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Interventions outside the workplace for reducing sedentary behaviour in adults under 60 years of age (Review)

Murtagh EM, Murphy MH, Milton K, Roberts NW, O'Gorman CSM, Foster C

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[Intervention Review]

Interventions outside the workplace for reducing sedentary behaviour in adults under 60 years of age

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ABSTRACT

Background

Adults spend a majority of their time outside the workplace being sedentary. Large amounts of sedentary behaviour increase the risk of type 2 diabetes, cardiovascular disease, and both all-cause and cardiovascular disease mortality.

Objectives

Primary

• To assess effects on sedentary time of non-occupational interventions for reducing sedentary behaviour in adults under 60 years of age

Secondary

• To describe other health effects and adverse events or unintended consequences of these interventions

• To determine whether specific components of interventions are associated with changes in sedentary behaviour

• To identify if there are any differential effects of interventions based on health inequalities (e.g. age, sex, income, employment)

Search methods

We searched CENTRAL, MEDLINE, Embase, Cochrane Database of Systematic Reviews, CINAHL, PsycINFO, SportDiscus, and ClinicalTrials.gov on 14 April 2020. We checked references of included studies, conducted forward citation searching, and contacted authors in the field to identify additional studies.

Selection criteria

We included randomised controlled trials (RCTs) and cluster RCTs of interventions outside the workplace for community-dwelling adults aged 18 to 59 years. We included studies only when the intervention had a specific aim or component to change sedentary behaviour.

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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 trial authors for additional information or data when required. We examined the following primary outcomes: device-measured sedentary time, self-report sitting time, self-report TV viewing time, and breaks in sedentary time.

Main results

We included 13 trials involving 1770 participants, all undertaken in high-income countries. Ten were RCTs and three were cluster RCTs. The mean age of study participants ranged from 20 to 41 years. A majority of participants were female. All interventions were delivered at the individual level. Intervention components included personal monitoring devices, information or education, counselling, and prompts to reduce sedentary behaviour. We judged no study to be at low risk of bias across all domains. Seven studies were at high risk of bias for blinding of outcome assessment due to use of self-report outcomes measures.

Primary outcomes

Interventions outside the workplace probably show little or no difference in device-measured sedentary time in the short term (mean difference (MD) -8.36 min/d, 95% confidence interval (CI) -27.12 to 10.40; 4 studies; I^2 = 0%; moderate-certainty evidence). We are uncertain whether interventions reduce device-measured sedentary time in the medium term (MD -51.37 min/d, 95% CI -126.34 to 23.59; 3 studies; I^2 = 84%; very low-certainty evidence)

We are uncertain whether interventions outside the workplace reduce self-report sitting time in the short term (MD -64.12 min/d, 95% CI -260.91 to 132.67; I^2 = 86%; very low-certainty evidence).

Interventions outside the workplace may show little or no difference in self-report TV viewing time in the medium term (MD -12.45 min/d, 95% CI -50.40 to 25.49; 2 studies; I^2 = 86%; low-certainty evidence) or in the long term (MD 0.30 min/d, 95% CI -0.63 to 1.23; 2 studies; I^2 = 0%; low-certainty evidence).

It was not possible to pool the five studies that reported breaks in sedentary time given the variation in definitions used.

Secondary outcomes

Interventions outside the workplace probably have little or no difference on body mass index in the medium term (MD -0.25 kg/m^2, 95% CI -0.48 to -0.01; 3 studies; I^2 = 0%; moderate-certainty evidence). Interventions may have little or no difference in waist circumference in the medium term (MD -2.04 cm, 95% CI -9.06 to 4.98; 2 studies; I^2 = 65%; low-certainty evidence).

Interventions probably have little or no difference on glucose in the short term (MD -0.18 mmol/L, 95% CI -0.30 to -0.06; 2 studies; I^2 = 0%; moderate-certainty evidence) and medium term (MD -0.08 mmol/L, 95% CI -0.21 to 0.05; 2 studies, I^2 = 0%; moderate-certainty evidence)

Interventions outside the workplace may have little or no difference in device-measured MVPA in the short term (MD 1.99 min/d, 95% CI -4.27 to 8.25; 4 studies; I^2 = 23%; low-certainty evidence). We are uncertain whether interventions improve device-measured MVPA in the medium term (MD 6.59 min/d, 95% CI -7.35 to 20.53; 3 studies; I^2 = 70%; very low-certainty evidence).

We are uncertain whether interventions outside the workplace improve self-reported light-intensity PA in the short-term (MD 156.32 min/d, 95% CI 34.34 to 278.31; 2 studies; I^2 = 79%; very low-certainty evidence).

Interventions may have little or no difference on step count in the short-term (MD 226.90 steps/day, 95% CI -519.78 to 973.59; 3 studies; I^2 = 0%; low-certainty evidence)

No data on adverse events or symptoms were reported in the included studies.

Authors' conclusions

Interventions outside the workplace to reduce sedentary behaviour probably lead to little or no difference in device-measured sedentary time in the short term, and we are uncertain if they reduce device-measured sedentary time in the medium term. We are uncertain whether interventions outside the workplace reduce self-reported sitting time in the short term. Interventions outside the workplace may result in little or no difference in self-report TV viewing time in the medium or long term. The certainty of evidence is moderate to very low, mainly due to concerns about risk of bias, inconsistent findings, and imprecise results. Future studies should be of longer duration; should recruit participants from varying age, socioeconomic, or ethnic groups; and should gather quality of life, cost-effectiveness, and adverse event data. We strongly recommend that standard methods of data preparation and analysis are adopted to allow comparison of the effects of interventions to reduce sedentary behaviour.

PLAIN LANGUAGE SUMMARY

Interventions outside the workplace to reduce sedentary behaviour

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Background

Adults spend most of their time outside of their workplace being sedentary, for example, sitting while watching TV or using a computer, or travelling to and from work in a car. Prolonged sedentary behaviour has been linked with increased risk of several diseases and premature death. We do not yet know if interventions to reduce sedentary behaviour outside the workplace are effective. This review will tell us whether there is evidence that these interventions reduce sedentary behaviour.

Main findings

We searched for studies up to 14 April 2020. We found 13 relevant studies involving a total of 1770 participants. All were conducted in high-income countries, at universities, in home/community, online, and in primary care. The average age of participants in these studies was between 20 and 41 years. Most participants were female. All interventions were targeted at the individual: none were environmental or policy. Intervention components included personal monitoring devices, information or education, counselling, and prompts to reduce sedentary behaviour.

We examined the following primary outcomes: device-measured sedentary time, self-report sitting time, self-report TV viewing time, and breaks in sedentary time. The certainty of evidence was moderate to very low, mainly due to concerns about risk of bias, inconsistent findings, and imprecise results. "Moderate" indicates that further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. "Very low" indicates that any estimate of effect is very uncertain. Overall there is not enough evidence to support conclusions about whether interventions are effective in reducing sedentary behaviour. Collectively, studies did not provide evidence of an effect on device-measured total sedentary time, nor on the subsets of self-report sitting time, TV viewing time, or breaks in sedentary time.

We examined the following secondary outcomes: body composition, markers of insulin resistance, device measured moderate-to-vigorous physical activity (MVPA), self-report light physical activity (PA), and step count. The certainty of evidence was moderate for body mass index and glucose, therefore interventions outside the workplace probably have little or no different on these outcomes. Interventions may have little or no difference on MPVA in the short term, steps and waist circumference (low-certainty evidence). We are uncertain whether interventions improve MVPA in the medium term and light PA (very low-certainty evidence). The included studies did not report any data on adverse events or symptoms.

Conclusions

Interventions outside the workplace to reduce sedentary behaviour probably lead to little or no difference in sedentary time. We are uncertain whether interventions outside the workplace reduce sitting time. Interventions may produce little or no difference in self-report TV viewing time. More research is needed to assess the effectiveness of interventions, and studies should include participants from varying age, socioeconomic, and ethnic groups.

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Summary of findings 1. Intervention compared to Control for reducing sedentary behaviour in adults under 60

Intervention compared to control for reducing sedentary behaviour in adults under 60

Patient or population: community-dwelling adults under 60 years of age
Setting: outside the workplace
Intervention: individual-level interventions aiming to reduce sedentary behaviour
Comparison: no intervention or attention control

Outcomes	Anticipated absolute effects* (95% CI)		№ of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with Control	Risk with Intervention			
Device-measured sedentary time	*Short-term follow-up (up to 4 months)*				
	Control group mean was 574.44 min/d	MD 8.36 lower (-27.12 lower to 10.40 higher	262 (4 RCTs)	⊕⊕⊕⊖ MODERATE [1]	
	Medium-term follow-up (> 4 months to 12 months)				
	Control group mean was 590.67 min/day	MD 51.37 lower (126.34 lower to 23.59 higher	188 (3 RCTs)	⊕⊖⊖⊖ VERY LOW [1 2 3]	
Self-report TV viewing time	*Medium follow-up (> 4 months to 12 months)*				
	Control group mean was 99.30 min/day	MD 12.45 lower (50.40 lower to 25.49 higher)	459 (2 RCTs)	⊕⊕⊖⊖ LOW [1 4]	
	Long-term follow-up (> 12 months)				
	Control group mean was 111.22	MD 0.30 higher (0.63 lower to 1.23 higher)	709 (2 RCTs)	⊕⊕⊖⊖ LOW [5 6]	
Device-measured MVPA	*Short-term (up to 4 months)*				
	Control group mean was 48.76 min/day	MD 1.99 higher (4.27 lower to 8.25 higher)	296 (4 RCTs)	⊕⊕⊖⊖ LOW [1 7]	
	Medium-term follow-up (> 4 months to 12 months)				

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	Control group mean was 62.97 min/day	MD 6.59 higher (7.35 lower to 20.53 higher)	214 (3 RCTs)	⊕⊖⊖⊖ VERY LOW [1 2 8]
Self-report light PA	*Short-term follow-up (up to 4 months)*			
	Control group mean was 232.86 min/day	MD 156.32 higher (34.34 higher to 278.31 higher)	115 (2 RCTs)	⊕⊖⊖⊖ VERY LOW [5 9 10]
Adverse events and symptoms	None 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; **MD**: mean difference; **RCT**: randomised controlled trial; **min/day**: minutes per day

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] Concerns about imprecision due to wide confidence intervals and small sample sizes
[2] Low risk of bias for outcome assessment, however 2 studies have high risk for several domains
[3] Large variation in effect, I^2 = 87%
[4] High risk of bias for outcome assessment for this outcome, unclear risk of bias for several other domains.
[5] High risk of bias for outcomes assessment, unclear or high risk of bias for several other domains
[6] Large sample size however large confidence intervals lead to uncertainty
[7] Low risk of bias for outcome assessment, however majority of studies have unclear or high risk of bias for several domains
[8] Large variation in effect, I^2 = 71%
[9] Large variation in effect, CI's slightly overlap, Chi2 P < 0.05, I^2 = 79%
[10] Very serious concerns about precision due to large confidence internals and small sample size

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BACKGROUND

Description of the condition

Research into sedentary behaviour is an emerging and rapidly growing field. Sedentary behaviour is defined as waking activity characterised by an energy expenditure of 1.5 or fewer metabolic equivalents and a sitting or reclining posture (Sedentary Behaviour Research Network 2012). A recent overview of systematic reviews of observational studies concluded that there is strong evidence of a positive relationship between sedentary behaviour and all-cause mortality, fatal and non-fatal cardiovascular disease, and type 2 diabetes and metabolic syndrome, along with moderate evidence of increased incidence of ovarian, colon, and endometrial cancers (De Rezende 2014). Conversely, interrupting sedentary time and/or replacing it with light-intensity activity has been shown to improve several markers of cardiovascular disease risk (Dunstan 2012; Peddie 2013; Thorp 2014). Some research suggests that sedentary behaviour may be a distinct risk factor, independent of physical activity, for multiple adverse health outcomes (Chomistek 2013; Stamatakis 2011; Thorp 2011). Indeed, even people who are physically active at or above recommended levels experience the adverse effects of sedentary behaviour (Katzmarzyk 2009). Researchers estimate that people need approximately 60 to 75 minutes per day of moderate-intensity physical activity to eliminate the increased risk of death associated with high sitting time; however, this high activity level reduces but does not eliminate the increased risk associated with high TV-viewing time (Ekelund 2016).

The mechanisms through which sedentary behaviours lead to cardiovascular morbidity and mortality are under-explored in the literature, but hypotheses point to defects in lipoprotein metabolism, early atherosclerosis, insulin resistance, and development of the metabolic syndrome (Same 2016). Obesity may act as a mediator between sedentary behaviours and negative health outcomes (Same 2016). Research from the genetics field has identified a genotype that is particularly susceptible to the adverse effects of excessive sedentary periods on glycaemic regulation (Alibegovic 2010), thus suggesting a potential gene–environment interplay that determines who is most susceptible to developing diabetes when exposed to excess sedentary time (Wilmot 2012).

Sedentary behaviour in adults is characterised as TV viewing and other screen-focused behaviours in domestic environments, prolonged sitting in the workplace, and time spent sitting in automobiles (Owen 2011). Accelerometer data from a representative sample of US adults show that over 50% of waking hours are spent sedentary (Healy 2011). Weekday self-reported sitting time varies considerably across European countries, with adults in northwestern European countries sitting the most (means 5.6 to 6.8 hours/d) (Bennie 2013). Accelerometer data suggest that UK men and women actually spend approximately 7.5 and 7 hours per day, respectively, being sedentary (Ekelund 2009). Many interventions to reduce sitting time in adults have focused on the workplace setting (Shrestha 2016); however, workplace sitting represents only one domain of sedentary behaviour, as adults spend approximately 70% of their non-work time being sedentary as well (Parry 2013). TV viewing is a major contributor to sedentary behaviour in the USA, with the average adult watching five hours of TV per day (Pettee 2009; The Nielsen Company 2009). In addition, inactive travel modes and other non-occupational behaviours such as leisure-time computer use are increasing (Brownson 2005; Chau 2012). Serial cross-sectional US data show that from 2001 to 2016, the estimated prevalence of computer use outside school or work for at least one hour per day increased from 29% to 50% for adults (Yang 2019). There are several known individual correlates of sedentary behaviour, such as age, physical activity level, body mass index, and socioeconomic status, and evidence related to social and environmental factors is emerging (O'Donoghue 2016). A taxonomy of sedentary behaviours is currently under development to provide a structure for current and future knowledge of sedentary behavior and a basis for distinguishing different behaviours (Chastin 2013).

Although no global (e.g. World Health Organization (WHO)) guidelines on sedentary behaviour exist, several countries have made population-based recommendations. Much of the focus thus far is related to screen time for children. For example, since 2001, the American Academy of Pediatrics has recommended that parents limit children's total entertainment media time to no more than one to two hours of quality programming per day (American Academy of Pediatrics 2001). This two-hour limit for children is consistent with the 2004 Australian guidelines (Australian Government 2004). Canada addressed general sedentary behaviour in its 2011 guidelines by recommending that children should minimise the time that they spend being sedentary each day (Tremblay 2011). More recently, the WHO included a screen time guideline for children younger than five years of age (WHO 2019). In 2011 the UK Chief Medical Officers joined Australia (among others) in providing public health guidelines aimed specifically at highlighting the potential health risks associated with sedentary behaviour for adults (BHFNC Physical Activity and Health 2012). The UK guidelines recommend that all adults minimise the amount of time spent being sedentary (sitting) for extended periods (Department of Health 2011), without specifying a duration of time. The Australian guidelines recommend that adults minimise the amount of time spent in prolonged sitting and break up long periods of sitting as often as possible (Australian Government 2014). A recent paper led by UK researchers suggested that for predominantly desk-based occupations, workers should aim to initially progress towards accumulating two hours per day of standing and light activity during working hours, eventually progressing to a total accumulation of four hours per day (Buckley 2015); however, this is not an official guideline from the UK Chief Medical Officers.

Public health agencies have yet to present a quantified time limit on daily or weekly volumes of sedentary behaviour. Indeed several researchers suggest that the development of quantitative public health guidelines is premature, as little is known about the independent detrimental health effects of sitting, and there are many inconsistencies in how the evidence based was developed and interpreted (Stamatakis 2019). Some evidence suggests that a reduction of one to two hours of sedentary time per day could equate to substantial reductions in cardiovascular disease risk (Healy 2011). One study estimated that beneficial effects on cardiovascular disease risk biomarkers were associated with the reallocation of 30 minutes per day of sedentary time with an equal amount of sleep, light-intensity physical activity, or moderate to vigorous physical activity (Buman 2013). A recent review of experimental studies concluded that breaking up sitting time and replacing it with light-intensity ambulatory physical activity and standing may be a sufficient stimulus to induce acute favourable changes in postprandial (the period after eating a meal) metabolic parameters such as glucose and insulin response in people who

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are physically inactive and have type 2 diabetes, whereas a higher intensity or volume seems to be more effective in rendering such positive outcomes in young, regularly active people (Benatti 2015). However Stamatkais and colleagues noted the absence of long-term prospective epidemiological evidence from studies that use objective measures of actual sitting, as opposed to absence of ambulatory movement (Stamatakis 2019). Of note is that the Second Edition of the Physical Activity Guidelines for Americans concludes that the existing evidence base does not allow a specific healthy target for total sedentary behaviour time to be determined (PA Guidelines Advisory Committee 2018). Similarly, the UK Expert Working Group for Sedentary Behaviour (tasked with examining evidence to decide if changes to current physical activity recommendations are warranted) did not support any significant changes to existing guidance nor suggest that a time limit or minimum threshold for sedentary behaviour should be added (Cooper 2018). The Expert Group supports a recommendation to interrupt prolonged periods of sedentary behaviour with light-intensity physical activity but does not suggest that prolonged sedentary time should be interrupted by standing (Cooper 2018).

Description of the intervention

Our review assessed effects of interventions that aim to reduce sedentary behaviour among adults in non-occupational settings. This will include studies that incorporate any component intending to reduce sedentary time, including if this is part of a larger intervention. We define a component as any strategy that explicitly targets a reduction in sedentary behaviour and is reported as a component of the intervention. This approach allows our review to include not only studies that focus exclusively on sedentary behaviour but also those that take a combined approach to reduce sedentary behaviour and increase physical activity. We note from the literature that some studies target a specific sedentary behaviour, such as TV viewing, or a collection of behaviours like overall use of screen time.

Interventions may be delivered at the individual, environmental, or policy level and include interventions within domestic environments, transport, and the wider community. Interventions include education and counselling sessions, wherein participants develop an implementation plan for behaviour change (De Greef 2010); self-monitoring of behaviour alongside goal-setting, where participants are encouraged to track their sitting time and set goals to increase breaks from sitting (Adams 2013); and multi-component lifestyle interventions. Interventions targeting the environmental level may include point-of-decision prompts to encourage adults to stand (Lang 2015), or they could consist of controls placed on use of screen time, for example, limiting TV viewing by installing an electronic lockout system (Otten 2009). Those delivering the interventions will include counsellors, researchers, exercise physiologists, psychologists, general practitioners (GPs), and other public health professionals. Delivery modes are likely to involve face-to-face individual and/or group sessions, telephone support, provision of written leaflets, and use of online platforms. Many studies incorporate specific behaviour change strategies in the design, with self-monitoring behaviour, problem-solving, modifying social and physical environments, and giving information on the health impact of sitting most closely associated with promising interventions (Gardner 2016).

How the intervention might work

Several frameworks have emerged from recent research for understanding sedentary behaviour and informing intervention development (Owen 2014; Prapavessis 2015). An ecological model of sedentary behaviours highlights a behaviour- and context-specific approach to understand the multiple determinants (Owen 2011). The behaviours and contexts of primary concern are TV viewing and other screen-focused behaviours in domestic environments, prolonged sitting in the workplace, and time spent sitting in automobiles (Owen 2011). Trial authors suggest that change to sedentary behaviour in these domains may be altered by focusing on a specific setting with due consideration of the correlates of sedentary behaviour for that setting along with understanding factors related to high levels of overall sedentary time. A recent review of behaviour change strategies used in interventions for sedentary behaviour concluded that the most promising interventions were based on environmental restructuring, persuasion, or education (Gardner 2016). In addition, the following behaviour change techniques were particularly promising: self-monitoring, problem-solving, and restructuring of the social or physical environment.

We developed a logic model based on Baker 2015 to illustrate how the interventions might work and to describe the interactions between intervention activities and outcomes (Figure 1). We envisage several ways that interventions in non-occupational settings may reduce sedentary behaviour in adults under 60 years of age.

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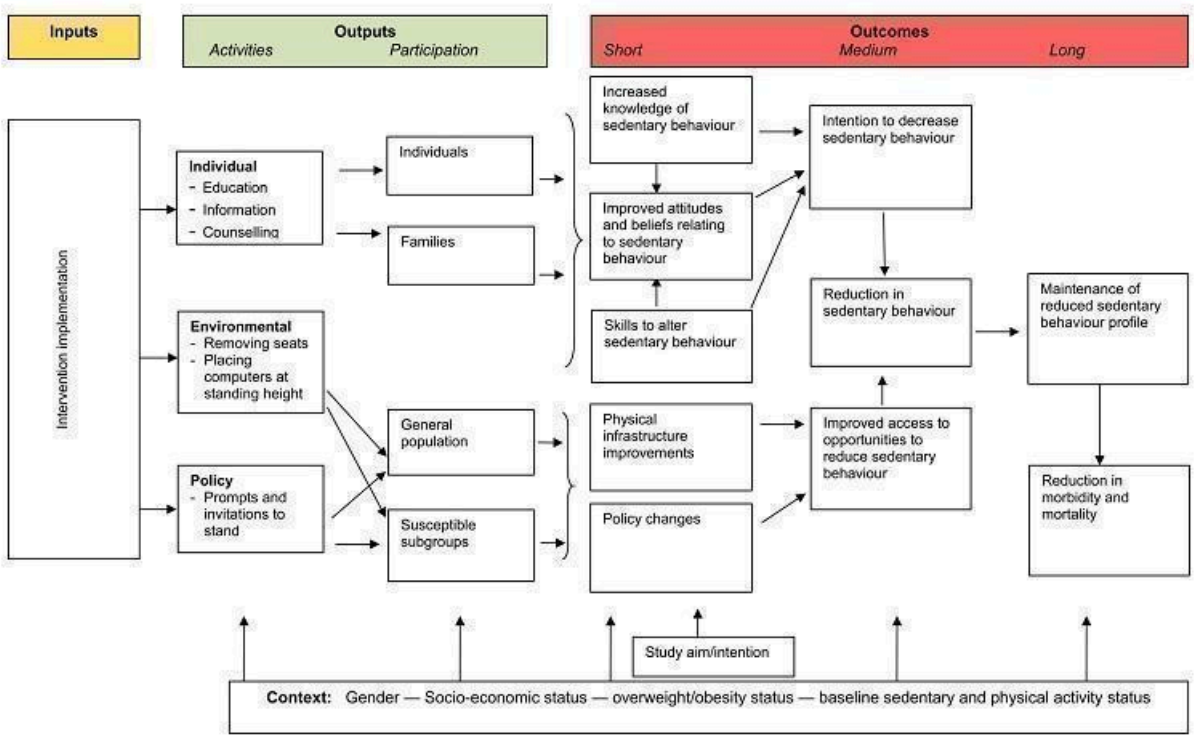
Figure 1. Logic Model for interventions targeted outside of workplace settings for reducing sedentary behaviour (adapted from Baker 2015).



- *Individual, including education/information/counselling*: adults may be willing to alter behaviour after learning about the health risks of a sedentary lifestyle. To support efforts to change behaviour, counsellors could encourage adults to track their sitting time and set goals to increase breaks. Similarly, they may receive suggestions to reduce sitting time.
- *Environmental*: for example, removing seats from certain carriages on a train would force commuters to stand for the journey. Similarly, studies could limit recreational TV viewing by installing a lockout system that engages after a specific usage period per day, thus encouraging adults to change their usual behaviour. Placing computers at standing height would also prompt standing.
- *Policy, including challenges to socials norms*: for example, by providing prompts and invitations to encourage standing at events, participants may be more likely to stand for some or all of the duration.

