 17.8 104.1 (83.1–107.8)	−0.9 (−2.9-1.1)
Height (cm)	173.5 ± 10.2 173 (163.6–182.1)		
BMI (kg/m^2)	33.2 ± 3.1 32.4 (31.5–34.1)	33 ± 3.5 31.7 (31.3–33.5)	−0.2 (−0.7-0.4)
Waist circumference (cm)	103.6 ± 12.9 106.2 (93.6–112.5)	102.2 ± 14.5 104.3 (91.9–109.6)	−1.4 (−5.0-2.2)
Hip circumference (cm)	118.8 ± 6.7 119.4 (115.4–124.6)	119.1 ± 8.4 116.5 (112.9–126.3)	0.2 (−3.6-4.1)
Waist: Hip ratio	0.9 ± 0.1 0.9 (0.8–0.9)	0.9 ± 0.1 0.9 (0.8–0.9)	
Lean mass (kg)	52.8 ± 9.8 51.2 (44.5–61.9)	52.8 ± 9.9 52.0 (43.9–61.6)	0.03 (−1.0-1.0)
Fat mass (kg)	43.1 ± 9.0 41.1 (38.6–47.8)	42.2 ± 9.9 40.2 (36.6–46.7)	−0.9 (−2.1-0.4)
Trunk fat (%)	50 ± 5.8 52.5 (48.8–53.1)	49.3 ± 5.4 51.2 (47.0–52.6)	−0.7 (−1.7-0.2)
Body fat (%)	44.9 ± 5.3 45.4 (41.5–48.3)	44.3 ± 5.4 43.6 (41.5–48.2)	−0.6 (−1.3-0.1)
Blood pressure			
Brachial SBP (mmHg)	142 ± 10 143 (137–146)	136 ± 13 138 (128–149)	−6 (-17-6)
Brachial DBP (mmHg)	91 ± 12 89 (82–98)	86 ± 12 90 (83–93)	−5 (-11-1)
Central SBP (mmHg)	145 ± 11 150 (135–154)	139 ± 13 136 (132–147)	−5 (-19-10)
Central DBP (mmHg)	93 ± 12 92 (83–100)	87 ± 12 91 (84–94)	−5 (-12-2)
Arterial stiffness			
PWV (m/sec)	7.8 ± 0.8 7.9	7.6 ± 0.8 7.8	−0.1 (-0.5-0.3)

(*continued on next page*)

Table 3 (*continued*)

Participant characteristics (n = 8)	Baseline	Post-intervention	Change and 95% CI
	(7.6–8.3)	(7.5–8.2)	
AI adjusted to HR 75BPM (%)	19.8 ± 8.7 17.0 (13.2–27.2)	22.6 ± 6.5 20.7 (18.9–23.8)	3.9 (-2.8-10.5)
Clinical chemistries			
HbA1c (mmol/L)	35.8 ± 2.1 36.0 (34.0–36.5)	35.4 ± 2.4 35.0 (34.0–36.3)	−0.4 (-2.6-1.9)
HbA1c (%)	5.4 ± 0.2 5.4 (5.3–5.5)	5.4 ± 0.2 5.4 (5.3–5.4)	−0.03 (-0.2-0.1)
Fasting Insulin (mU/L)	9.9 ± 4.6 8.0 (6.8–13.0)	7.9 ± 5.6 6.0 (4.8–9.0)	−2.0 (-5.7-1.7)
Fasting Glucose (mmol/L)	5.2 ± 0.3 5.2 (5.0–5.4)	5.0 ± 0.4 4.9 (4.8–5.0)	−0.2 (-0.4-0.0)
Total cholesterol (mmol/L)	5.8 ± 1.2 5.5 (5.0–6.1)	5.4 ± 0.9 5.4 (4.9–6.2)	−0.4 (-0.9-0.2)
HDL (mmol/L)	1.5 ± 0.5 1.4 (1.2–1.8)	1.4 ± 0.5 1.4 (1.2–1.7)	−0.03 (-0.2-0.1)
LDL (mmol/L)	3.3 ± 1.0 3.1 (3.0–3.3)	3.2 ± 0.9 3.1 (3.0–3.4)	0.3 (-1.0-1.5)
Triglyceride (mmol/L)	2.2 ± 1.8 1.4 (1.2–2.5)	1.9 ± 1.1 1.6 (1.1–2.3)	−0.3 (-1.3-0.6)
Cardiorespiratory fitness			
VO_2 peak (ml.kg.min)	20.3 ± 2.6 20.7 (18.0–21.6)	21.8 ± 2.2 21.5 (20.0–22.9)	1.4 (-2.2-3.6)
VO_2 peak (L.min)	2.0 ± 0.4 1.9 (1.8–2.4)	2.2 ± 0.5 2.1 (1.8–2.3)	0.1 (-0.1-0.4)