Why it is important to do this review

The evidence base reporting the health implications of sedentary behaviour and interventions to address this problem is rapidly expanding. Although studies first identified an increase in cardiovascular disease (CVD) risk experienced by people in highly sedentary jobs in the 1950s, only in recent years have the potential CVD risks from sedentary behaviour, as distinct from physical activity, come to be appreciated (Ford 2012). Recent observational and experimental evidence makes a compelling case for reducing and breaking up prolonged sitting time in both primary prevention and disease management contexts (Dempsey 2014). The scale of the problem is evidenced by the fact that the adverse health effects of sedentary behaviour are present even among those who are physically active at or above recommended levels (Katzmarzyk 2009). An estimated 5.9% of deaths may be attributable to daily total sitting time, suggesting that its reduction in the population could produce comparable benefits to those achieved by reducing smoking, inactivity, and overweight and obesity (Chau 2013). In this comparison, physical inactivity is defined as "doing no or very little physical activity at work, at home, for transport, or in discretionary time" (Bull 2004; WHO 2009). See Published notes.

Although several reviews have examined interventions to reduce sedentary time in children and young people, a paucity of systematic reviews in adults have been published. The reviews to date have often included interventions designed to increase physical activity but have also reported changes in sedentary time

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as unintended or secondary outcomes, rather than solely focusing on interventions that purposely aimed to reduce sedentary behaviour (Martin 2015; Prince 2014). A recent review found that the most promising interventions targeted sedentary behaviour instead of physical activity (Gardner 2016). The key difference between our review and these previous reviews is that we will examine only the effects of interventions to reduce sedentary behaviour on sedentary time and health outcomes in non-occupational settings (Martin 2015; Prince 2014; Shrestha 2016). A recent Cochrane Review examined interventions to reduce sitting time in the workplace setting (Shrestha 2016), another Cochrane Review is examining interventions for reducing sedentary behaviour in community-dwelling older adults (Chastin 2017), and two further Cochrane Reviews have examined workplace interventions for increasing standing or walking for preventing and decreasing musculoskeletal symptoms among sedentary workers (Parry 2017a; Parry 2017b). However, to our knowledge, there is only one published synthesis of evidence in non-occupational settings (Thraen-Borowski 2017), and a meta-analysis was not conducted in that review. As adults spend approximately 60% to 70% of their non-work time being sedentary (Clemes 2014; Parry 2013), there is great scope for intervention, and a synthesis of evidence on existing interventions will help guide this task. We believe that non-occupational settings may offer greater scope for changing sedentary behaviour than occupational settings, where individuals may have less control over their working environments and practices.

The need that policymakers and practitioners have for this Cochrane Review is evident in the focus on sedentary behaviour at the governmental level worldwide. This is also reflected in much being written in the media about the dangers of sitting. Countries are expanding their public health guidelines to include recommendations on limiting sedentary time (e.g. see Healthy Ireland 2016 and Sedentary Behaviour and Obesity Working Group 2010). This review will also provide key evidence for countries that seek to update existing sedentary behaviour guidelines in future years (e.g. Australian Government 2014). The findings of the review will therefore aid evidence-based decision-making by policymakers and practitioners working to address sedentary behaviour worldwide. This rapidly growing field will inform the development of public health policy over the coming decade, and a regularly updated, robust, comprehensive review of the evidence is required to support this task.

OBJECTIVES

Primary

- To assess effects on sedentary time of non-occupational interventions for reducing sedentary behaviour in adults under 60 years of age

Secondary

- To describe other health effects and adverse events or unintended consequences of these interventions
- To determine whether specific components of interventions are associated with changes in sedentary behaviour
- To identify if there are any differential effects of interventions based on health inequalities (e.g. age, sex, income, employment)

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials (RCTs) and cluster randomised controlled trials (cluster RCTs) aimed at changing sedentary behaviour. Given the growing volume of research on interventions targeting sedentary behaviour, particularly RCTs, we believe that solely including RCTs and cluster RCTs will allow us to draw conclusions from the best available evidence.

Types of participants

We included studies involving community-dwelling adults aged 18 to 59 years who are free from pre-existing medical conditions that may limit participation in the intervention.

Types of interventions

We included interventions targeted outside of workplace settings. Hypothetically, these may include interventions within domestic environments, transport, and the wider community. The following are examples of interventions that may be included in the review.

- Counselling/education to reduce and self-monitor sedentary behaviour.
- Limits/controls placed on screen time.
- Environmental change interventions, for example, point-of-decision prompts to encourage standing.
- Multi-component lifestyle interventions that include a sedentary behaviour element.
- Community-level interventions that specifically aim to address sedentary behaviour.

Interventions may be delivered at the individual, environmental, or policy level. We excluded interventions provided in workplace settings, as they fall under the scope of a separate Cochrane Review (Shrestha 2016). In addition, we excluded studies with participants 60 years of age and older, as another Cochrane Review is focusing on that age group (Chastin 2017). We also excluded studies that aim to improve physical activity levels but happen to report sedentary time, as they do not specifically target sedentary behaviour in their design.

Comparison was between those receiving the intervention and those receiving no intervention or attention controls.

Types of outcome measures

We included studies that report sedentary behaviour as a primary or secondary outcome.

Primary outcomes

The primary outcome is sedentary behaviour, assessed at baseline and post intervention. There is no international consensus on a gold standard measure of sedentary behaviour. With this in mind, we included studies that utilised device-based (e.g. accelerometer, inclinometer) or self-report (e.g. diary, questionnaire) measures of sedentary time. We included studies that report sedentary behaviour in one domain only, for example, sitting during transport or TV viewing at home, as well as those reporting total daily sedentary behaviour. We considered both total duration of

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sedentary behaviour reported and breaks in sedentary behaviour as primary outcome measures.

We included the following primary outcomes.

- Device-measured sedentary time.
- Self-report sitting time.
- Self-report TV viewing.
- Breaks in sedentary time.

Secondary outcomes

We included the following secondary outcome measures.

- Energy expenditure.
- Body composition (e.g. body mass index, waist and hip circumference, body fat percentage, body weight).
- Cholesterol (e.g. total cholesterol, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol).
- Markers of insulin resistance (e.g. fasting blood glucose, liver transaminases, insulin levels or insulin resistance/impaired insulin sensitivity).
- Inflammatory markers (e.g. C-reactive protein (CRP), interleukin (IL)-6, tumour necrosis factor (TNF)-α).
- Measures of carotid intima media thickness (e.g. ultrasound).
- Measures of endothelial function (e.g. peripheral arterial tonometry).
- Measures of mental health (e.g. stress symptoms, anxiety, depression, self-image).
  * Mood
  * Wellness
- Adverse events and symptoms (e.g. musculoskeletal injuries/pain, cardiovascular events).
- Unintended outcomes (e.g. social approval/disapproval by others, change in overall physical activity behaviour).
  * Device-measured moderate to vigorous physical activity (MVPA)
  * Self-report MVPA
  * Self-report light, moderate, vigorous, and total physical activity (PA)
  * Step count

Search methods for identification of studies

Electronic searches

We searched the following electronic databases up to 14 April 2020, using a search strategy developed by NR and EM in liaison with the Cochrane Public Health Group (CPHG) Trials Search Co-ordinator (see Appendix 1).

- CPHG Specialised Register.
- Cochrane Central Register of Controlled Trials (CENTRAL), in the Cochrane Library, Wiley.
- MEDLINE (Ovid MEDLINE Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE Daily and Ovid MEDLINE) (OvidSP) (1946 to present).
- Embase (OvidSP) (1974 to present).
- Cochrane Database of Systematic Reviews, in the Cochrane Library, Wiley.
- Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCOHost) (1982 to present).
- PsycINFO (OvidSP) (1806 to present).
- SportDiscus (EBSCOHost).

We did not impose any language, publication status, or date restrictions. We contacted trial authors and research groups for information about unpublished or ongoing studies.

Searching other resources

We handsearched reference lists of included studies and key systematic reviews. We searched the Clinicaltrials.gov trial register (http://clinicaltrials.gov) on 14 April 2020. We contacted authors of included studies and relevant systematic reviews to identify additional studies. In addition, we contacted experts in the field and asked them to identify further articles. We also searched the websites of organisations involved in addressing and reporting research on sedentary behaviour.

- Sedentary Behaviour Research Network (http://www.sedentarybehaviour.org).
- World Health Organization (http://www.who.int).
- US Centers for Disease Control and Prevention (http://www.cdc.gov).
- International Society for Physical Activity and Health (http://www.ispah.org).
- National Physical Activity Plan (http://www.physicalactivityplan.org).
- The Community Guide (http://www.thecommunityguide.org).
- European Commission, Public Health (https://ec.europa.eu/health/home_en).

NR and EM carried out the searches.

Data collection and analysis

Selection of studies

We downloaded the references retrieved through electronic searches and handsearching to the reference management software Endnote, removing duplicates (Endnote 2015). Two review authors (EM and MM) independently undertook an initial screening of titles and abstracts to exclude records outside the scope of the review. A third review author (CF) reviewed any items of disagreement to reach a consensus. We obtained full-text papers when we deemed titles to be relevant, or when eligibility was unclear. Inclusion decisions were based on the full texts of potentially eligible studies. Two review authors, working independently, determined whether each study met the eligibility criteria (EM and MM). When any disagreements occurred, a third review author (CF) examined the paper and the three review authors reached a consensus. We kept a record of reasons for excluding studies. If we identified papers detailing study design, study protocols, or process evaluations, we contacted the study authors to locate published or unpublished findings from the study. We collated multiple reports of the same study and treated each study as the unit of interest. We did not find any potentially relevant title of a paper in a language other than English, so we did not require translation services.

We used the online software Covidence to manage the study selection process (Covidence 2016).

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Data extraction and management

Two review authors (EM and KM) independently extracted study characteristics and outcome data using a modified version of the Public Health Group Data Extraction and Assessment Form. We consulted a third review author (CF) when disagreements occurred and we reached consensus among the three authors. All participating review authors piloted the Data Extraction and Assessment Form, modifying it where necessary to ensure comprehensiveness and comparability between results. We completed data extraction online using Covidence software and exported data directly to Review Manager 5 (Covidence 2016; RevMan 2014). When information was missing or when we needed clarification, we contacted the authors of included studies. We report relevant information in the Characteristics of included studies table. When we found multiple articles from the same study, we compared them for completeness and possible contradictions.

We extracted the following data.

- *Study objectives*: for example, to decrease sedentary time or to decrease sedentary time and increase physical activity.
- *Study design*: RCTs and cluster RCTs.
- *Methods*: study location, study setting, dates of study, duration of intervention, and duration of follow-up. We recorded how investigators measured sedentary behaviour, for example, by questionnaire/accelerometer.
- *Participants*: number randomised to each group, age, withdrawals. We extracted sociodemographic characteristics at baseline and at endpoint using the PROGRESS framework (Place, Race, Occupation, Gender, Religion, Education, Socioeconomic status, Social status).
- *Intervention*: content of intervention, description of comparison. We noted whether or not interventions included particular strategies to address diversity or disadvantage. We also noted the theoretical basis for the intervention when reported.
- *Outcomes*: outcome measures post intervention and at follow-up when available. We noted whether clustering was taken into account in cluster RCTs. When data on multiple measures of the same or similar outcomes were available, for example, body composition measures of body mass index (BMI) and body fat percentage, we recorded both.
- *Notes*: funding received and conflicts of interest as declared by study authors.

In addition to study characteristics and outcomes data, we collected from included studies any available information about context, implementation factors, equity, cost, and sustainability and reported it in the Characteristics of included studies table (CPHG 2011). We view sustainability of the interventions as a combination of intervention components (dose) and magnitude of effect over time. We collected any available data related to sustainability (e.g. follow-up measures) and assessed the data using an adapted version of the approach adopted by Müller-Riemenschneider 2008. We included potential moderators and confounders of study outcomes, such as age, race, and gender, on the Data Extraction and Assessment Form.

For several studies, it was necessary to process data in preparation for analysis. For example, in four studies, sedentary time was converted from hours per day to minutes per day (Barwais 2013; Biddle 2015; French 2011; Laska 2016). To calculate the mean device-measured MVPA in Ellingson 2016, we summed the mean values reported for moderate PA and vigorous PA. For Arrogi 2017, we calculated the mean value for device-measured sedentary time by obtaining the average of weekday and weekend day results reported in the paper. We utilised the same methods to calculate mean device-measured MVPA in Jago 2013.

In Finni 2011, three of the time points for data collection (6, 9, and 12 months) would all be considered as medium-term follow-up in the present review (i.e. > 4 months to 12 months). We used the data collected at 12 months as the medium-term value for subgroup analysis. Similarly, Williams 2019 reported data at 17 weeks and 6 months; we used the data collected at 6 months in our analysis.

Assessment of risk of bias in included studies

Two review authors (EM and KM) independently assessed risk of bias using the Cochrane 'Risk of bias' tool (Higgins 2011a). When disagreements occurred, a third review author (MM) reviewed the studies, and review authors together reached consensus by discussion. This tool assesses:

- selection bias (sequence generation and allocation concealment);
- performance bias (blinding of participants and personnel);
- detection bias (blinding of outcome assessment);
- attrition bias (incomplete outcome data); and
- reporting bias (selective reporting).

We graded each domain as being at 'low', 'high', or 'unclear' risk of bias.

We considered blinding separately for different key outcomes when necessary, for example, the risk of bias for sitting measured by means of an inclinometer may be very different from that for a self-reported reduction in sitting time (Shrestha 2016). We did not consider blinding of participants and personnel for risk of bias assessment, as it is not possible to blind these individuals in studies examining attempts to modify activity behaviour (Shrestha 2014). We considered the following additional criteria for cluster RCTs, as recommended in Section 16.3.2 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011b): recruitment bias; baseline imbalance; loss of clusters; incorrect analysis; and comparability with individually randomised trials.

We summarised risk of bias at the outcome level and judged each outcome as being at 'low', 'medium', or 'high' overall risk, given the study design and the potential impact of identified risks noted in the table for each study that contributed results for that outcome (CPHG 2011).

Measures of treatment effect

For studies with continuous outcome measures, we reported mean scores and standard deviations. We used the mean difference between post-intervention values of intervention and control groups to analyse the size of the effects of interventions. For cluster RCTs we used the adjusted MD between groups.

Unit of analysis issues

We identified one study with multiple intervention groups (Kitagawa 2020). We pooled the intervention arms into one group to create a single pair-wise comparison, as recommended in

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Section 16.5.4 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011b). This method avoids including a group of participants twice in the same meta-analysis. All of the included cluster RCTs made allowance for the design effect of clustering; therefore it was not necessary to re-analyse data.

Dealing with missing data

We contacted study authors via email when data were missing or unclear (to request e.g. missing information on methods, missing participants due to dropout, and missing statistics). We retrieved email addresses from author information provided in the study publication and, when necessary, accessed contact directories from the authors' documented affiliated organisations. We noted missing data on the data extraction form and reported this in the 'Risk of bias' table. If numerical outcome data such as standard deviations or correlation coefficients were missing, and we could not obtain them from the study authors, we calculated these values from other available statistics such as P values, according to the methods described in Chapter 16 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011b; Shrestha 2014). We used the RevMan calculator to determine standard deviation (SD) from standard error (SE) for several studies (Biddle 2015; Laska 2016; Williams 2019). Similarly, for French 2011, we used the SE of the mean difference to calculate the SD in intervention and control groups post intervention. For outcomes that are reported narratively, we used the RevMan calculator to determine MD for several studies (Barwais 2013; Cotten 2016; Ellingson 2016; French 2011; Sui 2018).

Assessment of heterogeneity

We considered methodological heterogeneity by assessing differences between included studies in terms of study design. We considered clinical heterogeneity by assessing variability among participants, interventions, and outcomes, as recorded in the Characteristics of included studies table. We visually inspected forest plots to assess statistical heterogeneity and used the I^2 statistic to quantify the level of heterogeneity present ($P < 0.10$). This describes the percentage of variability in effect estimates due to heterogeneity rather than to sampling error (chance) (Deeks 2011). We planned to perform sensitivity analyses to investigate heterogeneous results; however due to the number of included studies, we did not conduct these analyses.

Assessment of reporting biases

As we included fewer than 10 studies per outcome, we could not use funnel plots to assess reporting bias, as the power of these tests would be too low to distinguish chance from real asymmetry (Sterne 2011).

Data synthesis

Given that participants, interventions, and comparisons were sufficiently similar, we conducted a meta-analysis using RevMan 5. We used the random-effects model, as it allows for a greater level of natural heterogeneity between studies. The appropriate method of meta-analysis depends on the nature of the data, and we followed the guidelines presented in Chapter 9 ("Analysing data and undertaking meta-analyses") of the *Cochrane Handbook for Systematic Reviews of Interventions* (Deeks 2011). We included data from cluster randomised trials in meta-analyses, as trial authors had taken clustering into account. We were unable to examine the effects of interventions according to types of intervention, as all were provided at the individual level.

When it was not possible to conduct a meta-analysis, we reported results narratively. We grouped the data by outcome, as this makes the most sense for the reader. We presented data in tables and summarised results narratively.

We created Summary of findings table 1 for the main comparisons. Summary of findings table 1 includes the numbers of participants and studies for the primary outcomes (device-based and self-report measures of sedentary behaviour), summarises the intervention effects, and includes a measure of the certainty of evidence (see Quality of the evidence section below). We also reported the following secondary outcomes as they were deemed most relevant: device-measured MVPA, self-report light PA, steps.

We identified the theoretical frameworks and models identified in the primary studies. We considered costs and sustainability of studies in preparing the synthesis.

Subgroup analysis and investigation of heterogeneity

Given the small number of common outcomes across studies, we were unable to conduct the planned range of subgroup analyses for our primary outcome to see if there was any evidence of differential responses to the intervention. We included subgroup analysis for length of follow-up. When studies reported several follow-up points, we included data from each relevant time point. In addition, we assessed subgroup heterogeneity by examining forest plots and quantification by using the I^2 statistic.

Had sufficient data been available, we planned to carry out the following subgroup analyses for our primary outcome to see if there was any evidence of differential responses to interventions.

- *Intervention type*: e.g. personal monitoring device, information/education, counselling, text messages or combinations of these categories.
- *Gender*: given the unique sedentary behaviour profiles of men and women (Bennie 2013; Matthews 2008), and the fact that interventions to reduce sedentary behaviour seem to have limited effects when targeting women only (Martin 2015), outcomes by gender should be examined (men, women, men and women).
- *Socioeconomic group* (education or income): because variations in response to public health interventions according to socioeconomic status are frequent (White 2009), outcomes by socioeconomic group should be compared. It has been noted that high levels of education are associated with higher levels of sitting (Bennie 2013).
- *Age*: subgroup analysis to consider the influence of the age of participants.
- *Intensity of the intervention*: using an adapted version of the approach used by Baker 2015.
- *Category of study setting*: as interventions may be setting-specific, the influence of study setting should be considered (e.g. schools/universities, transport, home).
- *BMI or another measure of overweight/obesity*: to consider the influence of body composition given the evidence that associations between prolonged sitting and risk of CVD are

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stronger in overweight than in normal weight adults (Chomistek 2013).

- *Study aim*: as previous reviews have demonstrated differential effects between interventions that solely aim to reduce sedentary behaviour or that take a combined approach to reducing sedentary behaviour and increasing physical activity (Gardner 2016; Martin 2015), subgroup analysis to compare outcomes by study intention are warranted.
- *Baseline sedentary status*: as daily sedentary time for adults varies across studies (Bennie 2013), whether baseline sedentary level has an influence on outcomes should be investigated.
- *Baseline physical activity*: influence of baseline physical activity level should be considered.

Sensitivity analysis

Given the small number of studies included in the review, we did not undertake sensitivity analysis. Had sufficient data been available, we planned to use sensitivity analysis for primary outcomes to explore the impact of risk of bias on study findings, while excluding studies at high or unclear risk of bias.

Summary of findings and assessment of the certainty of the evidence

We used the GRADE system to assess the certainty of the body of evidence for each outcome, and to draw conclusions about this within the text of the review. The certainty of a body of evidence as assessed by GRADE is understood as the extent to which one can be confident in the estimate of effect (Guyatt 2008). We summarised the assessment in a 'Summary of findings' table created with GRADEpro software (GRADEpro GDT). Two review authors independently assessed outcomes across studies (EM and KM). We resolved disagreements by consensus.

We rated evidence as very low, low, moderate, or high certainty by considering the GRADE domains. Table 1 presents definitions for these ratings (Balshem 2011). The GRADE approach to rating the quality of evidence begins with the study design (randomised trials start as high quality) and then addresses five reasons to possibly downgrade the quality of evidence (Balshem 2011). The five factors that may lead to downgrading the certainty of evidence are:

- study limitations - risk of bias;
- publication bias - available evidence derived from a number of small studies;
- imprecision - random error;
- inconsistency - inconsistency in the magnitude of effect in studies of alternative management strategies (Guyatt 2011a); and
- indirectness - indirect participants, interventions, outcomes, or comparisons.

If one of these factors is found to exist, it is classified either as serious (rating down by one level) or as very serious (rating down by two levels). We followed guidance from Ryan 2016 when incorporating the GRADE ratings into the results of the review, so that the certainty of evidence is clear.

RESULTS

Description of studies

See Characteristics of included studies, Characteristics of excluded studies, Characteristics of ongoing studies.

Results of the search

Our searches to 14 April 2020 yielded 21,100 hits from electronic databases and 79 from other studies. This resulted in 10,976 hits following removal of duplicates (Figure 2). The full search strategies and the number of hits for the eight electronic databases and the clinical trials registry can be found in the Appendices. After reading titles and abstracts, we excluded 10,799 records and selected 177 reports for full-text review. Of these, we excluded 144 reports. We collated multiple reports of the same study, with the paper that reported the outcomes of particular note to this review chosen as the main source of study results. We identified 24 reports, representing 13 unique studies, for inclusion in this review (Arrogi 2017; Barwais 2013; Biddle 2015; Cotten 2016; Ellingson 2016; Finni 2011; French 2011; Jago 2013; Kitagawa 2020 Laska 2016; Lioret 2012; Sui 2018; Williams 2019). In addition, we identified eight studies that are classified as ongoing (NCT02909725; ISRCTN58484767; NCT03698903; Latomme; Martin Borras 2014; NCT04257539; Pinto 2017; Schroe 2019). For one study, we could not locate a full-text version (Marcinkevage 2012), and we categorised this as a study awaiting classification (see Characteristics of studies awaiting classification).

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Figure 2. Study flow diagram.

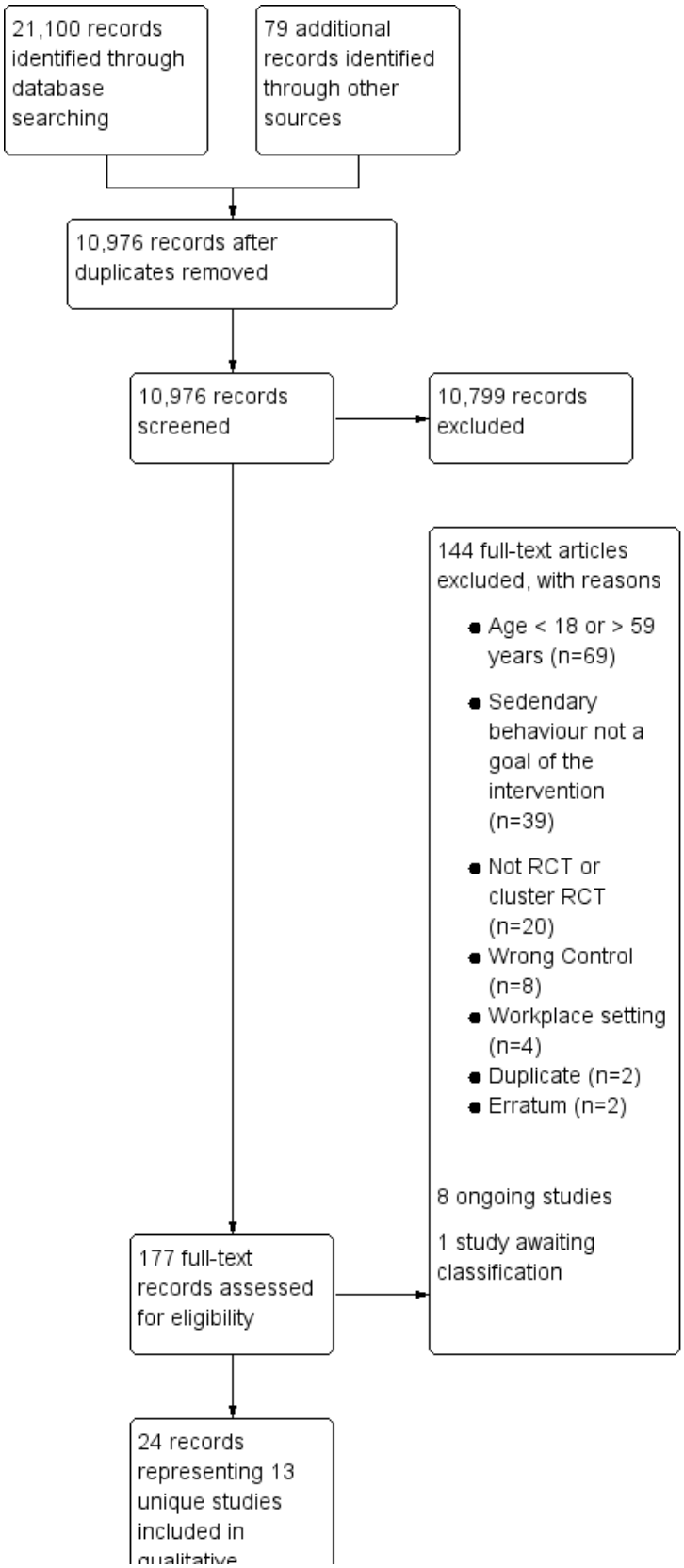

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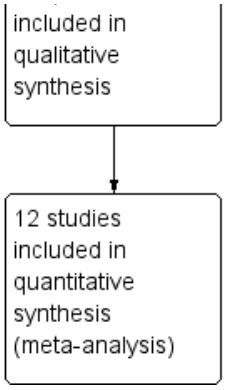
Figure 2. (Continued)



We sent requests to the authors of several studies to obtain additional data or to clarify data (Biddle 2015; Finni 2011; French 2011; Marcinkevage 2012; Martin Borras 2014). We received unpublished data from the authors of two studies (Biddle 2015; Finni 2011).

Included studies

Design

Ten studies are RCTs (Arrogi 2017; Barwais 2013; Biddle 2015; Cotten 2016; Ellingson 2016; Jago 2013; Kitagawa 2020; Laska 2016; Sui 2018; Williams 2019), and three are cluster RCTs (Finni 2011; French 2011; Lioret 2012). See the Characteristics of included studies table for further information. All of the cluster RCTs reported adjusted results; therefore re-analysis of data was not required. One study included multiple intervention groups (Kitagawa 2020).

Setting

Settings for all studies were outside the workplace and included home/community (Arrogi 2017; Finni 2011; Jago 2013; Kitagawa 2020; Lioret 2012), online (Barwais 2013), primary care (Biddle 2015; Williams 2019), university (Cotten 2016; Ellingson 2016; French 2011; Sui 2018), and community college (Laska 2016).

Three studies were undertaken in the United States (Ellingson 2016; French 2011; Laska 2016), three in the United Kingdom (Biddle 2015; Jago 2013; Williams 2019), two in Australia (Barwais 2013; Lioret 2012), and two in Canada (Cotten 2016; Sui 2018). Finally, one study each was undertaken in Belgium, Finland and Japan (Arrogi 2017; Finni 2011, Kitagawa 2020 respectively),

Participants

The included studies involved 1770 participants. Sample sizes ranged from 30 participants in Ellingson 2016 to 542 participants in Lioret 2012. In nine studies, a majority of participants were female (Arrogi 2017; Biddle 2015; Cotten 2016; Finni 2011; French 2011; Jago 2013; Laska 2016; Lioret 2012; Sui 2018). One study reported that there was not a considerable difference in the proportions of males and females (Ellingson 2016). Another two studies included only females (Kitagawa 2020; Lioret 2012). The mean age of study participants ranged from 20 years in Ellingson 2016 to 41 years in French 2011. Five of the studies involved participants in their 20's (Barwais 2013; Cotten 2016; Ellingson 2016; Laska 2016; Sui 2018). Several studies targeted the family (Finni 2011; Jago 2013; Lioret 2012).

Few studies provided sociodemographic characteristics, apart from gender, using the PROGRESS framework (Place, Race, Occupation, Gender, Religion, Education, Socioeconomic status, Social status). Six studies noted the occupation of participants (97% officer workers in Arrogi 2017; 63% officer workers in Barwais 2013; 100% housewives in Kitagawa 2020; 100% university students in Cotten 2016, Ellingson 2016, and Sui 2018). Six studies reported race/ethnicity (Biddle 2015; Ellingson 2016; French 2011; Jago 2013; Laska 2016; Williams 2019). Biddle 2015 reported that participants were recruited from areas with a diverse ethnic and socioeconomic makeup. Two studies reported income data of participants (French 2011; Laska 2016). Education level was reported in one study (Lioret 2012).One study purposively recruited adults with a diagnosis of a serious mental illness (Williams 2019)

Interventions

Nine studies aimed to reduce sedentary behaviour (Arrogi 2017; Biddle 2015; Cotten 2016; Ellingson 2016; Finni 2011; French 2011; Jago 2013; Kitagawa 2020; Sui 2018), and four sought to both reduce sedentary behaviour and increase physical activity levels (Barwais 2013; Laska 2016; Lioret 2012; Williams 2019). All interventions were delivered at the individual level (i.e. none were considered environmental or policy activities) (see Figure 1). Table 2 provides a summary of the interventions. Three studies used a personal monitoring device (Arrogi 2017; Barwais 2013; Kitagawa 2020). Several studies included some form of information or education (French 2011; Laska 2016; Lioret 2012; Jago 2013), or some type of counselling (Finni 2011; Sui 2018). Two studies included both information/education and a personal monitoring device (Biddle 2015; Ellingson 2016). One study incorporated information/education, a personal monitoring device and counselling (Williams 2019). One study sent daily text messages to participants (Cotten 2016).

In terms of sustainability of the interventions, five included a follow-up measure of at least 12 months (Biddle 2015; Finni 2011; French 2011; Laska 2016; Lioret 2012).

Control group

The comparison group in five studies was a no intervention control (Arrogi 2017; Barwais 2013; Finni 2011; French 2011; Jago 2013), with one of these specifically instructing participants to follow their normal daily lifestyle patterns (Barwais 2013). Other studies provided information leaflets to the control group regarding sedentary behaviour (Biddle 2015; Kitagawa 2020), or consisting

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of basic health promotion information (Laska 2016; Lioret 2012; Williams 2019). Three studies used attention control. In one study, participants received daily text messages about random health facts (Cotten 2016), and in another study, participants were given an accelerometer to wear without feedback (Ellingson 2016). Finally in one study, the control group was given strategies to achieve Canada's Food Guide weekly food group servings (Sui 2018).

Outcomes

Primary outcomes

We found 13 studies that reported using two principal forms of continuous outcomes - device-derived and self-reported. These were categorised into three groups: device-measured sedentary time, self-reported TV viewing, and self-reported sitting time.

Self-report measures of sedentary behaviour were utilised in nine studies, device-based measures were used in four studies, and a further two studies used both. Seven studies used a questionnaire (Biddle 2015; Ellingson 2016; French 2011; Jago 2013; Laska 2016; Lioret 2012; Sui 2018). Two studies used the 7-Day Sedentary and Light Intensity Physical Activity Log (7-Day SLIPA Log) (Barwais 2013; Cotten 2016); however in the study by Cotten and colleagues, participants were asked to fill out the items based on a typical weekday and a typical weekend day, rather than on a daily basis. Six studies used a device-based measure of sedentary time (Arrogi 2017; Biddle 2015; Ellingson 2016; Finni 2011; Kitagawa 2020; Williams 2019). Three of these studies used a thigh-worn device that measured posture (Arrogi 2017; Biddle 2015; Ellingson 2016) and two studies used a waist-worn accelerometer (Biddle 2015; Finni 2011), with both using < 100 counts per minute (cpm) as the definition of sedentary. Two further studies used a wrist-worn accelerometer (Kitagawa 2020; Williams 2019). Note that two of the aforementioned studies included both a device-based and a self-report measure of sedentary behaviour (Biddle 2015; Ellingson 2016).

Six studies reported total sedentary time (Arrogi 2017; Barwais 2013; Biddle 2015; Ellingson 2016; Finni 2011; Williams 2019). Several other studies reported sedentary behaviour in one domain only: TV viewing (French 2011; Jago 2013; Laska 2016), or TV, video, and DVD viewing (Lioret 2012). Biddle 2015 reported sedentary behaviour separately for multiple domains: daily sitting time, sitting while travelling, sitting at work, sitting while watching TV, sitting while using a computer at home, and sitting in leisure time. One study reported longest prolonged sitting time (Kitagawa 2020). Five studies presented findings in relation to breaks in sedentary time. Two of these studies reported frequency of breaks in sedentary time (i.e. breaks every X minutes) (Cotten 2016; Sui 2018), and three studies reported number of breaks per hour or day in sedentary time (Arrogi 2017; Biddle 2015; Finni 2011). Arrogi 2017 defined breaks as the number of sit-to-stand transitions. Biddle 2015 reported bouts of light to vigorous physical activity as breaks in sedentary time. Finni 2011 defined a break as "an interruption in sedentary time when accelerometer counts rose up to or above 100 counts/min for a minimum of one minute".

Secondary outcomes

We found one study that reported energy expenditure; this was reported specifically in relation to leisure-time physical activity and was assessed using the Paffenbarger Questionnaire (Laska 2016).

Several studies reported measures of body composition. Two of these reported body fat data; one used total fat mass percentage measured using dual-energy X-ray absorptiometry (Finni 2011), and the other reported body fat percentage measured used bioelectrical impedance analysis (Biddle 2015). Three studies reported BMI (Biddle 2015; Finni 2011; French 2011), two studies provided data on weight (Biddle 2015; Finni 2011) and two studies reported waist circumference (Biddle 2015; Williams 2019).

Only one study reported cholesterol as an outcome measure (Biddle 2015). Two studies provided data on glucose control and insulin sensitivity (Biddle 2015; Finni 2011). Both reported fasting glucose and fasting insulin. In addition, Biddle 2015 reported two-hour post-challenge glucose and glycosylated haemoglobin (HbA1c). Finni 2011 included homeostatic model assessment of insulin resistance (HOMA-IR) and homeostatic model assessment of β-cell function (HOMA-%B).

One study included mood state as an outcome variable and used a Profle of Mood State (POMS) to assess mood over the course of the previous week (Ellingson 2016). Another study assessed wellness using an online version of the Wellness Evaluation of Lifestyle (WEL) inventory (Barwais 2013).

Five studies reported MVPA as measured by an accelerometer (Biddle 2015; Ellingson 2016; Finni 2011; Jago 2013; Williams 2019). Different methods of classifying moderate and vigorous physical activity were used across studies. Two studies used widely known cut-points developed by Freedson and Troiano and colleagues (Biddle 2015; Freedson 1998; Jago 2013; Troiano 2008). Finni 2011 used cut-points calibrated from Troiano 2008. Ellingson 2016 employed the sojourn method (Lyden 2014) and Williams used the thresholds developed by Esliger 2011.

Self-report physical activity was measured in several studies using a variety of assessment tools including the 7-Day Sedentary and Light-Intensity Physical Activity (SLIPA) Log (Barwais 2013; Cotten 2016), the seven-day physical activity recall questionnaire (Cotten 2016), an unspecified physical activity questionnaire (Lioret 2012), the short form of the International Physical Activity Questionnaire (IPAQ) (Barwais 2013; Biddle 2015), and a modified version of the long-form IPAQ (French 2011). Ellingson 2016 did not report which version of IPAQ was used. Note that some studies used several self-report instruments, with each assessing activities of different intensity.

Three studies reported step counts per day. One of these studies measured steps using a thigh-worn ActivPAL accelerometer (Arrogi 2017), another measured steps using the waist-worn Actigraph GT3X accelerometer (Biddle 2015) and the third measured steps using a wrist-worn UP24 accelerometer Kitagawa 2020.

Duration of follow-up varied across studies. In seven studies, the duration of longest follow-up was four months or less (Arrogi 2017; Barwais 2013; Cotten 2016; Ellingson 2016; Jago 2013; Kitagawa 2020; Sui 2018); these were defined as providing short-term follow-up. Four studies conducted a follow-up measure between 4 and 12 months (Biddle 2015; Finni 2011; French 2011; Williams 2019); these were considered to provide medium-term follow-up. We categorised studies with a follow-up measure longer than 12 months as providing long-term follow-up. Only two studies met this criteria (Laska 2016; Lioret 2012). If studies reported multiple

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follow-up time points, the data for each time point were pooled as appropriate with short-, medium- or long-term studies.

Excluded studies

See Characteristics of excluded studies.

Risk of bias in included studies

Risk of bias varied across studies (Figure 3). No study was judged to be at low risk of bias across all domains (Figure 4). Only one study was assessed as having low risk of bias in six of the seven domains (Biddle 2015).

Figure 3. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

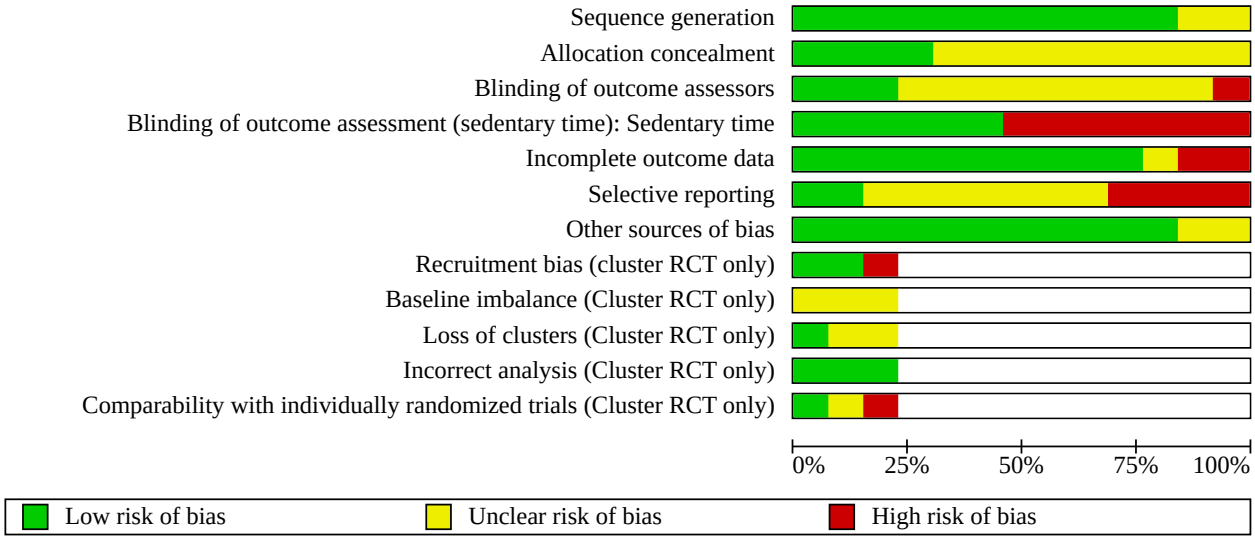

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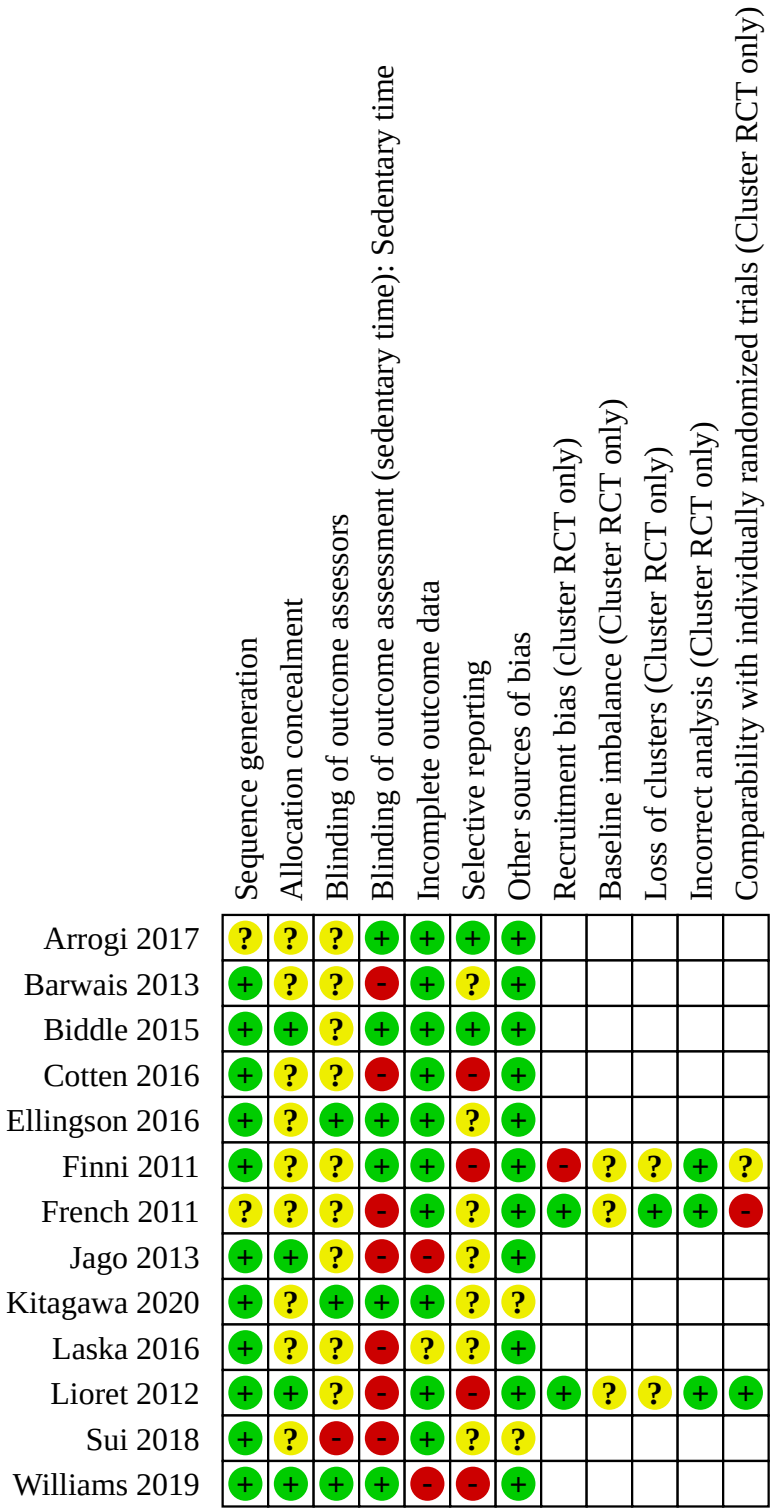
Figure 4. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



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Allocation

Most studies described a random component in the sequence generation process (Barwais 2013; Biddle 2015; Cotten 2016; Ellingson 2016; Finni 2011 Jago 2013; Kitagawa 2020; Laska 2016; Lioret 2012; Sui 2018; Williams 2019); we therefore judged them to be at low risk of bias. Methods included utilising a random number generator (Barwais 2013; Cotten 2016; Ellingson 2016; Lioret 2012), a computer-generated list or sequence (Biddle 2015; Jago 2013; Kitagawa 2020; Laska 2016), a web service (Sui 2018; Williams 2019), and coin flipping (Finni 2011).

The remaining two studies did not provide sufficient information to permit a judgement (Arrogi 2017; French 2011).

Selection bias due to inadequate concealment of allocations before group assignment was judged as having unclear risk in nine studies due to failure to provide sufficient information to assign a judgement of low or high risk (Arrogi 2017; Barwais 2013; Cotten 2016; Ellingson 2016; Finni 2011; French 2011; Kitagawa 2020; Laska 2016; Sui 2018). Four studies reported appropriate methods used to conceal allocation to intervention or control and were therefore judged as having low risk of bias (Biddle 2015; Jago 2013; Lioret 2012; Williams 2019). Allocation was determined by an independent statistician (Biddle 2015; Jago 2013; Lioret 2012) or researcher (Williams 2019).

Blinding

Due to the nature of the intervention, performance bias was not considered for this review. For detection bias, we considered outcome assessment and outcome assessors separately.

For outcome assessment, six studies included a device-based measure of sedentary behaviour (Arrogi 2017; Biddle 2015; Ellingson 2016; Finni 2011; Kitagawa 2020; Williams 2019); these were judged to be at low risk of bias. Seven studies used only self-report measures of sedentary behaviour, and we judged these to have high risk of bias for outcome assessment (Barwais 2013; Cotten 2016; French 2011; Jago 2013; Laska 2016 Lioret 2012; Sui 2018).

Regarding blinding of outcome assessors, three studies reported any level of blinding to group assignment among those responsible for data entry or analysis. We therefore judged Ellingson 2016, Kitagawa 2020 and Williams 2019 to be at low risk of bias. Sui 2018 stated that assessors were not blinded to group allocation, and we judged this study to be at high risk of bias. As the remaining studies did not report on blinding, we judged them to have unclear risk of bias (Arrogi 2017; Barwais 2013; Biddle 2015; Cotten 2016; Finni 2011; French 2011; Jago 2013; Laska 2016; Lioret 2012).

Incomplete outcome data

Ten studies were judged to be at low risk for attrition bias. Missing data were similar across groups in seven of these studies (Arrogi 2017; Biddle 2015; Cotten 2016; Finni 2011; French 2011; Lioret 2012; Sui 2018). In Barwais 2013 and Kitagawa 2020 there did not appear to be any missing data. In Ellingson 2016, the reasons provided for missing data were unlikely to be related to the outcome.

Two studies were judged to have high risk of attrition bias, as dropout was not balanced across intervention and control groups (Jago 2013; Williams 2019).

Laska 2016 was considered to be at unclear risk of bias, as reporting of attrition was insufficient to permit a judgement.

Selective reporting

We judged the majority of studies to be at unclear risk for reporting bias as information was insufficient to permit a judgement of high or low risk (Barwais 2013; Ellingson 2016; French 2011; Jago 2013; Kitagawa 2020; Laska 2016; Sui 2018). Three studies were deemed to be at high risk of bias (Cotten 2016; Lioret 2012; Williams 2019). In the case of Lioret 2012 and Williams 2019, some variables outlined in the protocol were not reported. Another study reported that the self-reported sitting measure was not included in the analysis, and this decision was made after data collection (Cotten 2016).

Other potential sources of bias

We judged the majority of studies to have low risk of other potential sources of bias (Arrogi 2017; Barwais 2013; Biddle 2015; Ellingson 2016; Finni 2011; French 2011; Jago 2013; Laska 2016; Lioret 2012; Williams 2019). Cotten 2016 was deemed to be at high risk of bias as not all instruments used were established validated tools of sedentary behaviour. The remaining two studies were deemed as having unclear risk of bias due to insufficient information to assess whether an important risk of bias exists (Kitagawa 2020; Sui 2018).

Additional risk of bias domains for cluster RCTs

Five additional items were considered for cluster RCTs: recruitment bias; baseline imbalance; loss of clusters; incorrect analysis; and comparability with individually randomised trials.

We judged two studies to be at low risk of recruitment bias (French 2011; Lioret 2012). In Finni 2011, recruitment occurred after randomisation of clusters, and this study was considered to be at high risk of bias.

For baseline imbalance, information was insufficient to permit a judgement of high or low risk; therefore all studies were deemed to be at unclear risk of bias.

French 2011 reported similar dropout across groups; we judged this study to have low risk of bias in relation to loss of clusters. For Finni 2011 and Lioret 2012, information was insufficient to permit a judgement of high or low risk; we therefore judged these studies as having unclear risk of bias.

We judged all three cluster RCTs to have low risk of bias for incorrect analysis (Finni 2011; French 2011; Lioret 2012), as all reported adjusted results.

Regarding the risk of bias associated with comparability with individually randomised trials, one study was considered as having low risk of bias because clustering took place at the level of parent groups, and therefore contamination between groups was unlikely (Lioret 2012). In French 2011, households were recruited from various sites in the community; therefore the possibility of contamination existed. We judged this study as having high risk of bias. Finally, for Finni 2011, information was insufficient to permit a judgement of high or low risk, and this study was therefore deemed to be at unclear risk of bias.

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Effects of interventions

See: **Summary of findings 1** Intervention compared to Control for reducing sedentary behaviour in adults under 60

See Summary of findings 1 for the main comparison. We present results using only outcomes for which data were available. We were unable to address all of the secondary objectives set for this review due to lack of available data.