were not cycling regularly before partaking in the study however participants were asked if they could cycle during screening.

Fig. 2 shows there was a directional effect observed in favour of body fat (%), fasting blood glucose and brachial diastolic blood pressure.

4. Discussion

This study sought to determine the feasibility of a behavioural supported e-bike intervention. Overall, eight participants completed the study with participants cycling on average 49.9 km per week. All participants expressed enjoyment of the experience, and all advised they would be interested in purchasing their own e-bike. We observed increases in self-reported PA levels and self-efficacy for exercise. We observed downward trends in body fat percentage, blood glucose and brachial diastolic blood pressure, suggesting e-

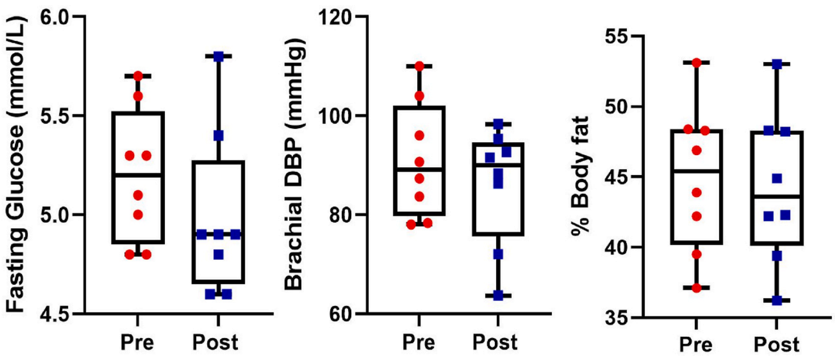

Fig. 2. Body fat (%), fasting blood glucose and brachial diastolic blood pressure change pre-to post-intervention. Data are expressed as median, upper and lower quartile and individual data points.

cycling may be associated with improved health parameters within this population. Based on the progression criteria from Haines (2020) and Hawkins et al. (2019) we have deemed that our outlined feasibility criteria have been met and that a larger trial could be conducted with this methodology.

4.1. Feasibility

The method used for recruitment allowed for extensive reach within the suburbs near the university campus. The reach of the adverts allowed for a high level of interest. Of those that were eligible to take part, the majority (75%) consented to the study. This recruitment strategy is feasible, however inclusion of an online survey to allow participants to self-screen would have been beneficial. This would ensure the process was more streamlined and could potentially lead to more eligible participants as many were lost to follow-up. Inclusion of a pre-screening survey would allow researchers the opportunity to contact those who are interested in the study and have met the initial inclusion criteria.

The high retention rate, 8 of 9 participants, meets the progression criteria outlined previously. The high retention rate within this study could be due to the loan of the e-bike. Many participants commented they had previously been interested in purchasing an e-bike however were concerned regarding the expense of the e-bike. They advised the 6-week intervention allowed them a real-world opportunity to understand their e-bike use before committing to purchasing their own. Further, participants willingness to complete the intervention measures could have been to gain an understanding the impact e-cycling had their health and well-being.

The intervention delivery was deemed feasible by the researchers involved. A limitation of the intervention was the number of available e-bikes at any one time; therefore, recruitment was staggered to allow for this. The tailored behavioural intervention components were specifically developed for the participants of the study and the intervention strategies included were deemed acceptable. The Facebook group posts delivered by researchers were deemed acceptable by researchers. If scaling the study up, posts designed on Canva (Canva Pty Ltd) could be scheduled via a scheduling tool (e.g., buffer) to ensure intervention fidelity is high.