Primary outcomes

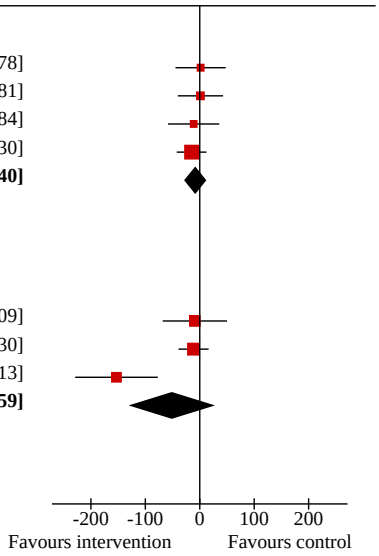
We pooled studies according to outcome measures.

Device-measured sedentary time

We pooled four studies that compared effects of the intervention versus control on device-measured sedentary time with short-term follow-up (up to four months) (Arrogi 2017; Biddle 2015; Ellingson 2016; Finni 2011). The interventions probably made little or no difference in device-measured sedentary time in adults under 60 years of age (mean difference (MD) -8.36 min/d, 95% confidence interval (CI) -27.12 to 0.40; I^2 = 0%; Analysis 1.1; Figure 5). Results were imprecise due to wide confidence intervals and small sample sizes. Overall the certainty of evidence was moderate; therefore further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Figure 5. Forest plot of comparison: 1 Intervention vs control, outcome: 1.1 Device-measured sedentary time (min/day)

Study or Subgroup	MD	SE	Intervention Total	Control Total	Weight	Mean Difference IV, Random, 95% CI
1.1.1 Short-term follow-up (up to 4 months)						
Arrogi 2017	0	23.5631	27	27	16.5%	1.60 [-44.58 , 47.78]
Biddle 2015	0	21.23	34	35	20.3%	1.20 [-40.41 , 42.81]
Ellingson 2016	0	24.0008	15	13	15.9%	-11.20 [-58.24 , 35.84]
Finni 2011	0	13.9288	57	54	47.2%	-15.00 [-42.30 , 12.30]
Subtotal (95% CI)			**133**	**129**	**100.0%**	**-8.36 [-27.12 , 10.40]**
Heterogeneity: Tau² = 0.00; Chi² = 0.62, df = 3 (P = 0.89); I² = 0%						
Test for overall effect: Z = 0.87 (P = 0.38)						
1.1.2 Medium-term follow-up (> 4 months to 12 months)						
Biddle 2015	0	30.1496	32	29	32.6%	-9.00 [-68.09 , 50.09]
Finni 2011	0	14.1329	54	52	38.7%	-11.40 [-39.10 , 16.30]
Williams 2019	0	38.7119	8	13	28.8%	-153.00 [-228.87 , -77.13]
Subtotal (95% CI)			**94**	**94**	**100.0%**	**-51.37 [-126.34 , 23.59]**
Heterogeneity: Tau² = 3584.12; Chi² = 12.14, df = 2 (P = 0.002); I² = 84%						
Test for overall effect: Z = 1.34 (P = 0.18)						
Test for subgroup differences: Chi² = 1.19, df = 1 (P = 0.28), I² = 16.0%						



Three studies provided data for medium-term follow-up (longer than 4 to 12 months) (Biddle 2015; Finni 2011; Williams 2019). We are uncertain whether interventions reduce device-measured sedentary time in the medium term (MD -51.37 min/d, 95% CI -126.34 to 23.59; I^2 = 84%; Analysis 1.1; Figure 5). Results were imprecise due to wide confidence intervals and small sample sizes. In addition we had concerns about risk of bias, with two studies having high risk of bias for several domains. There was also a large variation in effect. The certainty of evidence was very low; therefore any estimate of effect is very uncertain.

Self-report sitting time

We are uncertain whether interventions outside the workplace reduces self-reported sitting time in the short term. Evidence was drawn from two studies with 61 participants (Barwais 2013; Ellingson 2016) (MD -64.12 min/d, 95% CI -260.91 to 132.67; I^2 = 86%; Analysis 1.2; Figure 6). We had concerns about risk of bias, as several domains were judged to be unclear and outcomes assessment was at high risk of bias. Results were inconsistent due to large variation in effect and high levels of heterogeneity. Both studies recruited participants who reported high levels of sedentary behaviour and employed interventions of similar duration using personal activity monitors. It is unclear why the direct effect was different. In addition, imprecision was evident due to the wide confidence intervals and small sample sizes. Overall the certainty of evidence was very low; therefore any estimate of effect is very uncertain.

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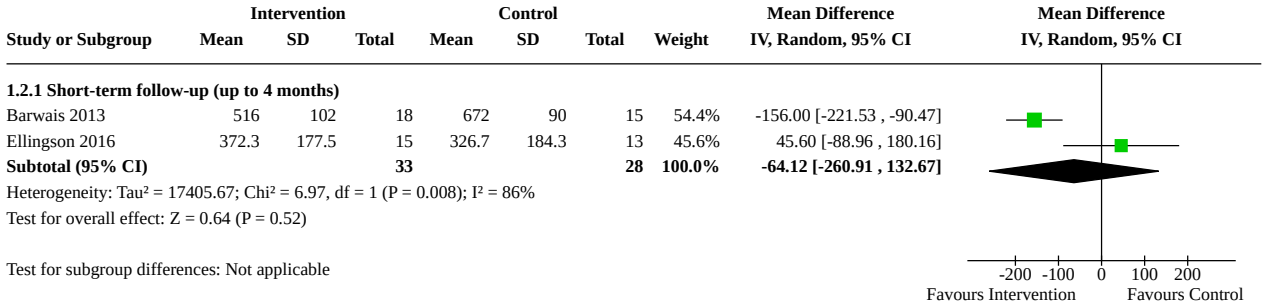
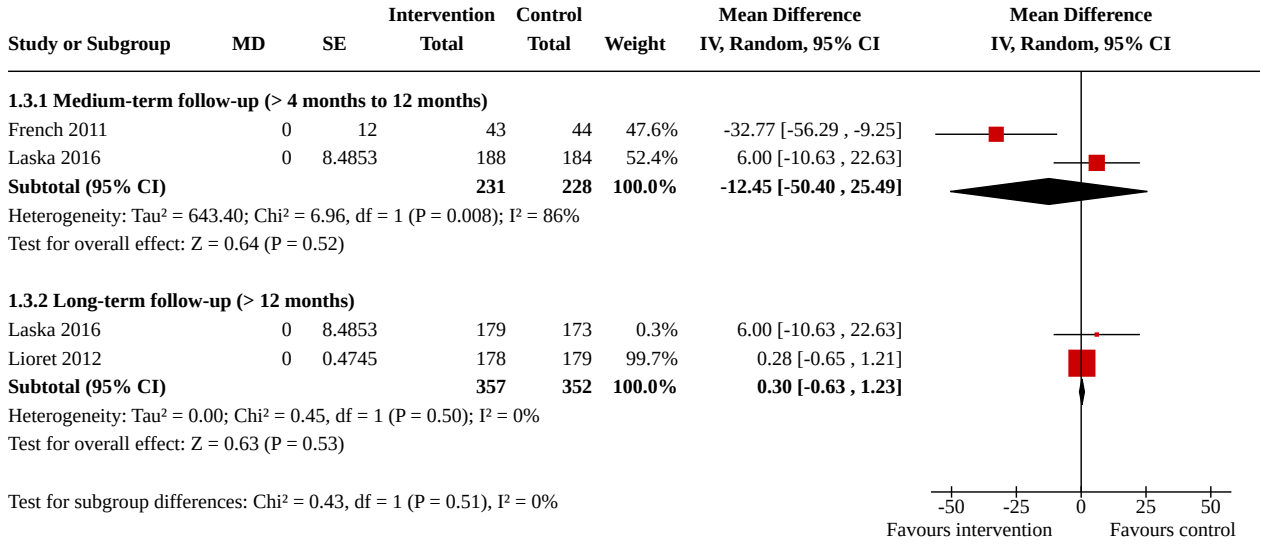
Figure 6. Forest plot of comparison: 1 Intervention vs control, outcome: 1.2 Self-report sitting time (min/d).



Self-report TV viewing time

Interventions outside the workplace may make little or no difference in self-reported TV viewing in the medium term (MD -12.45 min/d, 95% CI -50.40 to 25.49; I^2 = 86%; Analysis 1.3; Figure 7). We pooled two studies with 459 participants that recorded data at medium-term follow-up (French 2011; Laska 2016). The width of confidence intervals raises concerns about imprecision. We determined that studies were at high risk of bias for outcome assessment, and we judged several other domains to be unclear.

Figure 7. Forest plot of comparison: 1 Intervention vs control, outcome: 1.3 Self-report TV viewing time (min/day)



We pooled two studies that provided data for the comparison at long-term follow-up (> 12 months) (Laska 2016; Lioret 2012). Interventions may make little or no difference in self-report TV viewing in the long term (MD 0.30 min/d, 95% CI -0.63 to 1.23; I^2 = 0%; Analysis 1.7; Figure 7). Sample sizes were large, but the large confidence intervals led to uncertainty. There was high risk of bias for outcome assessment, and we judged several other domains to be at unclear risk.

Overall the certainty of evidence for self-report TV viewing time was low; therefore 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.

Breaks in sedentary time

It was not possible to pool all studies that reported breaks in sedentary time given the variation in the definition used for a "break" (Arrogi 2017; Biddle 2015; Cotten 2016; Finni 2011; Sui 2018). Table 3 provides a summary of data collection methods, break definitions, and study findings.

In Arrogi 2017 a mean difference in sit-to-stand transitions of 5.7 per day (95% CI 1.0 to 10.4) was reported at short-term follow-up. Biddle 2015 reported the number of breaks in sedentary behaviour per day (i.e. light to vigorous PA bouts) at short-term (MD -29.6, 95% 95% CI -97.0 to 37.9) and medium-term follow-up (MD -2.96, 95% CI -73.0 to 67.0). Cotten 2016 reported self-reported frequency of breaks at short-term follow-up (MD -10.25, 95% CI -25.58 to 5.08). Finni 2011 reported device-determined breaks per sedentary hour during leisure time at short-term (MD 1.0, 95% CI -0.2 to 2.2) and medium-term follow-up (MD 0.6, 95% CI -0.6 to 1.8). In Sui 2018, a MD of -53.12 (-96.98 to -9.28) in self-reported break frequency was found at short-term.

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Secondary outcomes

Energy expenditure

Laska 2016 reported that the intervention did not change energy expenditure in leisure-time physical activity at 24 months (MD -66.5 weekly kcal).

Body composition

We pooled three studies that reported medium-term follow-up points for body mass index (Biddle 2015; Finni 2011; French 2011) (MD -0.25 kg/m^2, 95% CI -0.48 to -0.01; I^2 = 0%; moderate-certainty evidence; Analysis 1.4). Most studies had high risk of bias for two domains. Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate. Biddle 2015 also reported data for short-term follow-up (MD -13.3 kg/m^2, 95% CI -15.0 to 41.6).

Biddle 2015 reported no changes in waist circumference at 3 months (MD 13.4 cm, 95% CI -14.7 to 41.5). We pooled two studies that report waist circumference at medium-term follow-up (Biddle 2015; Williams 2019) (MD -2.04 cm 95% CI -9.06 to 4.98, I^2 = 65%; low-certainty evidence; Analysis 1.5). There were concerns about imprecision due to small sample size. In addition, one study had high risk of bias for two domains. 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.

Biddle 2015 reported no change in body fat percentage at 3 months (MD 0.54, 95% CI -38.4 to 39.5) or at 6 months (MD -0.25, 95% CI -2.72 to 2.22). In Finni 2011, there was no change in total fat mass percentage at 6 months (MD -0.54, 95% CI -1.2 to 0.11) or at 12 months (MD -0.60, 95% CI -1.26 to 0.07); however percentage leg lean mass changed between groups at 12 months (MD 0.48, 95% CI 0.18 to 0.77), and a decrease within the control group was observed.

Biddle 2015 reported no changes in body weight at 3 months (MD 14.3 kg, 95% CI -16.1 to 44.6) or at 6 months (MD 0.46 kg, 95% CI -5.06 to 5.97), whereas Finni 2011 reported changes at 6 months (MD -0.83 kg, 95% CI -1.64 to -0.02) and at 12 months (MD -0.95 kg, 95% CI -1.76 to -0.13).

Cholesterol

Only one study reported the effects of the intervention on cholesterol (Biddle 2015). No changes were noted for serum total cholesterol (MD 0.21 mmol/L, 95% CI -0.15 to 0.40), HDL cholesterol (MD 0.06 mmol/L, 95% CI -0.02 to 0.14; P= 0.122), triglycerides (MD -0.17 mmol/L, 95% CI, -0.42 to 0.08), or LDL cholesterol (MD 0.13 mmol/L, 95% CI -0.10 to 0.36) at 3 months and at 12 months (findings for 12 months are shown).

Markers of insulin resistance

We pooled two studies (Biddle 2015; Finni 2011 that reported glucose (Biddle 2015; Finni 2011) at short-term follow-up (MD -0.18 mmol/L, 95% CI -0.30 to -0.06, I^2 = 0%; moderate-certainty evidence; Analysis 1.6) and medium-term follow-up (MD -0.08 mmol/L, 95% CI -0.21 to 0.05, I^2 = 0%; moderate-certainty evidence; Analysis 1.6). There were concerns in relation to risk of bias as unclear or high for several domains. Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Finni 2011 noted no change in insulin at 3 months (MD -0.55 pM, 95% CI -9.15 to 8.05) or at 6, 9, or 12 months (MD -1.47 pM, 95% CI -10.3 to 7.37).

Biddle 2015 reported two-hour glucose challenge at 3 months (MD -0.08 mmol/L, 95% CI -0.63 to 0.46) and 12 months (MD 0.10 mmol/L, 95% CI -0.65 to 0.84). No changes were seen in HbA1c at 3 months (MD 0.01%, 95% CI -0.08 to 0.11) or at 12 months (MD 0.06%, 95% CI -0.04 to 0.16).

Finni 2011 reported HOMA-%B at 3 months (MD 12.62, 95% CI -6.81 to 32.05) and 12 months (MD 7.93, 95% CI -12.1 to 27.96).

Inflammatory markers

No data were reported.

Meaures of carotid intima media thickness

No data were reported.

Measures of endothelial function

No data were reported.

Meaures of mental health

Mood

Ellingson 2016 reported a group by time interaction for mood state, favouring the intervention group ($F_{1,27}$ = 4.17; P = 0.05).

Wellness

Barwais 2013 revealed a time by treatment effect on total wellness ($F_{1,31}$ = 9.5; P < 0.001), with increases in wellness scores seen in the intervention group (t_{17} = -6.5; P < 0.001).

Adverse events and symptoms

No data were reported.

Unintended outcomes

Device-measured moderate to vigorous physical activity

Interventions outside the workplace may make little or no difference in device-measured MVPA in the short term (MD 1.99 min/d, 95% CI -4.27 to 8.25; I^2 = 23%; low-certainty evidence; Analysis 1.7; Figure 8). Four studies with 296 participants provided data for this outcome (Biddle 2015; Ellingson 2016; Finni 2011; Jago 2013). Most studies had unclear or high risk of bias in several domains. Small sample sizes and wide confidence intervals raised concerns about imprecision. 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.

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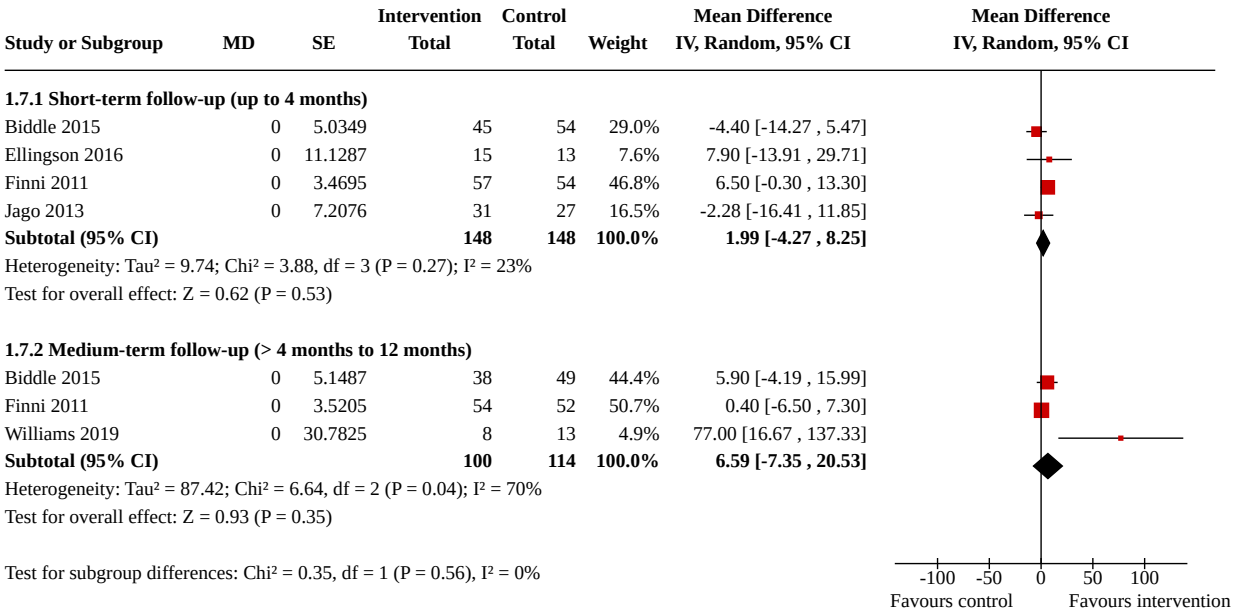
Figure 8. Forest plot of comparison: 1 Intervention vs control, outcome: 1.6 Device-measured MVPA (min/day)



We are uncertain whether interventions improve device-measured MVPA in the medium term (MD 6.59 min/d, 95% CI -7.35 to 20.53; I^2 = 70%; very low-certainty evidence; Analysis 1.7). Three studies with 214 participants were pooled (Biddle 2015; Finni 2011;Williams 2019). Results were imprecise due to wide confidence intervals and small sample sizes. Two studies had unclear or high risk of bias for several domains. In addition there was a large variation in effect. The certainty of evidence was very-low and any estimate of effect is very uncertain.

Self-report moderate to vigorous physical activity

French 2011 reported self-report MPVA at medium-term follow-up (MD 29.6331 min/d; 95%CI 4.60 - 54.66).

Self-report light-intensity physical activity

Two studies with 115 participants reported data on light-intensity PA, assessed using the 7-Day SLIPA Log (Barwais 2013; Cotten 2016). We are uncertain whether interventions outside the workplace improve light-intensity PA in the short-term (MD 156.32 min/d, 95% CI 34.34 to 278.31; I^2 = 79%; Analysis 1.8). Results were inconsistent due to large variation in effect and high levels of heterogeneity. We had very serious concerns about precision due to the very large confidence intervals. In addition, risk of bias was high for outcome assessment and unclear for several domains. The certainty of evidence was very low, meaning that any estimate of effect is very uncertain.

Self-report moderate-intensity physical activity

Three studies reported self-report moderate-intensity PA with short-term follow-up. Cotten 2016 reported moderate-intensity activity as minutes per week with a MD of 50.39 (95% CI -76.27 to 177.05). Barwais 2013 found a MD of 457.0 MET/min per week (95%CI 202.43 to 711.58).The third study found a MD of -22.10 min/d (95%CI -87.59 to 43.39) (Ellingson 2016).

Self-report vigorous-intensity physical activity

Barwais 2013 reported vigorous-intensity physical activity in MET-minutes per week and found a MD of 540.00 (95% CI 129.53 to 950.47) at short-term follow-up. Ellingson 2016 reported minutes per day of vigorous activity at short-term (MD -15.60, 95% CI -33.37 to 2.17). Biddle 2015 found a MD of -2.5 vigorous METs at short-term (95% CI -536.9 to 531.8) and -242.0 (95% CI -849.9 to 365.8) at long-term follow-up.

Self-report total physical activity

Lioret 2012 found no change in self-report total physical activity at long-term follow-up (MD 0.75 min/week, 95% CI -0.90 to 2.40).

Steps

We pooled three studies that reported step count at short-term follow-up (Arrogi 2017; Biddle 2015; Kitagawa 2020) (MD 226.90 steps/day, 95% CI -519.78 to 973.59, I^2 = 0%; low-certainty evidence; Analysis 1.9). There were concerns about imprecision due to large confidence internals and small sample sizes. 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.

Biddle 2015 also reported data for medium-term follow-up and found no change in average steps per day (MD 402.7, 95% CI -807.9 to 1613.4).

DISCUSSION

Summary of main results

We included 13 studies in this review. A synopsis of findings for the primary outcomes of device-measured sedentary time, self-report sitting time, and self-report TV viewing time can be seen in Summary of findings table 1. Interventions outside the workplace to reduce sedentary behaviour probably make little or no difference in device-measured sedentary time in adults under 60 years of age in the short term (moderate-certainty evidence). We are uncertain

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whether such interventions reduce device-measured sedentary time in the medium term (very low-certainty evidence). We are uncertain whether interventions outside the workplace reduce self-reported sitting time in the short term (very low-certainty evidence). Interventions may make little or no difference in self-reported TV viewing time (low-certainty evidence). We were unable to pool studies that reported breaks in sedentary time due to the multiple ways that studies defined a break.

We were able to complete meta-analyses for only five of the secondary outcomes: body mass index, waist circumference, device-measured moderate to vigorous physical activity (MVPA), self-report light-intensity physical activity (PA) and step count. Interventions outside the workplace to reduce sedentary behaviour probably make little or no difference in BMI among adults under 60 years of age in the medium term (moderate-certainty evidence). Interventions outside the workplace may make little or no difference in device-measured MVPA in the short term (low-certainty evidence). We are uncertain whether interventions increase device-measured MVPA in the medium term (very low-certainty evidence) . We are uncertain whether interventions outside the workplace improve self-report light-intensity PA (very low-certainty evidence). Interventions outside the workplace may make little or no difference in daily step count in the short term (low-certainty evidence)

A majority of study participants were female and were aged 20 to 41 years. Two studies reported follow-up measures undertaken more than 12 months post baseline. Despite six studies assessing outcomes using device-based measures, the overall certainty of evidence was determined as moderate to very low.

All interventions were delivered at the individual level, and none were considered environmental or policy activities. Interventions at an individual level included information/education, counselling, wearable technology, apps, SMS prompts, web-based interventions and phone calls. Interventions were delivered in home or community settings, within primary care or educational settings. Details of the frequency and intensity of these different elements and their fidelity were missing. No interventions yielded data on cost-effectiveness, quality of life, or adverse events.

Overall completeness and applicability of evidence

A majority of studies recruited female participants and younger participants (aged 20 to 41) in high-income countries. Therefore it is not clear to what extent these types of interventions might be effective among other population groups.

The identified studies were insufficient to address all of the objectives of the review. We could not investigate most of the secondary outcomes (related to health effects) due to absence of eligible studies reporting these outcomes. BMI status was reported in only three studies. No studies reported data on adverse events or cost-effectiveness.

We were unable to determine whether specific components of interventions are associated with changes in sedentary behaviour. In addition, we could not examine if there were any differential effects of interventions based on health inequalities. Very few studies reported sociodemographic characteristics at baseline and endpoint using the PROGRESS framework (Place, Race, Occupation, Gender, Religion, Education, Socioeconomic status, Social status). No studies were conducted in low- or middle-income countries, and we found a dearth of quality research in marginalised and poorer populations.

This review was limited to trials involving a randomised controlled trial (RCT) or cluster RCT study design. It is possible that other evidence is available from other, less robust, studies.

Overall the evidence presented may not hold true for middle-aged adults and those from low-middle-income countries (for which trials were not available) or for adults over 60 years of age (outside the scope of the review).

Quality of the evidence

The body of evidence identified does not allow a robust conclusion regarding the objectives of this review. We included data from 13 studies and 1770 participants. We found certainty of evidence, according to GRADE, to range from very low to moderate. Uncertainty was mainly due to concerns about imprecision, risk of bias, and inconsistency. 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.

Available studies demonstrate that it is possible to conduct RCTs of non-workplace interventions to reduce sedentary behaviour; however no studies were considered to have low risk of bias. In addition to the limitations of self-report tools, a common challenge to undertaking high-quality trials relates to blinding of outcome assessments. Blinding was possible in studies that used device-based measures. Most studies used self-report measures of sedentary behaviour. These measures are subject to recall bias and may lack precision; however any misclassification is non-differential (as both intervention and control groups complete the measure) and attenuates the effects of the intervention (Richards 2013). We also note that the use of self-report measures and the wide ranges of values for sedentary behaviours could contribute to uncertainty around intervention effects. Although none of our studies blinded participants to their group allocation, we believe that this criterion was not appropriate because it is very difficult to do this for any intervention that requires movement.

Potential biases in the review process

Assessing risk of bias and certainty of the body of evidence (GRADE) involves personal judgement and the potential for some degree of subjectivity (Hombali 2019). We tried to minimise the potential for bias by ensuring that two review authors conducted these assessments independently. To avoid language bias, we did not impose any language restrictions in our searches. To increase the likelihood that all relevant studies were identified, we (1) emailed trial authors and research groups for information about unpublished or ongoing studies, (2) contacted experts in the field and asked them to identify further articles, (3) handsearched reference lists of included studies and key systematic reviews, and (4) searched a clinical trial registry and the websites of organisations involved in addressing and reporting research on sedentary behaviour.

One limitation of this review is the potential for publication bias. Unpublished studies may exist but have not been submitted or accepted for publication, or only those with positive results may have been published. However we were unable to examine a funnel plot due to the small numbers of studies with common

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outcome measures. One principal investigator declared receiving in-kind support through provision of a sit-to-stand desk by Ergotron from 2012-2014. This study reported no intervention effects (Biddle 2015).

Agreements and disagreements with other studies or reviews

This is the first review of interventions intended to change sedentary behaviour delivered in contexts outside of workplaces. This review is relevant, as adults spend approximately 70% of their non-work time being sedentary, plus not all adults work.

A recent systematic review reported that 10 of the 13 studies observed a reduction in objectively measured sitting time (Thraen-Borowski 2017). However this review included non-randomised and uncontrolled studies. Another review - including only RCTs - noted that effects reported between 7 and 12 months were not sustained beyond 12 months, with high heterogeneity between studies (Martin 2015). However only eight non-workplace studies were identified for the review. In addition, in the subgroup analysis by study setting (workplace vs home/community), no attempt was made to discriminate between interventions that were designed to increase physical activity and those that purposely aimed to reduce sedentary behaviour. This is important, as the same review and another demonstrated differential effects between interventions that solely aim to reduce sedentary behaviour or take a combined approach of reducing sedentary behaviour and increasing physical activity (Gardner 2016).

We were concerned that most of our studies recruited younger adults outside of workplace settings; this has the potential to increase health inequalities (i.e. differential responses in recruitment and focus on effects on the younger and potentially more active). We support the conclusions of these reviews that it remains a priority to identify what is a clinically meaningful change in sedentary behaviour.

AUTHORS' CONCLUSIONS

Implications for practice

It is currently unclear what interventions outside of the workplace, if any, might be effective for reducing sedentary behaviour. Interventions outside the workplace probably has little or no difference on device-measured sedentary time in the short term and we are uncertain whether they reduce sedentary time in the medium term. Evidence is uncertain about the effects of non-workplace interventions on self-reported sitting time in the short term. Interventions may result in little or no difference in self-report TV viewing time in the medium or long term.

We were not able to draw conclusions about the effectiveness of individual components of the interventions, and we are unable to demonstrate what the most effective strategies were within the interventions. We cannot comment on the balance of benefits or harms, as no studies provided data for adverse events, quality of life, or cost-effectiveness. The decision for policymakers or practitioners to recommend interventions outside the workplace for adults under 60 years should consider the certainty of this evidence base.

Many of the interventions used some type of feedback mechanism to encourage participants to reduce their sedentary behaviour time. This feedback about current behaviour is a common strategy used in physical activity interventions. Feedback was generated by devices and/or self-monitoring. Encouragement to take the opportunity to stand (in non-workplace settings) was included in a few studies, but this may prove still to be a difficult behaviour to undertake in an unsupportive environment (e.g. modified desks or tables). Unless the environment can support the behaviour, future attempts to change sedentary behaviour will prove difficult to start and maintain.

We note that, particularly in high-income countries, there is much media attention on the use of home equipment or furniture to reduce sedentary behaviour. Recent estimates of the market value of the standing desk industry suggest that the global market will grow to US$ 2.80 billion by 2025 (Credence Research 2017). However, the unit cost of such equipment or furniture may mean that they are available only for those who can afford them, and practitioners may wish to consider (if proved effective) whether this intervention is an equitable option.

Implications for research

Future RCTs are clearly needed to build and improve this evidence base by assessing the impact of interventions outside the workplace for reducing sedentary behaviour in adults under 60 years of age for at least 6 to 12 months and ideally beyond 12 months. Methods of measurement need careful consideration in future research on sedentary behaviour outcomes. Blinding of the outcome assessment was possible in studies that used device-based measures; therefore a transition towards greater use of device-based measures in future studies would help to overcome some of the limitations of the current evidence base. However, until standard methods of data collection, preparation, and analysis are adopted, it will prove difficult to compare effects of studies. This is a research priority. For most studies, it is unclear whether outcome assessors were blinded; therefore better executed and reported studies are needed.

To address concerns about imprecision, studies with larger sample sizes in experimental and control groups are needed. Future studies must recruit participants from varying age, socioeconomic, and ethnic groups to examine differential effects in relevant subgroups. In addition, study authors should gather quality of life, cost-effectiveness, and adverse event data. We suggest that studies adopt the use of PAT plots (graphical representations of interventions) to show intervention components and intensity (Perera 2007). Studies conducted to examine environmental or policy level interventions are needed. It may be particularly prudent for future trials to evaluate the effectiveness of interventions that are potentially scalable at the population level.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Arrogi 2017

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** flyer and email in the local area **Study SB/PA objective/aim:** short-term effectiveness of the stAPP smartphone-based intervention on prolonged sitting behavior in healthy adults. It was hypothesised that use of stAPP would result in more interruptions in prolonged sitting. More specifically, we expected (1) a decrease in total prolonged sitting time and (2) a decrease in the number and duration of prolonged sitting bouts

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Arrogi 2017 *(Continued)*

	Country: Belgium **Setting:** home/community **Study dates:** recruitment between November 2013 and March 2014; study duration: 2 weeks
Participants	**Included criteria:** convenience sample, 18 to 55 years. Desk-bound job and/or predominantly sedentary leisure time. Able to work a smartphone **Excluded criteria:** none stated **Baseline characteristics** Intervention • *Age (SD)*: 33.6 (8.3) • *Occupation*: 30 office workers, 1 labourer • *Gender (% female)*: 54.8 • *Number randomised to intervention group*: 31 Control • *Age (SD)*: 39.2 (11.5) • *Occupation*: 26 office workers, 1 retiree • *Gender (% female)*: 48.1 • *Number randomised to control group*: 27 Overall • *Age (SD)*: 36.2 (10.2) • *Occupation*: 56 office workers, 1 labourer, and 1 retiree • *Number randomised*: 58 **Pretreatment:** sociodemographic variables and work characteristics did not differ between groups except for age. Specifically, the control group was found to be older than the intervention group: 39.2 (11.5) years vs 33.6 (8.3) years. No significant baseline differences emerged in any of the activPAL parameters between intervention and control groups (P > 0.05)
Interventions	**Intervention characteristics** Intervention • *Content*: the stAPP intervention consisted of an Android-based smartphone (provided by researchers), a motion sensor (Shimmer), and a smartphone app. The app contained a score system that was based on the following criteria: (1) perfect behaviour corresponded to never exceeding 30 minutes of uninterrupted sitting (maximum score), (2) minimum score corresponded to staying seated the entire day, (3) length of the sitting interruption did not influence the score because there is still no consensus on how long sedentary behaviour should be interrupted, (4) sitting for longer than 30 minutes should be penalised by loss of points, but the score should never drop below zero, and (5) at the end of the day, a score should be available that did not depend on the number of waking hours • *Strategies to address diversity or disadvantage*: NR • *Cost*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: 2 weeks • *Theoretical basis*: in development of the app, 4 principles of behavioural change techniques were taken into account, as put forward by Abraham and Michie (2008), Michie et al (2011), and Gardner et al (2016): education, instructions, feedback, and encouragement Control • *Content*: participants in both groups received brief information with regards to the health consequences of prolonged sitting. The CG did not receive any intervention

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Arrogi 2017 *(Continued)*

Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Total sitting time on weekdays and weekend days, activPAL3 inclinometer (min/d) • Number of sedentary breaks on weekdays and on weekend days (i.e. number of sit-to-stand transitions); activPAL3 inclinometer (n/d) • Prolonged sitting bouts (> 30-minute bouts of sitting) on weekdays and on weekend days, activPAL3 inclinometer (n/d and min/d) **Other outcomes** • Daily step count, activPAL3 inclinometer (n/d)
Identification	**Sponsorship source:** Department of Welfare, Public Health and Family of the Flemish Government **Author's name:** An Bogaerts **Institution:** KU Leuven **Email:** an.bogaerts@kuleuven.be **Address:** Faculty of Kinesiology and Rehabilitation Sciences, KU Leuven, Leuven, Belgium **Conflicts of interest declared:** not stated **Publication type:** journal article
Notes	Clinical trial number NCT01975870

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Unclear risk	No information reported to allow judgement
Allocation concealment	Unclear risk	No information reported
Blinding of outcome assessors	Unclear risk	Not reported
Blinding of outcome assessment (sedentary time) Sedentary time	Low risk	Device-based measure
Incomplete outcome data	Low risk	Missing data similar across groups
Selective reporting	Low risk	Study protocol available on clinical trials registry. The study's prespecified outcomes have been reported
Other sources of bias	Low risk	None

Barwais 2013

Study characteristics

Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group

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Barwais 2013 *(Continued)*

Recruitment: advertisements in local newsletters, flyers, and emails at a metropolitan university in Brisbane, Australia, during October/November 2012

Study SB/PA objective/aim: to reduce sedentary behaviour and increase physical activity levels in daily living

Country: Australia

Setting: university recruitment/online delivery

Study dates: recruitment during October/November 2012; study duration: 4 weeks (data collection at baseline and at 4 weeks)

Participants

Included criteria: only those who reported a high total sitting time, defined as spending > 7 hours per day, were invited to participate in the study

Excluded criteria: NR

Baseline characteristics

Intervention

- *Age (SD)*: 29.0 (4.4)
- *Gender (% female)*: 33.3
- *Number randomised to intervention group*: 18

Control

- *Age (SD)*: 26.4 (3.0)
- *Gender (% female)*: 33.3
- *Number randomised to control group*: 15

Overall

- *Age (SD)*: 27 (4.0)
- *Place*: metropolitan university in Brisbane, Australia
- *Occupation*: 63% office workers and 37% full-time students.
- *Gender (% female)*: 33.3
- *Number randomised*: 33

Interventions

Intervention characteristics

Intervention

- *Content*: participants interacted with an online personal activity monitor (Gruve Solution™, MUVE, Inc., Wayzata, MN, USA). The device was designed to motivate a reduction in sedentary behaviour and to increase physical activity in activities of daily living. It monitors a person's daily physical activity and subsequently provides the user with an easy-to-understand visualisation of daily activity patterns. Goal-setting features are activated alongside simple graphs and charts to enhance self-monitoring of energy expenditure. An indicator (a halobar) on top of the device also highlights the user's progress towards his or her daily goal. When palpated throughout the day, the indicator bar provides a light-emitting diode (LED) colour corresponding to the user's progress towards his or her daily activity goal. Participants wore the monitor on a daily basis both on weekdays and on weekends during activities daily of living (except when sleeping, bathing, or swimming). To increase their motivation, participants were encouraged to achieve their daily monitor goals and view their daily online homepages. Weekly motivational emails from the online system were sent to participants when they achieved their goals. The emails were designed to encourage participants to continue to be more active than their habitual physical activity level as determined during the baseline week
- *Strategies to address diversity or disadvantage*: NR
- *Cost*: NR
- *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: n/a

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Barwais 2013 *(Continued)*

	• *Theoretical basis*: NR Control • *Content*: control group did not interact with the monitor and were asked to follow their normal,daily lifestyle patterns
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Sedentary time, 7-day Sedentary and Light-Intensity Physical Activity Log (hours/d) • Light, moderate, and vigorous physical activity, International Physical Activity Questionnaire (MET-min/week) • Walking, International Physical Activity Questionnaire (MET-min/week) **Other outcomes** • Total wellness, Wellness Evaluation of Lifestyle inventory (%)
Identification	**Sponsorship source:** NR **Author's name:** Faisal A Barwais **Institution:** Queensland University of Technology and Umm Al-Qura University **Email:** faisal.barwais@student.qut.edu.au **Address:** School of Exercise and Nutrition Sciences, Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Australia **Publication type:** journal article and PhD thesis **Conflicts of interest declared:** "The author declares that they have no competing interests"
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	Computer random number generator was used
Allocation concealment	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessors	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (sedentary time) Sedentary time	High risk	"7-Day Sedentary and Light-Intensity Physical Activity Log (7-Day SLIPA Log)"
Incomplete outcome data	Low risk	No data appear to be missing
Selective reporting	Unclear risk	Insufficient information to permit judgement. No protocol published
Other sources of bias	Low risk	No comments

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Biddle 2015

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** recruited from primary care in Leicestershire and Northamptonshire. Invitations were sent from the general practitioner to potential participants **Study SB/PA objective/aim:** to reduce sitting time **Country:** England **Setting:** primary care **Study dates:** 9 March 2011 to 23 October 2012; study duration: 12 months (data collected at baseline and at 3 and 12 months after baseline)
Participants	**Included criteria:** (1) age 18 to 40 years inclusive; (2) BMI in the obese range (> 30 kg/m^2 with > 27.5 kg/m^2 for South Asians) or BMI in the overweight range (> 25 kg/m^2 with > 23 kg/m^2 for South Asians) and with 1 or more additional risk factors for diabetes from (a) family history of diabetes or cardiovascular disease in a first-degree relative; (b) previous gestational diabetes; (c) polycystic ovarian syndrome; (d) HbA1c > 5.8%; (e) impaired glucose tolerance; and/or (f) impaired fasting glucose **Excluded criteria:** NR **Baseline characteristics** Intervention • *Age (SD)*: 32.4 (5.4) • *Race (% black and minority ethnic group)*: 19.4 • *Gender (% female)*: 70.2 • *BMI (mean SD)*: 34.6 (4.9) • *Number randomised to intervention group*: 94 Control • *Age (SD)*: 33.3 (5.8) • *Race (% black and minority ethnic group)*: 20.4 • *Gender (% female)*: 66.7 • *BMI (mean SD)*: 34.5 (5.0) • *Number randomised to control group*: 93 Overall • *Age (SD)*: 32.8 (5.6) • *Race (% black and minority ethnic group)*: 19.8 • *Gender (% female)*: 68.5 • *BMI (mean SD)*: 34.6 (4.9) • *Social or cultural characteristics*: recruited from primary care in Leicestershire and Northamptonshire, which are areas in central England with a diverse ethnic and socioeconomic makeup • *Number randomised*: 187 **Pretreatment:** random assignment led to the control group being slightly older and having fewer females than the intervention group, but these differences were small
Interventions	**Intervention characteristics** Intervention

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Biddle 2015 *(Continued)*

- *Content*: attended a single 3-hour group-based structured educational workshop delivered by 2 trained educators aimed at targeting knowledge and perceptions of prevalent risk factors for type 2 diabetes and promoting sedentary behaviour change. Participants were given an SB and PA self-monitoring device to aid behaviour change ('Gruve'; MUVE, Inc., Wayzata, MN, USA; http://www.gruvetechnologies.com/) and received a follow-up phone call 6 weeks after their attendance at the workshop. This was done to review their progress and to discuss their goals and barriers with the aim of supporting behaviour change
- *Cost*: NR
- *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: last intervention contact at 6 weeks. Follow-ip measures at 12 months
- *Theoretical basis*: combined several mutually supportive theories including Bandura's Social Cognitive Theory, Gollwitzer's implementation intentions concept, Behavioural Choice Theory, and Leventhal's Common Sense Model

Control

- *Content*: received an information leaflet focusing on key illness perceptions of being at risk for T2DM and the importance of increasing physical activity and decreasing sedentary behaviour

Outcomes

SB/PA outcome name and measurement tool (units of measurement)

- Sedentary time, Actigraph GT3X accelerometer (hours/d)
- Breaks in sedentary time (i.e. bouts of light to vigorous physical activity), Actigraph GT3X accelerometer (n/d)
- Sedentary time, ActivPAL3™ inclinometer (hours/d)
- Sit-to-stand transitions, ActivPAL3™ inclinometer (n/d)
- Light-, moderate-, and vigorous-intensity physical activity, Actigraph GT3X accelerometer (min/d)
- Total and vigorous-intensity physical activity, short-form International Physical Activity Questionnaire (MET-min)
- Sitting time, short-form International Physical Activity Questionnaire (hours/d)
- Sitting time and domain-specific sitting on weekdays and on weekend days, Total and Domain-Specific Sitting Questionnaire (hours/d)

Other outcomes

- Fasting and 2-hour oral glucose tolerance test, fasting insulin, HbA1c
- Lipids (cholesterol, triglycerides, low-density lipoprotein cholesterol (LDL))
- Body weight, body fat percentage, waist circumference
- Blood pressure
- Quality of life
- Self-efficacy for sedentary behaviour change
- Anxiety and depression

Identification

Sponsorship source: the STAND study was funded by a grant from the Medical Research Council (UK) under the National Prevention Research Initiative (Project #91409). The research was also supported by the National Institute for Health Research (NIHR) Diet, Lifestyle, Physical Activity Biomedical Research Unit based at University Hospitals of Leicester and Loughborough University, the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care–East Midlands (NIHR CLAHRC–EM), and the Leicester Clinical Trials Unit

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Address: Melbourne, Australia

Conflicts of interest declared

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Biddle 2015 *(Continued)*

Stuart Biddle: funding has been received since 2013 for consultancy work from Fitness First, Nuffield Health, and Unilever. None of these are currently active. Funding was received in 2016 for consultancy work for Halpern PR Limited. In-kind support through provision of a sit-to-stand desk was provided by Ergotron from 2012 to 2014. Unpaid advice has been requested by and offered to Bluearth, Active Working, and Get Britain Standing

Charlotte L Edwardson: no conflicts of interest to disclose

Trish Gorely: no conflicts of interest to disclose

Emma G Wilmot: no conflicts of interest to disclose

Thomas Yates: no conflicts of interest to disclose

Myra A Nimmo: discloses that funding has been received from Technogym during this trial

Kamlesh Khunti: no conflicts of interest to disclose

Melanie J Davies: no conflicts of interest to disclose.

Publication type: journal article × 3 (protocol, main results, process evaluation), conference abstract, additional data received from study authors

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	Randomisation (stratified by age, sex, and ethnicity) was set up by an independent statistician using a computer-generated list and was conducted remotely
Allocation concealment	Low risk	Determined in advance, remotely, by an independent statistician
Blinding of outcome assessors	Unclear risk	No information on who conducted the outcomes assessments
Blinding of outcome assessment (sedentary time) Sedentary time	Low risk	"The primary outcome was a reduction in sedentary behaviour at 12 months, measured using the Actigraph GT3X accelerometer" Comment: device-based measure
Incomplete outcome data	Low risk	Similar number/proportion lost to follow-up across groups. "In total, 30 (32%) in the intervention group and 25 (27%) in the control group were lost to follow-up at 12 months"
Selective reporting	Low risk	Protocol available. All outcomes reported (see Supplementary Table 4 for secondary outcomes by randomisation group)
Other sources of bias	Low risk	No comment

Cotten 2016

Study characteristics

Methods

Study design: randomised controlled trial

Study grouping: parallel group

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Cotten 2016 *(Continued)*

Recruitment: study was advertised through emails sent out to various faculties at Western University, and students who were interested in the study emailed the researcher to sign up. The study was also advertised through an article in the university newspaper due to the interest of a reporter

Study SB/PA objective/aim: increasing non-sedentary behaviours in university students

Country: Canada

Setting: University

Study dates: January to March 2015; study duration: measures taken at baseline and at 2, 4, and 6 weeks

Participants	**Included criteria:** participants had to be between the ages of 18 and 65, had to be able to read and write in English, had to own a mobile phone with free unlimited incoming text messages, and had to be a student at Western University **Excluded criteria:** none reported **Baseline characteristics** Intervention • *Age (SD)*: 21.37 (3.6) • *Place:* university • *Occupation*: 87.8% undergrad, 12.2% graduate student • *Gender (% female)*: 75.6 • *BMI (mean SD)*: 24.57 (3.56) • *Number randomised to intervention group*: 41 Control • *Age (SD)*: 21.02 (4.76) • *Place: university* • *Occupation*: 78% undergrad, 17% graduate student, 4.8% other • *Gender (% female)*: 73.2 • *BMI (mean SD)*: 23.22 (3.54) • *Number randomised to control group*: 41 Overall • *Age (SD)*: 21.43 (5.16) • *Gender (% female)*: 74.4 • *Number randomised:* 82 **Pretreatment:** groups were equivalent at baseline for all measures (all P values > 0.05)
Interventions	**Intervention characteristics** Intervention • *Content*: intervention group received text messages twice daily - 1 in the morning or early afternoon and 1 in the evening. Encouraging breaks from sitting, standing, light- and moderate-intensity physical activity • *Cost*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: n/a (6 weeks) • *Theoretical basis*: NR Control

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Cotten 2016 *(Continued)*

	• *Content*: control group received daily text messages in the evenings about random health or nutrition facts
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Frequency of breaks in sedentary time, questionnaire (minutes) • Length of breaks in sedentary time, questionnaire (minutes) • Standing time and light-intensity physical activity, 7-Day Sedentary and Light-Intensity Physical Activity Log used as recall questionnaire (min/d) • Moderate-intensity physical activity, short form of the 7-Day Physical Activity Recall Questionnaire (min/week) **Other outcomes** • Self-efficacy for decreasing sedentary behaviour, questionnaire (%)
Identification	**Sponsorship source:** none declared **Authors name:** Emma Cotten **Institution:** Western University **Email:** ecotten@uwo.ca **Address:** Exercise and Health Psychology LaboratorySchool of KinesiologyWestern UniversityRoom 408, Arthur and Sonia Labatt Health Sciences BuildingLondon, ON, N6A 5B9 Canada **Conflicts of interest declared:** "none declared" **Publication type:** journal article and MA thesis
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	Computer-generated randomised stratification
Allocation concealment	Unclear risk	"randomised by the researcher"
Blinding of outcome assessors	Unclear risk	No mention of who conducted assessments. Surveys were sent via email. Intervention and control groups received the same emails and surveys. Surveys were administered through a third party website called SoSCI
Blinding of outcome assessment (sedentary time) Sedentary time	High risk	"sedentary and light-intensity physical activity (SLIPA) questionnaire"
Incomplete outcome data	Low risk	"Taken together, all missing data were considered random" Similar dropout across groups
Selective reporting	High risk	"Although the SLIPA provides a measure of sedentary behavior, the goal of this text intervention was to directly target and positively change standing and light-intensity physical activity. After careful examination of the sedentary behavior items (items 1, 5, 6, 15, 16, 17, and 18), it became evident that some items were not relevant to the text intervention (e.g. driving a car) or overlapped each other (e.g. sitting-studying, writing, desk work, typing vs sitting-using a computer) causing many overestimated data points. For these

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Cotten 2016 *(Continued)*

		reasons, this sitting measure was not calculated and used in subsequent analyses"
Other sources of bias	Low risk	No comment

Ellingson 2016

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** recruited from a large midwestern university using posted flyers and word of mouth. To improve generalisability to the broader university population, participants were recruited using stratified sampling to enrol equal numbers of males and females and no more than 2 students from a single major **Study SB/PA objective/aim:** using wearable technology to reduce sedentary time in daily life **Country:** USA **Setting:** university **Comments:** study dates: NR **Study duration:** 9 weeks (5-week intervention, follow-up 4 weeks after end of intervention)
Participants	**Included criteria:** (1) being full-time students, (2) between the ages of 18 and 26 years, (3) absence of mobility limitations, (4) self-reporting of more than 3 hours of daily leisure-time sedentary behaviour **Excluded criteria:** NR **Baseline characteristics** Intervention • *Age (SD)*: 20.4 (1.5) • *Place*: university • *Race*: 73.3% white • *Occupation*: college students • *Gender (% female)*: 53.3 • *Education*: all university students • *BMI (mean SD)*: 24.1 (4.7) • *Number randomised to intervention group*: 15 Control • *Age (SD)*: 19.8 (1.5) • *Place*: university • *Race*: 84.6% white • *Occupation*: college students • *Gender (% female)*: 46.2 • *BMI (mean SD)*: 21.3 (4.5) • *Number randomised to control group*: 15 Overall • NR