4.2. Behavioural support

A unique aspect of this study was the inclusion of a closed Facebook group, which aimed to provide continued support during the study period. Previous research has shown that people who do not currently cycle reported it would be beneficial to have someone to start cycling with; as it can be intimidating to start alone (McVicar et al., 2022a,b). Furthermore, a quantitative study, which assessed whether e-bikes can increase women's PA levels found people sought a non-judgemental, inclusive space to ask questions regarding e-cycling (Wild et al., 2021). In the present study, the Facebook was created to allow participants the opportunity to discuss their rides and ask questions without fear of judgment. It was utilised by researchers to prompt the use of the e-bikes, provide safety reminders (e.g., helmet use) and tips (e.g., how to turn lights on and off or a reminder to wear gloves when cycling in the cold weather). Participants advised the Facebook group was encouraging however stated more members within the group at any one time would have been preferable. Findings from a systematic review that assessed the impact Facebook-based social support on physical and mental health outcomes (Gilmour et al., 2020) reported that Facebook-based social support positively impacted PA, physical health and well-being (Gilmour et al., 2020). The use of an e-bike support group, alongside the other behavioural intervention features, may have contributed to the acceptance of the e-bikes within our participant population.

Cooper et al. conducted a feasibility study, which assessed the potential of e-bikes to improve the health of people with type 2 diabetes (Cooper et al., 2018). Researchers determined e-cycling to be acceptable to people with type 2 diabetes and found predicted maximal aerobic power increased by 10.9%. Although our participants did not have type 2 diabetes, we found e-cycling to be acceptable to people who were overweight or obese and physically inactive. Cooper et al. provided participants with an e-bike familiarisation session and provided an e-bike over the intervention period. We implemented many behavioural support features into our feasibility study that were not reported in Cooper's feasibility study, which may explain the difference in weekly cycle distance. Participants of Coopers study e-cycled a median of 21.4 km/week over the 20-week period. We found our participants e-cycled a median of 49 km/week. Another study (Bock et al., 2001) reported the importance of individually tailored materials can have on PA adoption. Authors reported that individually tailored intervention materials showed a PA advantage over generic materials for PA adoption and maintenance. Our tailored intervention features may be a reason for the difference in e-bike use between the feasibility studies, however different weather conditions cannot be overlooked. Seasonal differences impact PA participation; precipitation is negatively associated with PA volume (Turrisi et al., 2021). Overall, Melbourne Australia provides drier weather conditions compared to those observed in Bristol, UK (184 and 234 days on average with precipitation respectively, source: weathertrends360.com). This intervention began in February and data collection was complete by August.

4.3. Health impact

Self-efficacy is defined as an individual's belief in their ability to achieve an outcome of interest. Furthermore, exercise self-efficacy is one of the strongest predictors of commitment to PA (Meadows and Bombak, 2019). Self-efficacy for exercise increased pre-to post intervention within the current study. This positive finding could be beneficial to participants as self-efficacy has previously been identified as a significant factor for a PA increase (Olander et al., 2013). Increasing exercise self-efficacy and moderate PA levels within our study population creates potential for an improvement in physical and mental health outcomes to occur. Participants commented on the impact e-cycling had on their physical and mental well-being. Participants advised the e-cycling helped them feel calmer and cleared their mind, others commented on how they felt fitter, stronger and had lost weight. A recent study interviewed 20 people who were inactive and overweight that had been e-cycling for 12-weeks (Anderson et al., 2022). Authors reported participants felt both mental and physical health benefits from using e-bikes as an alternative mode of transport. The interviews found participants reported feeling happier and more socially connected, and similar to our findings, participants reported they would recommend e-bikes to others (Anderson et al., 2022).

Regular moderate to vigorous levels of PA can have a plethora of health benefits (F. Bull et al., 2017) including, maintaining a healthy body weight (Jakicic, 2009) and improving fasting glucose levels (Boniol et al., 2017). PA levels in the current study increased pre-to post-intervention as measured by the IPA-Q. Results from the IPA-Q show no compensatory effect on walking as there was little variation in walking or sitting time pre-to post-intervention, however an increase in sitting time was observed within this study. This may be due to activity compensation, it is theorised that PA levels are regulated by homeostatic mechanisms and that PA levels are maintained within activity set-points (Swelam et al., 2022). This may provide an understanding as to why sitting time increased in response to the increased PA levels.