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Ellingson 2016 *(Continued)*

	Pretreatment: there were no significant differences in physical activity between groups at baseline
Interventions	**Intervention characteristics** Intervention • *Content*: before randomisation, participants were provided with minimal education regarding the risks of a sedentary lifestyle. After random assignment, participants in the SF (sedentary feedback) group were informed that they would receive real-time feedback every other week over the subsequent 5 weeks (3 weeks total) in the form of a small vibration provided by AP monitors when sedentary time exceeded 30 minutes. They were then given information (in 10 to 15-minute session) about developing new habits based on the habit theory of behaviour change to aid in reducing sedentary time: participants were instructed to use feedback from the AP to increase their awareness of their sedentary time and to note the location and activity when the vibration occurred on a daily log sheet provided for them (potential cues to break up sedentary time). They were encouraged to use this information to anticipate and move before the vibration alert (establishing a new routine) in whatever way was feasible at the time of the alert (e.g. stand up, take a walk) or as soon as possible for situations when breaking up sitting time was not practical (e.g. during class, while driving). Last, they were encouraged to take note of how breaking up sedentary time affected how they felt (e.g. energy levels, ability to focus while studying) to increase awareness of potential rewards associated with this new behaviour • *Were there particular strategies to address diversity or disadvantage*: to improve generalisability to the broader university population, participants were recruited using stratified sampling to enrol equal numbers of males and females and no more than 2 students from a single major • *Cost*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: follow-up 10 weeks after baseline • *Theoretical basis*: habit theory (Lally et al., 2011) Control • *Content*: before randomisation, participants were provided with minimal education regarding the risks of a sedentary lifestyle. After random assignment, participants in the MEC group were also given Actigraph and ActivPAL monitors, which they wore every other week over the subsequent 5 weeks (weeks 2, 4, and 6), but they did not receive real-time sedentary feedback or further information about behaviour change for the remainder of the study
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Sedentary time, activPAL3™ inclinometer (min/d) • Prolonged bouts of sedentary time > 30 minutes, activPAL3™ inclinometer (min/d) • Short bouts of sedentary time < 30 minutes, activPAL3™ inclinometer (min/d) • Sedentary time, Sedentary behaviour questionnaire (min/d) • Light-, moderate-, and vigorous-intensity physical activity; ActiGraph GT3X+ accelerometer (min/d) • Moderate- and vigorous-intensity physical activity, International Physical Activity Questionnaire (min/d) **Other outcomes** • Sedentary awareness, questionnaire (5-point Likert scale) • Mood, Profile of Mood States
Identification	**Sponsorship source:** this work was funded by the American College of Sports Medicine's Paffenbarger–Blair Fund for Epidemiological Research on Physical Activity. Jacob Meyer was supported by a National Research Service Award from the Health Resources and Services Administration T32HP10010 to the University of Wisconsin Department of Family Medicine and Community Health **Author's name:** Laura D Ellingson **Institution:** Iowa State University

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Ellingson 2016 *(Continued)*

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Conflicts of interest declared: "The authors have no conflicts of interest"

Publication type: journal article

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"they were randomly assigned (using a random number generator) to one of two groups"
Allocation concealment	Unclear risk	Method of concealment not described
Blinding of outcome assessors	Low risk	"data entry and quality checking of accelerometer data at the single-subject level were conducted by study personnel who were blind to the group assignment"
Blinding of outcome assessment (sedentary time) Sedentary time	Low risk	"...received a set of monitors to objectively measure sedentary (activPAL3™ VT (AP)) and physical activity behaviours (ActiGraph GT3X+ (AG)) over the subsequent 7 d under free-living conditions" Comment: device-based measure
Incomplete outcome data	Low risk	"One participant in the MEC group did not complete the study because of scheduling difficulties, and one participant (also in MEC) had AP malfunctions during baseline testing; both of these individuals were in the fall cohort" Comment: reasons provided for missing data
Selective reporting	Unclear risk	No protocol published
Other sources of bias	Low risk	No comment

Finni 2011

Study characteristics

Methods

Study design: randomised controlled trial

Study grouping: parallel group

Methods of recruitment: 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

Study SB/PA objective/aim: reduce sedentary time

Country: Finland

Setting: community

Study dates: recruitment started in April 2011; study duration: 12 months (data collected at baseline and at 3, 6, 9, and 12 months)

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Finni 2011 *(Continued)*

Participants	**Included criteria:** healthy men and women with children 3 to 8 years old, having an occupation where they self-reportedly sit more than 50% of their work time **Excluded criteria:** self-reported chronic, long-term musculoskeletal disease or progressive neurological disease, diagnosed cardiovascular or metabolic disease with regular medication, families with pregnant mother at baseline and BMI > 35 **Baseline characteristics** Intervention • *Age (SD)*: 36.6 (5) • *Gender (% female)*: 60 • *BMI (mean SD)*: 24.5 (3.5) • *Number randomised to intervention group*: 71 Control • *Age (SD)*: 39.6 (5.3) • *Gender (% female)*: 51.6 • *BMI (mean SD)*: 24.4 (4.1) • *Number randomised to control group*: 62 Overall • *Age (SD)*: 28 to 53 years • *Number randomised*: 133 **Pretreatment:** significant difference in age between groups at baseline
Interventions	**Intervention characteristics** Intervention • *Content*: tailored counselling to decrease time in sitting position and to increase non-exercise daily activity. Counselling is reinforced by a phone call after 1 and 5 months, during which compliance is asked and modifications to the agreement can be made. During the phone discussions, execution (both compliance and barriers) of each of the goals is asked and modified when required. Motivational emails with information on health promotion by lifestyle physical activity for adults and illustrative tips to increase physical activity and play developing FMS in children are sent monthly. This reinforcement period lasts for 6 months. At midline, subjects in the intervention group are given individual feedback on their daily inactivity and activity times. After the midline, there is no researcher contact with subjects except for 9-month measurements • *Were there particular strategies to address diversity or disadvantage?* Regarding socioeconomic regions, information from city registry was used to balance the areas. Thus, in each type of environment and socioeconomic region, there were to be 2 or more kindergartens and/or primary schools that were then randomised to control and intervention groups • *Cost*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: 3, 6, 9, and 12 months of follow-up • *Theoretical basis*: theory of planned behaviour Control • *Content*: control group did not receive the counselling intervention, but control group and intervention group underwent measurements similarly
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Sedentary time for total days, workdays, leisure days, and weekend days, Alive Technologies accelerometer (min/16 hours)

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Finni 2011 *(Continued)*

- Breaks in sedentary time for total days, workdays, leisure days, and weekend days, Alive Technologies accelerometer (n/hour)
- Light- and moderate to vigorous-intensity physical activity for total days, workdays, leisure days, and weekend days (Alive Technologies accelerometer (min/16 hours))

Other outcomes

- Energy intake and diet composition
- Anthropometrics (weight, BMI, arm/leg/trunk/total fat mass, arm/leg/trunk/total lean mass)
- Blood pressure
- Lipids (total, HDL and LDL cholesterol, VLDL diameter, LDL diameter, HDL diameter)
- Cardio-metabolic biomarkers (glucose, insulin, HOMA-IR, HOMA-%B, apoA-1, apoB, ratio of apoB to apoA-1)

Identification	**Sponsorship source:** Ministry of Education and Culture, Finland (DNRO 42/627/2010) **Author's name:** Taija Finni **Institution:** University of Jyväskylä **Email:** taija.finni@jyu.fi **Address:** Neuromuscular Research Center, Department of Biology of Physical Activity, University of Jyväskylä, Jyväskylä, Finland **Conflicts of interest declared:** "the authors declare that they have no competing interests" **Publication type:** 3 journal articles (including protocol) and PhD thesis
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"The 14 regions were randomised by flipping a coin to select intervention (n = 7) and control (n = 7) regions within each cluster"
Allocation concealment	Unclear risk	No information provided
Blinding of outcome assessors	Unclear risk	It does not state who the assessor was and whether the assessor was blinded
Blinding of outcome assessment (sedentary time) Sedentary time	Low risk	Device-based measure
Incomplete outcome data	Low risk	"Between the baseline and 12 month follow-up, seven participants dropped out from the control group (11%) and nine from the intervention group (13%), from which two (3%) withdrew before the allocated intervention" Similar dropout across groups
Selective reporting	High risk	Not all data are reported (e.g. occupational stress, quality of life, family influence questionnaire)
Other sources of bias	Low risk	NR

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Finni 2011 *(Continued)*

Recruitment bias (cluster RCT only)	High risk	"The recruitment is performed in the city of Jyväskylä, Finland, by delivering advertisements to parents via kindergartens and primary schools which have been pre-randomised to control and intervention groups" Recruitment after randomisation of clusters
Baseline imbalance (Cluster RCT only)	Unclear risk	NR
Loss of clusters (Cluster RCT only)	Unclear risk	Not stated
Incorrect analysis (Cluster RCT only)	Low risk	"Intervention effectiveness was tested with linear mixed-effects model fit by REML in statistical programming language R (R 3.0.1, NLME package, the R foundation for Statistical Computing). The analysis was based on a three level hierarchy, where the random grouping variables participants (n=133) where nested within families (n=89), and families were nested within the clusters (n=7)"
Comparability with individually randomized trials (Cluster RCT only)	Unclear risk	"In the randomization, the areas within the city centre and in different types of suburbs were balanced. Regarding socioeconomic regions, information from city registry was used to balance the areas. Thus, in each type of environment and socioeconomic region, there were to be two or more kindergartens and/or primary schools that were then randomized into control and intervention groups" Comment: possibility of herd effect due to diffusion of information within clusters, and contamination of control clusters if they knew of the intervention

French 2011

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel groups **Study SB/PA objective/aim:** reduce TV viewing **Methods of recruitment:** households (HHs) were recruited from the community over an 8-month period. Recruitment sources included community libraries, worksites, schools, daycare centres, health clinics, religious institutions, park and recreation centres, grocery stores, and food co-ops **Country:** USA **Setting:** university **Comments:** study dates:study duration: 12 months
Participants	**Included criteria:** (1) at least 1 child ≥ 5 years of age and 2 HH members ≥ 12 years of age; (2) residence in a private house or apartment within 20 miles of the university; (3) HH TV viewing weekly average ≥ 10 hours per person; (4) no HH members with dietary, medical, psychological, or physical limitations that would prevent their participation in intervention activities; and (5) willingness to be randomised to active intervention or control group **Excluded criteria:** NR **Baseline characteristics**

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French 2011 *(Continued)*

	Intervention • *Number randomised to intervention group*: 45 Control • *Number randomised to control group*: 45 Overall • *Age (SD)*:41 • *Race*: 79% white • *Gender (% female)*: 93 • *Education*: 63% of households had a member with a college or advanced degree • *Socioeconomic status*: 34% ≤ $45,000 per year; 29% between $50,000 and $95,000; and 37% ≥ $100,000 per year • *BMI (mean SD)*: 29.6 km/m^2 • *Social or cultural characteristics*: 62% married or cohabiting • *Number randomised* : 90 **Pretreatment:** not reported
Interventions	**Intervention characteristics** Intervention • *Content*: 6-monthly face-to-face group sessions, monthly newsletters, and 12 home-based activities. Group sessions: sessions were 2 hours in length, held on a weekday evening, and included behavioural education, interactive activities, 20 to 30 minutes of PA, and a healthy snack. Behavioural strategies: goal-setting, self-monitoring, and positive reinforcement, were used to promote and support behaviour changes at the HH and individual level. Home activities: designed to reinforce behavioural messages addressed at the previous group session, and to encourage parents to discuss the behaviours with any HH members not present at the group intervention session. Home scale: adults were instructed to self-weigh daily to monitor their body weight. TV-limiting device: the TV-limiting device provided an objective method to limit TV viewing by all HH members during the intervention period. Goals recommended by study staff were 50% reduction from HH baseline TV viewing hours per week. Telephone support calls: intervention staff telephoned each intervention HH monthly between sessions. Email also was used to maintain regular contact with intervention HHs. The purpose of these contacts was to provide support for the behaviour changes being made by HHs. Intervention staff queried the adult HH contact person about progress and problems, assisted with problem-solving when needed, and reinforced progress on HH behaviour changes • *Cost: NR* • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: 12-month follow-up • *Theoretical basis*: not stated Control • *Content*: control HHs received no intervention
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • TV viewing time, self-report questionnaire (Roberts et al., 1999) (hours/d) • Moderate to vigorous-intensity physical activity, modified long-form International Physical Activity Questionnaire (min/d) • Walking, modified long-form International Physical Activity Questionnaire (min/d) **Other outcomes** • Weight, height • Dietary intake and eating behaviours

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French 2011 *(Continued)*

- Home food inventory and household food purchase

Identification	**Sponsorship source:** this study was supported by grants #1U54CA116849 and #R21CA137240 from the National Institutes of Health/National Cancer Institute **Author's name:** Simone French **Institution:** University of Minnesota **Email:** frenc001@umn.edu **Address:** Division of Epidemiology Community Health, School of Public Health, University of Minnesota, Minneapolis, Minnesota, USA **Publication type:** journal article **Conflicts of interest declared:** study authors declared no conflict of interest
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Unclear risk	No information provided
Allocation concealment	Unclear risk	No information provided
Blinding of outcome assessors	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (sedentary time) Sedentary time	High risk	"TV viewing and computer use hours per day were self-reported using a standard set of questions"
Incomplete outcome data	Low risk	Similar number lost to follow-up in each group
Selective reporting	Unclear risk	No protocol available
Other sources of bias	Low risk	No comment
Recruitment bias (cluster RCT only)	Low risk	Recruitment took place before randomisation
Baseline imbalance (Cluster RCT only)	Unclear risk	Insufficient information to permit judgement
Loss of clusters (Cluster RCT only)	Low risk	Similar dropout across groups
Incorrect analysis (Cluster RCT only)	Low risk	"The study is a cluster randomized trial in which households (HHs) are randomized to intervention or control condition. In such a situation, it is imperative that HH be included in the statistical model as a random effect nested within randomization condition. Data are presented individually to the calculation of the maximum likelihood but are modeled as correlated within HH. The analysis essentially estimates an HH mean outcome, adjusted for individual characteristics, and analyses these means"

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French 2011 *(Continued)*

Comparability with individually randomized trials (Cluster RCT only)	High risk	"HHs were recruited from the community over an 8-month period. Recruitment sources included community libraries, worksites, schools, daycare centres, health clinics, religious institutions, park and recreation centres, grocery stores, and food co-ops" Comment: possibility of contamination

Jago 2013

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Methods of recruitment:** participants were recruited via leaflets and advertisements that were distributed across the community in coffee shops, children's centres, play groups, school playgrounds, and community centres and face-to-face in schools and community centres. Parents were invited to meet the study team at an informal coffee morning at their child's school or local community venue or to contact the study team by telephone **Study SB/PA objective/aim:** to reduce parents' TV viewing **Country:** UK **Setting:** community **Study dates:** not reported; study duration: 16 weeks
Participants	**Included criteria:** participants were parents with at least 1 child 6 to 8 years of age recruited from 2 neighbouring wards in Bristol (UK) **Excluded criteria:** NR **Baseline characteristics** Intervention • *Race*: white British 48%, African 32%, Indian 8%, Caribbean 4%, other ethnic group 4%, missing 4% • *Gender (% female)*: 61.9 • *Number randomised to intervention group*: 25 Control • *Race*: white British 65.2%, African 4.3%, Indian 4.3%, any other white 17.4%, any other Asian 4.3%, missing 4.3% • *Gender (% female)*: 68.8 • *Number randomised to control group*: 25 Overall • *Social or cultural characteristics*: 1 ward was selected from the lowest and 1 from the middle tertile of deprivation according to the index of multiple deprivation for the city of Bristol to sample approximate low and middle socioeconomic status areas of the city • *Number randomised*: 50 **Pretreatment:** control and intervention groups appear balanced on all variables at baseline except for parents' weekend MVPA, where intervention parents engaged in fewer minutes of MVPA than control parents (36.4 vs 53.0 minutes per day)

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Jago 2013 *(Continued)*

Interventions	**Intervention characteristics** Intervention • *Content*: 8-week parenting programme held in 1 of 3 local community centres. Parents attended without their children, and each weekly session lasted 2 hours. Each 2-hour session was made up of 3 main topic areas, together with time for refreshments, games, parent feedback, and the introduction of some tasks to be completed at home ('Put into Practice'). Material was delivered through group discussions and activities and used visual aids such as handouts, flip charts, and display boards that were prepared in advance of the session • *Were there particular strategies to address diversity or disadvantage*: NR • *Cost (if reported)*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: n/a • *Theoretical basis*: self-determination theory Control • *Content*: control group received no additional input during the period of intervention but was provided with written materials summarising intervention content at the end of the study
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • TV viewing time, questionnaire (categorised as < 2 hours/d or ≥ 2 hours/d) • Moderate to vigorous-intensity physical activity on weekdays and weekend days, ActiGraph GT1M accelerometer (min/d)
Identification	**Sponsorship source:** this project was funded by a project grant from the British Heart Foundation (PG/10/025/28302) **Author's name:** Russ Jago **Institution:** University of Bristol **Email:** Russ.Jago@bristol.ac.uk **Address:** Centre for Exercise, Nutrition Health Sciences, School for Policy Studies, University of Bristol, Bristol, UK **Publication type:** journal article **Conflicts of interest declared:** Professor Stewart-Brown is Vice-Chair of Parenting UK (http://www.parentinguk.org/)
Notes	.

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	Computer-generated random sequences
Allocation concealment	Low risk	"Participants who consented to take part were randomised, within their chosen course preference to the intervention or control arm by an independent statistician with no other involvement in the study"
Blinding of outcome assessors	Unclear risk	Insufficient information to permit judgement

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Jago 2013 *(Continued)*

Blinding of outcome assessment (sedentary time) Sedentary time	High risk	"Using a validated scale, parents were also asked to report the average number of hours per day that both they and the target child spent watching television" Comment: self-reported measure
Incomplete outcome data	High risk	"As a result, 25 participants allocated to the intervention group and 23 allocated to the control group provided baseline data. Some data were provided by 23 intervention and 15 control group participants at first follow up, and by 22 intervention and 11 control group participants at the second follow-up. Three intervention and 12 control group participants dropped out of the study during follow-up stages; 9 because of lost contact, 3 because they no longer wanted to take part" Comment: dropout not balanced across groups (see Figure SA in additional file)
Selective reporting	Unclear risk	No protocol available
Other sources of bias	Low risk	No comment

Kitagawa 2020

Study characteristics	
Methods	**Study design:** Randomised controlled trial **Study grouping:** Parallel group **Recruitment:** **Study SB/PA objective/aim:** We examined strategies to shorten housewives' sitting time. **Country:** Japan **Setting:** Sartphone app for use at home **Study dates:** 2014 - 2015 **Study duration:** One week intervention (plus additional week for baseline data collection)
Participants	**Included criteria:** aged ≧20 and <50 years, housewife (defined as being dedicated to housework without paid work, including part-time jobs), had a child who was in lower than primary school, and did not have a disease or was undergoing treatment. **Excluded criteria:** NR **Baseline characteristics** Intervention group 1 • *Age (SD)*: 35.9 (4.8) • *Place:* 7 city residents & 9 suburbs residents • *Occupation*: Housewives • *Gender (% female)*: 100 • BMI: 21.2 (4.3) • *Number randomised to intervention group 1*: 16 Intervention group 2

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Kitagawa 2020 *(Continued)*

- *Age (SD)*: 38.4 (4.0)
- *Place:* 6 city residents & 10 suburbs residents
- *Occupation*: Housewives
- *Gender (% female)*: 100
- BMI: 22.0 (3.7)
- *Number randomised to intervention group 2*: 16

Control

- *Age (SD)*: 39.5 (4.8)
- *Place:* 8 city residents & 8 suburbs residents
- *Occupation*: Housewives
- *Gender (% female)*: 100
- BMI: 21.3 (4.2)
- *Number randomised to control group*: 16

Overall

- *Age (SD)*: 38.0 (4.5)
- *Place:* 21 city residents & 27 suburbs residents
- *Occupation*: Housewives
- *Gender (% female)*: 100
- *Number randomised*: 48

Pretreatment: No significant differences were found in the age and BMI among the three groups before the intervention. Differences in PA and SB between the groups at baseline were not looked at or not reported.