Utilisation of an e-bike to increase PA levels could lead to health benefits, however it is important to understand which assistance levels are being utilised as this has an impact on physiological output (McVicar et al., 2022). Table 2 shows participants cycled approximately 46% the total distance cycled without assistance. Thereafter, cycle distance is split relatively evenly between the four assistance levels. These findings provide an understanding as to how e-bikes may be utilised by individuals like our participant group and new to e-cycling.

The current study showed a downwards trend in body fat (%), fasting blood glucose levels and brachial diastolic blood pressure supporting the use of e-bike to improve health. Peterman et al. measured body composition via DEXA and found no difference in people who were sedentary after e-cycling for 4-weeks. However, there was a significant reduction in 2 h-post OGTT glucose levels however no difference in fasting blood glucose levels (Peterman et al., 2016).

We observed no changes in cardiorespiratory fitness following a 6-week e-bike intervention. Similar to our findings, de Geus et al. (De Geus et al., 2013) did not find an increase in cardiorespiratory fitness after 6-weeks of e-cycling in people who were physically inactive. The duration of e-cycling may need to be longer than 6-weeks to observe an increase in cardiorespiratory fitness or e-cycling intensity may need to be higher to elicit a response in a shorter duration (Höchsmann et al., 2018). Contrary to these findings, Peterman et al. (2016) found cardiorespiratory fitness significantly increased pre-to post-intervention after 4-weeks of e-cycling. A systematic review assessing the health benefits of cycling concluded women and men would be required to cycle 170 and 250 min/week at an intensity of 6 METs to facilitate an increase in cardiorespiratory fitness (Oja et al., 2011). Furthermore, the American Office of Disease Prevention and Health Promotion advise an increase in cardiorespiratory fitness may be observed after a few weeks to months of regular participation in PA (Piercy et al., 2018). The appeal of e-bikes is the assistance which can be provided, this translates to a reduction in energy expenditure, heart rate, VO_2, power output and METs compared with conventional cycling (McVicar et al., 2022). This would have an impact on the duration needed to see an increase in fitness levels. However, health benefits can be observed from moderate-intensity PA (F. C. Bull et al., 2020) and are more likely to be sustained by people who are overweight or obese (Hall et al., 2012). Therefore e-cycling should be recommended to those looking to commence a more physically active lifestyle but are apprehensive due to fitness concerns.

4.4. *Strengths and limitations*

4.4.1. *Strengths*

This study implemented a tailored behavioural support intervention in conjunction with an e-bike to support an increase in PA levels among people who are overweight or obese and physically inactive. The use of both qualitative and quantitative methods has provided a detailed understanding of the impact e-cycling can have within our study population.

4.4.2. *Limitations*

We acknowledge more participants in the Facebook group at any one time would have helped create a continued sense of encouragement between participants. The study is underpowered due to the small sample size. Without a control or e-bike-only group, we cannot determine the impact of the behavioural support intervention on increasing e-bike use. The findings from the qualitative analysis were not reported back to participants within the current study and although thematic analysis was utilised, there may be potential influence from the researchers involved. Furthermore, participants volunteered to take part in this study therefore this intrinsic motivation to take part may have influenced increased e-bike use. E-bike usage data is lower than actual usage due to the removal of one participant's data.

4.5. *Perspectives*

Insufficient PA levels are a problem worldwide (F. C. Bull et al., 2020). Strategies to support individuals to engage in regular PA are needed. E-bikes have shown potential to help individuals meet recommended PA guidelines and therefore should be utilised. However, people are less likely to maintain behaviour change without behavioural support. This study has shown that providing e-bikes and supporting individuals to use them can increase PA levels. These findings are imperative for policymakers. Providing support to individuals who are interested in e-cycling can increase PA which can impact health. Further research is warranted to determine the physiological impact long-term e-cycling could have on cardiometabolic health markers.

5. Conclusion

The recruitment strategy, retention, adherence and acceptability of this study support future research. E-bikes are an acceptable way to help people who are physically inactive increase their PA levels. Furthermore, sustained use may contribute to health benefits and improve overall self-efficacy for exercise.

Credit author statement

JM, MK, and RM conceptualised the study. JM and MK oversaw recruitment. JM screened participants. JM, SO, LP & AB conducted lab-based measurements. JM, MK & RM developed behavioural intervention. All authors contributed to the manuscript. All authors approved final manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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