Interventions

Intervention characteristics

Intervention group 1 (self-feedback)

- *Content*:
  - Group 1 (self-feedback): Participants were handed the pamphlet between the first and the second weeks. The pamphlet used graphs and pictures to show that long periods of sitting lead to mortality and lifestyle diseases, including diabetes, obesity, cardiovascular disease, and cancer. Participants downloaded an application (UP) that displayed their physical activity, including the longest prolonged sitting time, to their smartphone. The application displayed the number of steps, total physical activity time, longest activity time, longest prolonged sitting time, calorie consumption (total, active, inactive), and activity amount per time zone. In addition, these participants were instructed how to provide feedback on the sitting time for themselves in the second week.
  - Group 2 (tailored feedback): content as per group 1 wtih addition of the following: Participants were provided personalized information. At the time of the intervention, a physical therapist analyzed the participant's lifestyle as related to prolonged sitting time using data from the first measure week, and then advised the participants on effective methods for shortening sitting time specific to each participant's lifestyle. Examples of suggested methods included standing and moving while doing housework; standing and moving during TV commercials or between chapters while reading; engaging in physically active play with the children; taking a break to move during conversations and phone calls rather than sitting the entire time; and placing their mobile phone far away so that the participant must move to check it.
- *Strategies to address diversity or disadvantage*: NR
- *Cost*: NR
- *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: NA (1 week intervention)
- *Theoretical basis*: NR

Control

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Kitagawa 2020 *(Continued)*

	• *Content*: All participants were handed the pamphlet between the first and the second weeks. The pamphlet used graphs and pictures to show that long periods of sitting lead to mortality and lifestyle diseases, including diabetes, obesity, cardiovascular disease, and cancer.
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Longest prolonged sitting time, UP24 accelerometer (min/day) • Total physical activity, UP24 accelerometer (mins/day) • Steps, UP24 accelerometer (counts/day) • Health-related quality of life, Short-Form 8. **Other outcomes**
Identification	**Sponsorship source:** NR **Author's name:** Tomomi Kitagawa **Institution:** Osaka Prefecture University **Email:** t-kitagawa@reha.shijonawate-gakuen.ac.jp **Address:** Graduate School of Comprehensive Rehabilitation, Osaka Prefecture University, 3-7-30 Habikino, Habikino city, Osaka 583-8555, Japan **Conflicts of interest declared: NR** **Publication type:** Journal article
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"Computer generated random numbers table"
Allocation concealment	Unclear risk	Not reported
Blinding of outcome assessors	Low risk	"The staff who performed assessments or interventions were masked as to participants group assignments."
Blinding of outcome assessment (sedentary time) Sedentary time	Low risk	Accelerometer used
Incomplete outcome data	Low risk	"None of the participants dropped out during the intervention, and all participants completed the measurements during the first and second weeks."
Selective reporting	Unclear risk	Insufficient information to permit judgement
Other sources of bias	Unclear risk	Insufficient information to assess whether an important risk of bias exists

Laska 2016

Study characteristics	
Methods	**Study design:** randomised controlled trial

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Laska 2016 *(Continued)*

Study grouping: parallel group

Methods of recruitment: colleges were required to agree to (1) allow project staff on campus to recruit students; (2) offer the one-credit weight management course through their college and help with logistics of making the course available to students; and (3) allow staff to conduct student measurements on campus. The university agreed to cover all costs related to conducting the research. CHOICES study staff recruited students to participate in the study with help from the administrative offices at the colleges using a variety of approaches, including email invitations, posters and table tents in the college, and information tables staffed by CHOICES staff

Study SB/PA objective/aim: physical activity and sedentary behaviours

Country: USA

Setting: 3 Minnesota community colleges

Study dates: 2011-2014; study duration: 24 months

Participants

Included criteria: eligibility requirements included being 18 to 35 years old; having BMI of 20 to 34.9 kg/m^2; and planning to be in the geographic area for ≥2 years. Original study eligibility requirements included BMI of 20 to 29.9 kg/m^2; due to challenging participant enrolment in this population and initial interest from students with BMI ≥ 30 kg/m^2, investigators expanded the BMI inclusion criteria to 20 to 34.9 kg/m^2 after enrolment began

Excluded criteria: individuals with BMI ≥ 35 kg/m^2 were ineligible because (1) CHOICES was a weight gain prevention trial, and (2) individuals with BMI ≥ 35 kg/m^2 have different intervention needs for weight loss. Additional EARLY trial criteria excluded participants with significant health problems

Baseline characteristics

Intervention

- *Age (SD)*: 22.9
- *Race*: 76.3% white; 7.6% Hispanic or Latino origin
- *Gender (% female)*: 67.0
- *Socioeconomic status*: 67.9% income less than $12,000
- *Number randomised to intervention group*: 224

Control

- *Age (SD)*: 22.8
- *Race*: 68.7% white; 7.4% Hispanic or Latino origin
- *Gender (% female)*: 68.2
- *Socioeconomic status*: 64.5% income less than $12,000
- *Number randomised to control group*: 217

Overall

- *Age (SD)*: 22.8
- *Race*: 72.6% white; 7.5% Hispanic or Latino origin
- *Gender (% female)*: 67.6
- *Education*: college students
- *Socioeconomic status*: 66.2% income less than $12,000
- *Number randomised to each group*: 441

Pretreatment: the only marginally significant sociodemographic or behavioural difference between intervention and control conditions was for percentage of participants identifying as white (intervention 76.3%, control 68.7%; P = 0.07)

Interventions

Intervention characteristics

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Laska 2016 *(Continued)*

	Intervention • *Content*: one-credit course offered through the college in which participants were enrolled. The course was developed and delivered by CHOICES research staff and focused on eating, activity, sleep habits, and stress management as mechanisms for maintaining and/or achieving a healthy weight. Participants chose between 3 course sections (online, face-to-face, or hybrid) to meet scheduling needs and learning preferences. Students also participated in a social networking and support website, introduced as part of the course and continued as the primary intervention channel for 20 months. It was designed to reinforce, inform, and encourage exchange and support between participants. Students were encouraged to track their weight and up to 10 weight-related behaviours (i.e. sugary beverages; fast food; fruits/vegetables; breakfast consumption; eating mindfully; TV/movie viewing; computer and Internet use; physical activity; sleep duration; stress management) on the website. Trained interventionists primarily interacted with participants through the website but occasionally used texting and telephone calls to offer encouragement and help problem-solve. The website included articles, recipes, quizzes, videos, and ways to accumulate points for prizes • *Cost*: not reported • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: 24 months • *Theoretical basis*: intervention development was informed by ecological theories of health behavior, social-cognitive theory, and social network theory, suggesting weight-related behaviours are influenced by various personal and socioenvironmental factors Control • *Content*: students randomised to the control condition received health assessments per the study measurement schedule as well as basic health promotion information on a quarterly basis. Students in the control condition were not allowed to enrol in the course and were not granted access to the website
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Television viewing time, questionnaire (hours/d) • Leisure-time computer use, questionnaire (hours/d) • Leisure-time physical activity, Paffenbarger Questionnaire (min/week) • Energy expenditure in leisure-time physical activity, Paffenbarger Questionnaire (kcal/week) **Other outcomes** • Diet (fast food, sugary beverages, breakfast, at-home meal preparation) • Sleep (hours of sleep, time required to fall asleep, days not getting enough rest, difficulty staying awake)
Identification	**Sponsorship source:** this study was 1 of 7 randomised, controlled trials funded as part of the EARLY Trials consortium (Early Adult Reduction of weight through LifestYle intervention, earlytrials.org). This research was supported through a grant from NHLBI (1 U01 L096767-01). Additional salary support was provided by Grant Number K07CA126837 from the National Cancer Institute **Author's name:** Melissa N Laska **Institution:** School of Public Health, Division of Epidemiology and Community Health, Minneapolis, MN, USA **Email:** mnlaska@umn.edu **Address:** University of Minnesota, School of Public Health, Division of Epidemiology and Community Health, 1300 S. 2nd Street, Suite 300, Minneapolis, MN 55454, United States **Conflicts of interest declared:** study authors have no conflicts of interest to declare **Publication type:** 2 journal articles
Notes	

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Laska 2016 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"Blocked randomization was determined using computer-generated randomization"
Allocation concealment	Unclear risk	"The randomization sequence was generated by the study programmer"
Blinding of outcome assessors	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (sedentary time) Sedentary time	High risk	Self-report questionnaire used to report TV viewing
Incomplete outcome data	Unclear risk	Missing data not addressed in the article. Insufficient reporting of attrition/exclusions to permit judgement
Selective reporting	Unclear risk	Protocol not published
Other sources of bias	Low risk	No comment

Lioret 2012

Study characteristics	
Methods	**Study design:** cluster randomised controlled trial **Study grouping:** parallel group **Methods of recruitment:** mothers were recruited via pre-existing first-time parent groups. A 2-stage random sampling design was used to select first-time parent groups across all socioeconomic position areas **Country:** Australia **Setting:** community (parent groups) **Study dates:** not reported;**s**tudy duration: 18 months **Study SB/PA objective/aim:** to improve engagement in PA and decrease TV viewing
Participants	**Included criteria:** first-time parent groups; literacy in English and a minimum of 8 parents (in fact, mothers) in the groups consenting to participate (6 in low socioeconomic indices for areas) **Excluded criteria:** infants with chronic health problems likely to influence height, weight, physical activity, or eating behaviours were excluded from the analyses but could participate in the study **Baseline characteristics** Intervention • *Age (SD)*: 32.5 (4.2) • *Gender (% female)*: 100 • *Education*: low (secondary school or below): 22.0; intermediate (trade and certificate qualifications): 26.5; high (university degree or higher): 51.5 • *BMI (mean SD)*: 24.7 (5.6)

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Lioret 2012 *(Continued)*

- *Number randomised to intervention group*: 271

Control

- *Age (SD)*: 32.0 (4.4)
- *Gender (% female)*: 100
- *Education*: low: 20.3; intermediate: 22.9; high: 56.8
- *BMI (mean SD)*: 24.3 (5.0)
- *Number randomised to control group*: 271
- *BMI (mean SD)*: 24.3 (5.0)
- *Number randomised to control group*: 271

Overall

- *Age (SD)*: 32.3 (4.3)
- *Gender (% female)*: 100
- *Education*: low: 21.1; intermediate: 24.7; high: 54.2
- *BMI (mean SD)*: 24.5 (5.3)
- *Number randomised*: 542

Pretreatment: no differences were observed at baseline in any sociodemographic variables between intervention and control groups

Interventions	**Intervention characteristics** Intervention • *Content*: this dietician-delivered intervention comprised six 2-hour sessions delivered quarterly during the regular meeting time of the first-time parent group. The intervention incorporated a range of modes of delivery and educational strategies including brief didactic sessions, use of group discussion and peer support, exploration of perceived barriers and facilitators, use of visual and written messages, and mail-outs. Intervention materials incorporated 6 purpose-designed key messages within a DVD and written handouts: “Eat together, play together”,“Colour every meal with fruit and veg”,“Parents provide, kids decide”,“Tap on water”,“Snack on fruit and veg”,“Off and running”. A newsletter reinforcing key messages was sent to participants between sessions. A range of cognitive feedback activities were employed to promote parental examination of personal eating, physical activity, and sedentary behaviours. Emphasis on these behaviours focused on the importance of personal health and on the ways in which parental behaviours would impact subsequent child health behaviours (via parental modelling in this instance) • *Were there particular strategies to address diversity or disadvantage*: NR • *Cost*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: 18 months • *Theoretical basis*: theory of anticipatory guidance Control • *Content*: control group families received usual care, and newsletters regarding generic issues in child health were sent to participating families 3-monthly
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Televison and video/DVD viewing time, self-administered questionnaire (min/d) • Total physical activity, questionnaire (min/week) **Other outcomes** • Diet (food frequency questionnaire)
Identification	**Sponsorship source:** SL is supported by a Deakin University Alfred Deakin Postdoctoral Fellowship. KJC and DC are supported by fellowships from the Victorian Health Promotion Foundation. ACS was

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Lioret 2012 *(Continued)*

supported by a Deakin University Postgraduate Research Scholarship. KH is supported by a National Heart Foundation of Australia Career Development Award. SAM is supported by an Australian Research Council Future Fellowship. The Melbourne Infant Feeding Activity and Nutrition Trial (InFANT) Program was funded by an Australian National Health and Medical Research Council Project Grant (number 425801)

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Publication type: 2 journal articles

Conflicts of interest declared: study authors declare that they have no competing interests

Notes

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"Randomization was undertaken using a computer-generated random number schedule"
Allocation concealment	Low risk	"Developed by a statistician who had no contact with the centers"
Blinding of outcome assessors	Unclear risk	Insufficient information to permit judgement
Blinding of outcome assessment (sedentary time) Sedentary time	High risk	"Mothers also reported the usual time spent watching television or videos/ DVD's on both weekdays and weekend days" Comment: self-report measure
Incomplete outcome data	Low risk	People with missing data were excluded from the analysis. Dropout was fairly even across groups
Selective reporting	High risk	Some variables in the protocol are not reported (e.g. BMI)
Other sources of bias	Low risk	No comment
Recruitment bias (cluster RCT only)	Low risk	"First-time parents groups will be randomised after recruitment in order to ensure baseline equivalence and minimise selection bias"
Baseline imbalance (Cluster RCT only)	Unclear risk	"No differences were observed at baseline in any sociodemographic variables between intervention and control groups, or between those retained or eliminated from the analyses (data not presented)" Comment: refers to groups overall rather than possible differences in clusters
Loss of clusters (Cluster RCT only)	Unclear risk	Unclear if any clusters (parent groups) dropped out
Incorrect analysis (Cluster RCT only)	Low risk	"Clustering by first-time parents' group was accounted for in all models"

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Lioret 2012 *(Continued)*

Comparability with individually randomized trials (Cluster RCT only)	Low risk	Clustering at parents' group level - contamination unlikely

Sui 2018

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** recruitment posters distributed by the university's poster distribution service onto specific poster boards on the university campus, emails to participants in previous studies conducted by the research group, and referrals from other participants, as well as Facebook posts in each faculty student page **Country:** Canada **Setting:** university **Study dates:** January to December 2016; study duration: 8 weeks **Study SB/PA objective/aim:** increase occupational (student) break frequency and decrease break duration
Participants	**Included criteria:** (1) 18 years of age or older, (2) a student attending university full-time, and (3) in self-reported good mental and physical health **Excluded criteria:** pregnant and/or unable to read and write in English **Baseline characteristics** Intervention • *Age (SD)*: 23.5 (4.07) • *Place*: university • *Occupation*: student • *Gender (% female)*: 82.12 • *Number randomised to intervention group*: 28 Control • *Age (SD)*: 23.54 (5.27) • *Place*: university • *Occupation*: student • *Gender (% female)*: 62 • *Number randomised to control group*: 24 Overall • *Age (SD)*: 23.52 (4..6) • *Gender (% female)*: 73.1 • *Specific social or cultural characteristics*: university students • *Number randomised*: 52 **Pretreatment:** there were no differences between groups for break frequency or duration at baseline

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Sui 2018 *(Continued)*

Interventions	**Intervention characteristics** Intervention • *Content*: counselling sessions. Participants were given a behavioural counselling table as reference for developing strategies as part of their Action Plan. The table included headings drawn from the FITT principle: frequency, intensity, time, and type. Frequency is how often a strategy should be used; intensity is the duration of breaks from sitting; time is when the strategy should be enacted; and type is the activity done during the break from sitting. In addition, in line with the HAPA model, there was a section titled "Coping Strategy". For those in the treatment arm of the study, strategies explicitly focused on the ultimate objective of increasing break frequency to every 30 to 45 minutes and achieving a break duration of 2 to 3 minutes, in the occupational domain of study (i.e. as a student; outside the classroom) • *Cost:* NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: intervention was 6 weeks, last follow-up was 2 weeks later (8 weeks from baseline) • *Theoretical basis*: health action process approach Control • *Content*: equal contact control group. Strategies focused on the objective of having participants achieve weekly food group servings in line with the age-respective recommendations of Canada's Food Guide
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Frequency of breaks from sitting, online modified domain-specific last 7 d sedentary time questionnaire (SIT-Q 7d) (min) • Duration of breaks from sitting, online modified SIT-Q 7d (min)
Identification	**Sponsorship source:** NR **Author's name:** Wuyou Sui **Institution:** University of Western Ontario **Email:** wsui3@uwo.ca **Address:** Department of Kinesiology, The University of Western Ontario, 1151 Richmond St., London, Ontario, N6A 3K7 Canada **Conflicts of interest declared:** NR **Publication type:** journal article
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"Randomisation into groups was determined using the Research Randomizer web service"
Allocation concealment	Unclear risk	Not stated
Blinding of outcome assessors	High risk	"Research staff, participants, and assessors were not blinded to group allocation"
Blinding of outcome assessment (sedentary time)	High risk	"Participants completed an SB questionnaire that assessed break frequency and duration of student SB"

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Sui 2018 *(Continued)*

Sedentary time		Comment: self-report
Incomplete outcome data	Low risk	"Taken together, all missing data were considered random. Hence, an intent-to-treat last observation carried forward was used to handle missing data" Comment: no differences between completers and dropouts and similar level of dropout between intervention and control
Selective reporting	Unclear risk	Protocol not published
Other sources of bias	Unclear risk	Insufficient information to assess whether an important risk of bias exists

Williams 2019

Study characteristics	
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment: c**are coordinators (case managers) were asked to identify and refer eligible service users. All service users referred to the study who met our criteria were sent a letter explaining the study with a follow-up telephone call a week later. **Study SB/PA objective/aim: "**We developed a health coaching intervention (Walk this Way) to reduce SB and increase PA in people with serious mental illness (SMI) living in the community" **Country:** UK **Setting:** Community Mental Health Team in South London **Study dates:** September 2015 - October 2017 **Study duration:** 17 week intervention
Participants	**Included criteria:** a diagnosis of any SMI (ICD-10 clinical diagnosis of a schizophrenia spectrum disorder (F20–29), bipolar affective disorder (F31) or serious depression (F32.3); meeting any one of the following criteria as determined by a care coordinator (case manager): i) overweight, ii) at risk of or have diabetes, iii) in the clinician's view, have a sedentary lifestyle, iv) or smoke tobacco; ability to provide informed consent; ability to understand English and over 18 years of age. **Excluded criteria:** under the age of 18, not having a diagnosis of SMI and unable to give informed consent. **Baseline characteristics** Intervention • *Race:* White 6; Black 12; Asian 1; Mixed 1; Other 0 • *Gender (% female)*: 35 • *Other characteristic identified*: Serious mental illness (schizophrenia 12; bipolar 3; psychosis 2; other 3) • *Number randomised to intervention group*: 20 Control • *Race:* White 5; Black 8; Asian 2; Mixed 4; Other 1 • *Gender (% female)*: 55 • *Other characteristic identified*: Serious mental illness (schizophrenia 10; bipolar 2; psychosis 1; other 7)

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Williams 2019 *(Continued)*

- *Number randomised to control group*: 20

Overall

- *Age (SD)*: 43
- Place: Community dwelling
- *Gender (% female)*: 45
- *Other characteristic identified*: Serious mental illness
- N*umber randomised*: 40

Pretreatment: levels of activity did not differ significantly between the two groups at baseline.

Interventions	**Intervention characteristics** Intervention • *Content*: Initial education session, fortnightly one-to-one health coaching, provision of pedometers and access to a weekly walking group • *Strategies to address diversity or disadvantage*: NR • *Cost*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: N/A (17 week intervention) • *Theoretical basis*: COM-B model of behaviour change Control • *Content*: Participants in the control group received treatment as usual which consisted of care coordination plus written information on the benefits of increasing activity levels.
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** • Sedentary time, GENEActiv accelerometer (min/day) • Total PA, GENEActiv accelerometer (min/day) • Light PA, GENEActiv accelerometer (min/day) • MVPA, GENEActiv accelerometer (min/day) **Other outcomes**
Identification	**Sponsorship source:** This research was supported by the Maudsley Charity and the National Institute for Health Research (NIHR) Collaboration for Leadership in Applied Health Research and Care South London (NIHR CLAHRC South London) at King's College Hospital NHS Foundation Trust. BS is supported by Health Education England and the National Institute for Health Research HEE/NIHR CA Programme Clinical Lectureship (ICA-CL-2017-03-001). No funding source had any role in the design and conduct of the study; collection, management, analysis or interpretation of the data; or preparation, review or approval of the manuscript. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care. **Author's name:** Julie Williams **Institution:** King's College London **Email:** julie.williams@kcl.ac.uk **Address:** Health Service and Population Research Department, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, UK **Conflicts of interest declared:** FG has received support or honoraria for CME, advisory work and lecturesfrom Bristol- Myers Squibb, Janssen, Lundbeck, Otsuka, Roche, and Sunovion,and has a family member with professional links to Lilly and GSK, includingshares. TC has received honoraria and travel support from pharmacompanies Lundbeck UK, Sanofi Aventis and Otsuka. He holds researchgrants

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Williams 2019 *(Continued)*

from governmental and charitable research organisations. All otherauthors declare they have no conflicts of interest.

Publication type: Journal article

Notes		

Risk of bias

Bias	Authors' judgement	Support for judgement
Sequence generation	Low risk	"random sequence generator (https://www.random.org)"
Allocation concealment	Low risk	"randomisation was done by a researcher independent of the study"
Blinding of outcome assessors	Low risk	"The researchers conducting the baseline assessment were unaware of which arm the participant had been allocated to when completing the baseline assessment"
Blinding of outcome assessment (sedentary time) Sedentary time	Low risk	"All participants were asked to wear a wrist-worn GENEActiv accelerometer"
Incomplete outcome data	High risk	"Two intervention participants did not have accelerometer data at follow up so accelerometer data at follow up is for 31 participants. At 6 months 21 participants had accelerometer data, with 8 in the intervention group and 13 in the control group. We therefore calculated the mean minutes for SB and each classification of PA over three consecutive days for which we had the most complete data at baseline. Follow-up data was available for 33 participants, resulting in a retention rate of 82.5%."
Selective reporting	High risk	Accelerometer protocol is different between protocol ("All participants will be required to wear a wrist-worn GENEActiv accelerometer for at least 4 days (including 1 weekend day if possible) at baseline") and results paper ("We therefore calculated the mean minutes for SB and each classification of PA over three consecutive days for which we had the most complete data at baseline.") Protocol also states that IPAQ would be used but data is not reported in the resutls paper: "(IPAQ) [25] will be used to capture self-reported physical activity and sedentary behaviour.". Protocol also states "number of disruptions in sedentary behaviour" as a secondary outcome, but this is not reported in results paper.
Other sources of bias	Low risk	The study appears to be free of other sources of bias.

apo: apolipoprotein.
BMI: body mass index.
CG: control group.
FITT: frequency, intensity, time, and type.
FMS: fundamental movement skills.
HAPA: health action process approach.
HbA1c: glycosylated haemoglobin.
HDL: high-density lipoprotein.
HOMA-%B: homeostatic model assessment of β-cell function.
HOMA-IR: homeostatic model assessment of insulin resistance.
LDL: low-density lipoprotein.
LED: light-emitting diode.
MET: metabolic equivalent.
MVPA: moderate to vigorous physical activity.

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n/a: not applicable.
NR: not reported.
PA: physical activity.
REML: reduced maximum likelihood approach.
SB: sedentary behaviour.
SD: standard deviation.
SLIPA: Sedentary and Light Intensity Physical Activity Log.
STAND: Study of Two Doses of Crizanlizumab Versus Placebo in Adolescent and Adult Sickle Cell Disease Patients.
stAPP: Smartphone-based intervention.
VLDL: very low-density lipoprotein.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Aadahl 2012	Sample includes participants over 59 years or under 18 years of age
Aadahl 2014	Sample includes participants over 59 years or under 18 years of age
Adams 2013a	Sample includes participants over 59 years or under 18 years of age
Adams 2015	Sample includes participants over 59 years or under 18 years of age
Balducci 2019	Sample includes participants over 59 years or under 18 years of age
Barone Gibbs 2018	Workplace setting
Barwais 2014	Not RCT/cluster-RCT
Barwais 2015	Not RCT/cluster-RCT
Bohn 2017	Not RCT/cluster-RCT
Bond 2014	Not RCT/cluster-RCT
Carr 2013	Workplace setting
Casey 2018	Workplace setting
Chiang 2019	Sample includes participants over 59 years or under 18 years of age
Conroy 2016	Wrong control (more than attention control or no intervention)
De Cocker 2008	Age < 18 or > 59 years of age
Dewa 2009	Not RCT/cluster RCT
Duncan 2016	Wrong control (more than attention control or no intervention)
Edwards 2016	Does not specifically target sedentary behavior (overall or TV viewing, computer use, etc.)
Garcia-Ortiz 2017	Sample includes participants over 59 years or under 18 years of age
Gardner 2014	Sample includes participants over 59 years or under 18 years of age
George 2018	Sample includes participants over 59 years or under 18 years of age

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Study	Reason for exclusion
Gine-Garriga 2017	Sample includes participants over 59 years or under 18 years of age
Hartman 2020	Does not specifically target sedentary behavior (overall or TV viewing, computer use, etc.)
Helgadottir 2017	Sample includes participants over 59 years or under 18 years of age
Jprn 2019	Not RCT/ cluster RCT
Judice 2015	Sample includes participants over 59 years or under 18 years of age
King 2016a	Wrong control (more than attention control or no intervention)
Kirk 2012	Not RCT/cluster-RCT
Kline 2017	Workplace setting
Kozey 2014	Not RCT/cluster-RCT
Kozey-Keadle 2014	Not RCT/cluster-RCT
Lakerveld 2013	Does not specifically target sedentary behavior (overall or TV viewing, computer use, etc.)
Lynch 2019	Sample includes participants over 59 years or under 18 years of age
Martin 2017	Sample includes participants over 59 years or under 18 years of age
Martinez-Perez 2018	Sample includes participants over 59 years or under 18 years of age
McNeil 2018	Sample includes participants over 59 years or under 18 years of age
Miyamoto 2017	Sample includes participants over 59 years or under 18 years of age
Nishimura 2019	Sample includes participants over 59 years or under 18 years of age
Overgaard 2017	Not RCT/cluster-RCT
Prince 2018	Sample includes participants over 59 years or under 18 years of age
Raynor 2013	Wrong control (more than attention control or no intervention)
Recio-Rodriguez 2018	Sample includes participants over 59 years or under 18 years of age
Rockette-Wagner 2015	Sample includes participants over 59 years or under 18 years of age
Rosenberg 2018	Sample includes participants over 59 years or under 18 years of age
Siddique 2017	Not RCT/cluster-RCT
Silva 2017	Sample includes participants over 59 years or under 18 years of age
Teixeira 2017	Sample includes participants over 59 years or under 18 years of age
Thomsen 2019	Sample includes participants over 59 years or under 18 years of age
van de Glind 2017	Sample includes participants over 59 years or under 18 years of age

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Study	Reason for exclusion
Wilson 2018	Not RCT / cluster RCT
Wyke 2019	Sample includes participants over 59 years or under 18 years of age

RCT: randomised controlled trial.

Characteristics of studies awaiting classification *[ordered by study ID]*

Marcinkevage 2012

Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** NR **Study SB/PA objective/aim:** reducing sedentary behaviour and increasing levels of moderate physical activity
Participants	**Included criteria:** overweight/obese black women **Excluded criteria:** NR **Baseline characteristics** Intervention • *Race*: black • *Gender (% female)*: 100 • *Number randomised to each group*: NR Control • *Race*: black • *Gender (% female)*: 100 • *Number randomised to each group*: NR Overall • *Race*: black • *Gender (% female)*: 100 • *Number randomised*: 55 **Pretreatment:** NR
Interventions	**Intervention characteristics** Intervention • *Content*: monthly meetings focused on reducing sedentary behaviour and increasing levels of moderate physical activity (PA) • *Cost*: NR • *Sustainability*: data from 14 weeks' gestation (mid-pregnancy) • *Theoretical basis*: NR Control • *Content*: regular prenatal care

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Marcinkevage 2012 *(Continued)*

Outcomes	**Outcomes measured in the study:** glucose, self-report PA, self-report sedentary behaviour (MET-hours/week), gestational weight gain
Notes	

MET: metabolic equivalent.
NR: not reported.
PA: physical activity.
SB: sedentary behaviour.

Characteristics of ongoing studies *[ordered by study ID]*

ISRCTN58484767

Study name	Using "IF-THEN" plans to increase physical activity
Methods	**Study design:** randomized controlled trial **Study grouping:** parallel group **Recruitment:** **Study SB/PA objective/aim:** The two conditions that complete a volitional help sheet (standard VHS and single situation VHS) will report greater physical activity and lower sedentariness at follow up than the control condition **Country:** UK **Setting:**
Participants	**Included criteria:** UK adults who are capable of engaging in physical activity **Excluded criteria:** 1. Children 2. People who are not capable of engaging in physical activity 3. People not based in the UK
Interventions	**Intervention characteristics** Intervention: • The standard volitional help sheet includes a list of situations when people might not want to be physically active (e.g., If I'm tempted not to be physically active when I'm under a lot of stress) and a list of solutions to overcoming these (e.g., then I will make myself do some physical activity anyway because I know I will feel better afterward). People are asked to draw a line from the situations that are relevant to them to their chosen solutions. They can create as many situation and solution pairs as they want. • The single situation volitional help sheet includes a stem but not a specific situation (e.g., IIf I'm tempted not to be physically active…) and a list of solutions to overcoming this (e.g., then I will make myself do some physical activity anyway because I know I will feel better afterward). People are asked to draw a line from the stem to them to their chosen solutions. They can create as many pairs as they want. Control: • The control condition includes the same list as the standard volitional help sheet but people are asked just to tick situation and solutions that are relevant to the
Outcomes	**SB/PA outcome name and measurement tool:**

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ISRCTN58484767 *(Continued)*

	• Physical activity is measured using the Sport England: Short active lives questionnaire and the IPAQ at baseline and 6 months follow up. • Sedentary behaviour is measured using a sedentary behaviour questionnaire at baseline and 6 months follow up
Starting date	May 2019
Contact information	Chris J Armitage, University of Manchester chris.armitage@manchester.ac.uk
Notes	ISRCTN58484767

Latomme

Study name	Feel 4 Diabetes
Methods	
Participants	
Interventions	European study in 7 countries aiming to promote healthy lifestyles (including sedentary behaviour) among families
Outcomes	
Starting date	Unknown
Contact information	Julie Latomme, Ghent University julie.latomme@ugent.be
Notes	

Martin Borras 2014

Study name	SEDESTACTIV
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** recruitment will take place in 13 PHCs in different regions of Spain (Barcelona, Lleida, Zaragoza, and Almeria). Primary healthcare professionals, who were selected on a voluntary basis from each of the participating centres, were trained. During the recruitment period, the opportunity to participate in the study will be offered at least once a week to all patients with overweight or mild obesity. A total of 30 subjects will be recruited in each PHC **Study SB/PA objective/aim:** to reduce sedentary time among overweight and mildly obese adults
Participants	**Included criteria:** (1) men and women aged 25 to 65 seen at the PHC for whatever reason; (2) diagnosis of being overweight or suffering mild obesity (BMI 25 to 34.9 kg/m^2); (3) autonomous subjects who have minimum physical aptitudes to follow the recommendations (being able to walk and stand up from a chair independently); (4) ≥ 6 hours of daily sitting; (5) can assure participation in the study for a year

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Martin Borras 2014 *(Continued)*

	Excluded criteria: will be based on certain medical conditions that could contraindicate fulfilment of the intervention. Patients who have had obesity surgery will also be excluded
Interventions	**Intervention characteristics** Intervention • *Content*: the intervention will be done according to the patient's willingness to reduce sitting time (stage of change), and considering whether the subject prefers a more or less intensive intervention: (1) pre-contemplative (not thinking about change) and contemplative (thinking about change), (2) ready to change with minimum professional support, (3) ready to change with intensive professional support. All of them will be handed a card with planned sessions and Mediterranean diet recommendations. Precontemplative and contemplative patients (1) will be informed of the risks of being 6 or more hours sitting and will be asked about the importance and confidence for change. Ready to change patients (2 and 3) will be proposed an intervention based on 2 to 5 meetings (visits face-to-face or phone calls depending on the situation of each professional and patient) with a trained professional during 6 months. At those meetings, the professional will work on finding alternatives to progressively reduce SB by developing the same activities walking • *Cost (if reported)*: NR • *Sustainability [note if duration of the intervention/follow-up at least 12 months]*: 12-month follow-up • *Theoretical basis*: NR Control • *Content*: subjects assigned to the control group will be given information on the study and will be asked to continue their routine daily activities. They will receive their usual care from their primary care practice. The health professional will give the patient a pamphlet with the Mediterranean diet recommendations
Outcomes	**Outcomes measured in the study:** the primary outcome is sitting time measured by using the activPAL device (PAL Technologies, UK). Sitting time will also be measured with the Marshall Questionnaire. Secondary outcomes include decreasing sitting time in the workplace among individuals involved in the intervention (occupational sitting and physical activity questionnaire), quality of life (EQ5D), attitudes towards changing behaviour (Prochaska Scale), physical activity (Brief Physical Activity Assessment Tool (CBPAAT)), anthropometric variables - BMI, triceps skinfold, waist circumference, metabolic indicators - triglycerides, total cholesterol, HDL, LDL, glycaemia, glycated haemoglobin in diabetic patients
Starting date	Unknown
Contact information	Carme Martín-Borràs, Primary Healthcare Research Institution IDIAP Jordi Gol and Universitat Ramon Llull mariacarmenmb@blanquerna.url.edu
Notes	

NCT02909725

Study name	BlossomUP
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** mass email recruitment, flyers posted at local community settings and at local OBGYN offices in Ames, IA

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NCT02909725 *(Continued)*

	Study SB/PA objective/aim: limit accumulation of sedentary time (achieve a goal of 250 steps/hour); walk (30 minutes, most days of the week; 150 minutes/week) **Country:** USA **Setting:** community
Participants	**Included criteria:** • Female aged 18 to 45 years • Women pregnant with 1 foetus between 16 and 22 weeks' gestation • Receiving regular prenatal care and physician-documented approval to participate in this study • Only inactive women will be enrolled; "inactive" is defined as self-reported participation in fewer than 3 planned exercise sessions/week for < 30 minutes per day for at least 6 months before conception **Excluded criteria:** • History of smoking during pregnancy • History of the following chronic diseases: type 1 diabetes, cardiovascular disease, or renal disease • Pre-pregnancy BMI > 40 kg/m^2 • Inability to communicate due to language barrier or mental status • Not having access to an UpBand compatible mobile device • Any adverse reactions to armband monitors (e.g. metal allergies, electromagnetic devices)
Interventions	**Intervention characteristics** Intervention: • *Group 1 (Limit accumulation of sedentary time):* participants will be asked to limit the accumulation of prolonged bouts (> 50 minutes) of sedentary time. Participants in this group receive a Fitbit Alta activity monitor, worn on the wrist for the entire intervention. The Alta is a fitness tracker designed to help individuals track their sedentary and physical activity behaviours when paired with an external device (e.g. iPhone, computer). Each participant will have a Fitbit account set up with a Blossom Project username code to ensure privacy of the participant's identity. Participants will be asked to achieve a goal of 250 steps/hour. Using the "reminder to move" function, if a participant has not reached the hourly goal at 50 minutes, the Alta will vibrate, cueing the participant to walk • *Group 2 (Walk 30 minutes most days of the week):* participants will be asked to walk 30 minutes per day on most days of the week. Participants in this group receive a Fitbit Charge activity monitor. There is no "reminder to move" function on this band. The Charge, worn on the wrist for the entire intervention, is a fitness tracker designed to help individuals track their physical activity when paired with an external device. Each participant will have a Fitbit account set up with a Blossom Project username code to ensure privacy of the participant's identity. Participants will be asked to meet current pregnancy physical activity recommendations: walking 30 minutes, most days of the week (150 minutes/week). Participants can use the app to view their "active minutes" Control: • *Active comparator:* normal daily routine/usual care: participants will be asked to continue on with their normal daily routine
Outcomes	**SB/PA outcome name and measurement tool (units of measurement)** Change in time spent sedentary as measured by data collected via ActivPAL analysis **Other outcomes:** maternal insulin resistance, maternal body weight change
Starting date	February 2016

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NCT02909725 *(Continued)*

Contact information	clmck@iastate.edu; ccampbel@iastate.edu
Notes	NCT02909725 Clinicaltrials.gov

NCT03698903

Study name	Take a STAND 4 Health
Methods	**Study design:** randomized controlled trial **Study grouping:** **Recruitment:** **Study SB/PA objective/aim:** The purpose of this study is to determine the effect of a 4-week sedentary behavior reduction intervention on objectively measured sedentary behavior of overweight or obese adults. **Country:** US **Setting:**
Participants	**Included criteria:** • Being 18 years or older • Having a BMI between 25 and 50 kg/m2 • Owning a smartphone that is accessible during the day Living or working within 30 miles of University of South Carolina (USC) • Willing to wear the activPAL for baseline assessment • An average self-reported sedentary time of at least 7 hours over the past 7 days • Willing to be randomized to either group **Excluded criteria:** • Inability to walk without assistance • Recent use of psychotropic medications or treatment for psychological issues, with the exception of anxiety and depression • Current treatment for cancer or other serious medical conditions such as renal failure Injury or illness that prohibits standing or walking • Pregnant or gave birth within the last 6 months • Does not live or work within 30 miles of USC • Currently enrolled in a weight loss, physical activity, or stress management program • A known vacation or a major alteration in their normal schedule in the next 4 months • Unwilling to wear the accelerometer for 7 days at any assessment period or had an adverse reaction to wearing the accelerometer during baseline
Interventions	**Intervention characteristics** Intervention: (1) an in-person introductory session to acquaint the individuals with all intervention elements, customize to their preferences and describe the mHealth component of the intervention; (2) a website that will provide individualized feedback over time on the participant's scheduled breaks, sedentary time reduction, and sedentary patterns; (3) texts to serve as prompts and alert the participant to stand or move, with a goal of a 60 minute reduction per day, which are customized to the individual's schedule, personal preference and sedentary profile; and (4) two coaching phone calls to trouble shoot and problem solve implementation of the intervention.

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NCT03698903 *(Continued)*

	Control:
Outcomes	**SB/PA outcome name and measurement tool:** • Change in percent time spent sedentary, activPAL device • Percent time spent in light physical activity, activPAL device • Percent time spent in moderate-to-vigorous physical activity [Time Frame: Baseline, 4 weeks, 8 weeks] activPAL device • Self-reported sedentary behavior, Sedentary Behavior Questionnaire • Self-reported physical activity, International Physical Activity Questionnaire- Short form **Other outcomes:** • Blood pressure, Automated blood pressure machine • Waist circumference, Gulick tape • Weight, Calibrated Tanita body weight scale • Height, Stadiometer • Treatment Satisfaction, Survey
Starting date	August 2018
Contact information	Chelsea Larsen, University of South Carolina calarsen@email.sc.edu
Notes	NCT03698903

NCT04257539

Study name	Sedentary Intervention Using Motivational Interviewing and Technology (SUMIT)
Methods	**Study design:** randomized controlled trial **Study grouping:** parallel group **Recruitment:** **Study SB/PA objective/aim:** This study will test the effects of a sedentary behavior intervention on pain processing, blood bio-markers and pain symptoms in individuals with chronic low back pain **Country:** US **Setting:**
Participants	**Included criteria:** • Chronic low back pain (Currently experiencing low back pain every day or nearly every day for longer than 3 months) • Elevated depressive symptoms (Patient Health Questionnaire-9 greater than or equal to 5) • Ability to safely complete exercise session (Physical Activity Readiness Questionnaire) • Willing to wear a physical activity tracker with an idle alert Regular access to computer or smart-phone **Excluded criteria:** • Currently using activity tracker with idle alert • Taking immunomodulatory medication Taking anti-depressant medication Changed medication or treatment in last 8 weeks

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NCT04257539 *(Continued)*

	• Have injuries or conditions that prevent change in activity level • Pregnant or planning to become pregnant during study enrollment
Interventions	**Intervention characteristics** Intervention: • These subjects will participate in a behavioral intervention that will focus on reducing sedentary behavior. This will include an initial, in-person behavioral intervention with a health coach trained and a 4 week phone call. Participants will receive a wrist-worn activity prompter to aid in sedentary behavior reduction. Control: • Wait-list Control GroupChronic low back pain participants in this group will not receive the intervention until completion of the study. Over the 8 week intervention period, participants will be asked to maintain currently levels of physical activity, sedentary behaviors, and treatment for low back pain. • Pain-free Control GroupThese subjects will be healthy, pain-free adults and receive no intervention. Over the 8 week intervention period, participants in this group will be asked to maintain currently levels of physical activity, sedentary behaviors, and medication regimen.
Outcomes	**SB/PA outcome name and measurement tool (units of measurement):** • Monitor-assessed sedentary time, activPAL • Self-reported sedentary time, SIT Q 7d • Monitor-assessed physical activity, activPAL **Other outcomes:** • Depressive symptoms, Patient Health Questionnaire (PHQ-9) • Low back pain symptoms, Minimal Dataset for Low Back Pain • Pain sensitivity levels, Medoc Pathway Pain & Sensory Evaluation System and applying thermal stimuli to the palm of the non-dominant hand • Pain inhibition, Exercise-induced hypoalgesia • Plasma cytokine levels (IL-6 and TNF-alpha) • Plasma endocannabinoid levels (anandamide and 2-arachidonoylglycerol) • Patient health and quality of life, 36-Item Short Form Survey • Mood, Profile of Mood States Short Form
Starting date	February 2020
Contact information	Jacob Meyer, Iowa State University
Notes	NCT04257539

Pinto 2017

Study name	Take a STAND for Health
Methods	
Participants	**Included criteria:** • bariatric surgery patients • age between 25 and 50 years

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Pinto 2017 *(Continued)*

Interventions	
Outcomes	
Starting date	Unknown
Contact information	Ann Pinto, Universidade de Sao Paulo ana.pinto@usp.br
Notes	

Schroe 2019

Study name	MyPlan 2.0
Methods	**Study design:** randomised controlled trial **Study grouping:** parallel group **Recruitment:** **Study SB/PA objective/aim:** to experimentally investigate the efficacy of three behaviour-change techniques (i.e. action planning, coping planning and self-monitoring) on physical activity, sedentary behaviour and related determinants among adults. **Country:** Belgium **Setting:**
Participants	**Included criteria:** (1) being ≥ 18 years old, (2) Dutch-speaking, (3) having Internet access and (4) being the owner of a smartphone **Excluded criteria:** Participants will be excluded when one item or more will be endorsed on the the 'Physical Activity Readiness Questionnaire' (PAR-Q)
Interventions	**Intervention characteristics** Intervention: • Each group will receive a different version of the self-regulation-based e- and m-health intervention 'MyPlan2.0', in which three behaviour-change techniques (i.e. action planning, coping planning, self-monitoring) will becombined in order to achieve self-formulated goals about physical activity or sedentary behaviour. • Before the start of the intervention, participantschoose which behaviour they want to improve. Participantsare free to select either PA or SB. The structure ofMyPlan 2.0 is the same for both PA and SB. After behaviourselection, the allocation to one of the researchgroups takes place. After being allocated into a researchgroup, users will receive different website links to thecorresponding interventions. Control: • The control group will receiveonly tailored feedback, information and tips and tricks
Outcomes	**SB/PA outcome name and measurement tool (units of measurement):**

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Schroe 2019 *(Continued)*

	• self-report level of physical activity, IPAQ • self-report level of sedentary behaviour, SIT-Q-7 **Other outcomes:** • Goal attainment
Starting date	
Contact information	Helene Schroé, Ghent University Helene.Schroe@ugent.be
Notes	

BMI: body mass index.
CBPAAT: Catalan Brief Physical Activity Assessment Tool.
EQ-5D: EuroQoL Group Quality of Life Questionnaire based on 5 dimensions.
HDL: high-density lipoprotein.
LDL: low-density lipoprotein.
NR: not reported.
PHC: primary health care clinic.
STAND: Study of Two Doses of Crizanlizumab Versus Placebo in Adolescent and Adult Sickle Cell Disease Patients.

ADDITIONAL TABLES

Table 1. Definitions for quality ratings in GRADE

Quality level	Definition
High	Further research is very unlikely to change our confidence in the estimate of effect
Moderate	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
Low	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	Any estimate of effect is very uncertain

Table 2. Summary of the interventions

Study	Target group	SB/PA-related aim	Intervention components	Last follow-up	Theory
Personal monitoring device					
Arrogi 2017	Adults aged 18 to 55 years with sedentary jobs and/or predominantly sedentary leisure time	SB	Motion sensor and smartphone app to provide feedback in relation to targets, including a warning signal to modify behaviour	2 weeks	BCT principles

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Table 2. Summary of the interventions *(Continued)*

Barwais 2013	People who reported high total sitting time	SB + PA	Online personal activity monitor to provide feedback on progress towards their daily goal	4 weeks	NR
Kitagawa 2020	Housewives	SB	Motion sensor and smartphone application to provide feedback on sitting time. The tailored feedback group also received individual suggestions to shorten sitting time.	2 weeks	NR
Information/Education					
French 2011	At least one child aged at least 5 years and two household members aged at least 12 years, with weekly average household TV viewing of at least 10 hours per person	SB	6 monthly face-to-face group sessions, monthly newsletters, 12 home-based activities, a TV-limiting device, and monthly telephone support calls	12 months	NR
Laska 2016	Adults aged 18 to 35 years, with BMI of 20 to 34.9 kg/m^2	SB + PA	1 credit course at university plus social networking and a support website	24 months	Ecological theories of health behaviour, social-cognitive theory, and social network theory
Lioret 2012	First-time mothers	SB + PA	6 quarterly 2-hour sessions at parent group and a newsletter	18 months	Theory of anticipatory guidance
Jago 2013	Parents with at least one child aged 6 to 8 years	SB	8 weekly 2-hour education sessions	16 weeks	Self-determination theory
Information/Education plus personal monitoring device					
Biddle 2015	Overweight or obese adults aged 18 to 40 years with one or more additional risk factors for diabetes	SB	1 × 3-hour group workshop and a self-monitoring device to view and track progress against personal goals and provide feedback via vibration notifications	12 months	Bandura's social-cognitive theory, Gollwitzer's implementation intentions concept, Behavioural Choice Theory, and Leventhal's Common Sense Model
Ellingson 2016	Full-time students aged 18 to 26 years, reporting more than 3 hours of dai-	SB	10 to 15-minute information session and personal monitor with vibration feedback to modify behaviour towards a set target	5 weeks	Habit theory

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Table 2. Summary of the interventions *(Continued)*

	ly leisure-time sedentary behaviour				
Counselling					
Finni 2011	Healthy men and women with children aged 3 to 8 years and an occupation where they sit for more than 50% of their work time	SB	Tailored counselling, 2 telephone calls at 1 and 5 months, and motivational emails	12 months	Theory of planned behaviour
Sui 2018	Full-time university students aged 18+ years with good physical and mental health	SB	Counselling sessions with an action plan	6 weeks	Health action process approach
Information/Education plus personal monitoring device plus counselling					
Williams 2019	Community dwelling adults with serious mental illness	SB + PA	Initial education session, fortnightly one-to-one health coaching, provision of pedometers and access to a weekly walking group	17 weeks	COM-B model of behaviour change
Daily text messages					
Cotten 2016	Adults aged 18 to 65 years	SB	Daily text messages	6 weeks	NR

BCT: behaviour change technique.
BMI: body mass index.
NR: not reported.
PA: physical activity.
SB: sedentary behaviour.

Table 3. Summary of studies reporting breaks in sedentary time

Study	Definition of break in sedentary time	Measure	Findings
Arrogi 2017	Number of sit-to-stand transitions per day	ActivPAL Monitor	Short-term follow-up: MD 5.7 per day (94% CI 1.0 to 10.4)
Biddle 2015	Bouts of light to vigorous physical activity per day	Actigraph Accelerometer	Short-term follow-up: MD -29.6 (95% CI -97.0 to 37.9) Medium-term follow-up: MD -2.96 (95% CI -73.0 to 67.0)
Cotten 2016	Frequency of breaks to "get up and move around every day" (break every X minutes). Options were provided every 30 minutes or less, 45 minutes, 60 minutes, 75 minutes, 90 minutes, 120 minutes, 180 minutes, or 240 minutes or longer	Questionnaire	Short-term follow-up: MD -10.25 (-25.58 to 5.08)

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Table 3. Summary of studies reporting breaks in sedentary time *(Continued)*

Finni 2011	An interruption in sedentary time when accelerometer counts rose up to or above 100 counts/min for a minimum of 1 minute. Breaks per sedentary hour	Alive Technologies Accelerometer	Short-term follow-up: MD 1.0 (95% CI -0.2 to 2.2) Medium-term follow-up: MD 0.6 (95% CI -0.6 to 1.8)
Sui 2018	Frequency of interrupting sitting time (break every X minutes). Options included less than every 30 min, every 30 to 45 min, every 45 minutes to 1 hour, every 1 to 1.5 hours, every 1.5 to 2 hours, every 2 to 3 hours, every 3 to 4 hours, every 4 to 5 hours, over every 5 hours, no interruption	Questionnaire	Short-term follow-up: MD -53.12 (-96.98 to -9.28)

CI: confidence interval.
MD: mean difference.

HISTORY

Protocol first published: Issue 2, 2017
Review first published: Issue 7, 2020

CONTRIBUTIONS OF AUTHORS

Drafting the protocol: EM, MM, CF, KM, NR, CO'G.

Selecting studies: EM, MM (CF as arbiter).

Extracting data from studies: EM, KM (CF as arbiter).

Entering data into RevMan: EM, KM.

Carrying out the analysis: EM, CF.

Interpreting the analysis: EM, CF.

Drafting the final review: EM, MM, CF, KM, NR, CO'G.

Resolving disagreements: as noted above.

Updating the review: EM, MM, CF, KM, NR, CO'G.

DECLARATIONS OF INTEREST

Elaine M Murtagh: none known.

Marie H Murphy: together with another Ulster University colleague, the Sport & Exercise Sciences Research Institute at UU has received 20 standing desks from Ergotron to allow us to undertake a small research project on the use of sit-to-stand desks in office workers. This work is at feasibility stage and will not feature in the review.

Charles Foster: none known.

Karen Milton: none known.

Nia W Roberts: none known.

Clodagh SM O'Gorman: none known.

SOURCES OF SUPPORT

Internal sources

- Deprtartment of Physical Education & Sport Sciences, University of Limerick, Ireland

  EM works at the University of Limerick

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External sources

- Cochrane Fellowship, Health Research Board, Ireland

  EM was supported by a Cochrane Fellowship from the Health Reseach Board in Ireland (2016-2018).

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

There are some differences between our published protocol (Murtagh 2017) and this review.

- We did not check timing of measures against published protocols and protocol registration documentation to consider its potential impact on risk of bias, as we deemed it not relevant given the small RCTs identified in the review.
- We did not need to express dichotomous outcomes or categorical data as risk ratios, as none were identified.
- We did not need to re-analyse data from cluster RCTs by undertaking approximately correct analyses as outlined in Chapter 16: "Special topics in statistics" of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011b).
- We did not investigate reporting bias using funnel plots, as fewer than 10 studies were available for meta-analysis

NOTES

'Physical inactivity' and 'insufficient physical activity' are sometimes used to refer to failing to meet physical activity guidelines. In both cases, this is distinct from 'sedentary behaviour', for which a definition already exists (see Sedentary Behaviour Research Network 2012).

INDEX TERMS

Medical Subject Headings (MeSH)

Bias; Confidence Intervals; Counseling; *Exercise; Fitness Trackers; Health Education; Independent Living; Randomized Controlled Trials as Topic; *Sedentary Behavior; Self Report; Sitting Position; Television [statistics & numerical data]; Time Factors

MeSH check words

Adult; Female; Humans; Male; Middle Aged; Young Adult

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