Interventions with potential to reduce sedentary time in adults: systematic review and meta-analysis

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ABSTRACT

Context Time spent in sedentary behaviours (SB) is associated with poor health, irrespective of the level of physical activity. The aim of this study was to evaluate the effect of interventions which included SB as an outcome measure in adults.

Methods Thirteen databases, including The Cochrane Library, MEDLINE and SPORTDiscus, trial registers and reference lists, were searched for randomised controlled trials until January 2014. Study selection, data extraction and quality assessment were performed independently. Primary outcomes included SB, proxy measures of SB and patterns of accumulation of SB. Secondary outcomes were cardiometabolic health, mental health and body composition. Intervention types were categorised as SB only, physical activity (PA) only, PA and SB or lifestyle interventions (PA/SB and diet).

Results Of 8087 records, 51 studies met the inclusion criteria. Meta-analysis of 34/51 studies showed a reduction of 22 min/day in sedentary time in favour of the intervention group (95% CI −35 to −9 min/day, n=5868). Lifestyle interventions reduced SB by 24 min/day (95% CI −41 to −8 min/day, n=3981, moderate quality) and interventions focusing on SB only by 42 min/day (95% CI −79 to −5 min/day, n=62, low quality). There was no evidence of an effect of PA and combined PA/SB interventions on reducing sedentary time.

Conclusions There was evidence that it is possible to intervene to reduce SB in adults. Lifestyle and SB only interventions may be promising approaches. More high quality research is needed to determine if SB interventions are sufficient to produce clinically meaningful and sustainable reductions in sedentary time.

INTRODUCTION

There is growing public health concern about the amount of time spent in sedentary behaviours (SB). SB are defined as behaviours where sitting or lying is the dominant posture and energy expenditure is very low. 1 Sedentary time accumulates daily while commuting, at work, at home and during leisure time. 2,3 Where studies have controlled for the influence of moderate-to-vigorous physical activity (MVPA), too much time spent in SB is associated with poor health, including elevated cardiometabolic risk markers, type 2 diabetes and premature mortality. 4,5,9 Where studies have controlled for the influence of total sedentary and moderate-to-vigorous activity time, increased breaks in sedentary time have been shown to be beneficially associated with waist circumference, body mass index (BMI), triglycerides and 2 h plasma glucose. 10 Interventions interrupting extended sitting with frequent short activity breaks have enhanced markers of cardio metabolic health. 11–13 Recent systematic reviews have summarised the literature in respect to health implications, 14–18 measurement, 19 prevalence, 20 correlates 21 and interventions in young people. 22 To date, only one review of the evidence on interventions to influence total SB in adults has been published. 23 The review concluded that interventions with a specific goal of increasing PA levels and those which combined an increase in PA levels with a decrease in sedentary time resulted in modest reductions in SB, while interventions focusing on SB only resulted in greater reduction of sedentary time. The present systematic review expands this existing evidence 23 in five ways: (1) evaluating intervention effects using more precise categories of interventions; (2) assessing effects on pattern of SB accumulation; (3) conducting subgroup analyses; (4) including only randomised controlled trials (RCTs); and (5) assessing effects on health outcomes.

The primary aim of this review was to evaluate the effect of interventions which included an SB outcome measure in adults. The secondary aim was to determine the effects of interventions, which included an SB outcome, on measures of health.

METHODS

The protocol for this review is available online at the International Prospective Register for Systematic Reviews. 24

Study selection criteria

Studies were eligible for inclusion if they met the following criteria:

- Study design: RCTs
- Population: Adults aged 18 years or more who have left school.
- Intervention: Any intervention which included an SB outcome measure in free-living adults was eligible; those in clinical settings such as hospitals were excluded. Eligible control conditions were no intervention, waiting list, attention control (eg, general health information), usual care (eg, diabetes treatment involving lifestyle counselling) and alternative treatment conditions (eg, a structured exercise programme).
- Outcomes: Studies reporting any of the following outcomes were included:
  - Objectively measured SB obtained from accelerometers.
Data sources and searches
In January 2014, the Cochrane Central Register of Controlled Trials (Issue 12 of 12 December 2013), MEDLINE (1946-November week 3 2013), EMBASE (1980-week 1 2014), PsycINFO (1806-November week 5 2013), SPORTDiscus (1975-7 January 2014), CINAHL (1937-7 January 2013), Cochrane Database of Systematic Reviews (Issue 1 of 12 January 2014), Database of Health Promotion Research (Biblomap, Issue 4 of 4, October 2013), Database on Obesity and SB Studies (16 January 2014), Conference Proceedings Citation Indexes (Web of Science, 1900 to current), controlled-trials.com (16 January 2014), WHO International Clinical Trial Registry (16 January 2014) and the Networked Digital Library of Theses and Dissertations (1900-current) were searched. The search strategy for MEDLINE is listed in online supplementary 1. Reference lists and citations of relevant studies were examined and experts in the field contacted for details of ongoing and unpublished studies.

Study selection
At least two reviewers independently screened the titles/abstracts (AM, RJ) and full text articles (AM and RJ, CF or DHS). Eligibility disagreements were resolved by a third reviewer (NM).

Data extraction and quality assessment
Duplicate data extraction was performed independently for 10% of the included studies (AM and RJ, CF or DHS) and discrepancies resolved through discussion. The following secondary outcomes for this review were recorded from included studies:

- Biomarkers of cardiometabolic risk including blood glucose levels, blood lipid levels, total cholesterol levels, glycosylated haemoglobin, blood pressure
- Mental health outcomes including depression and anxiety
- Objective obtained BMI, waist circumference and/or fat mass

The full list of extracted data items can be obtained from the study protocol. Quality of all studies was assessed by two reviewers (AM, DHS) using the Tool for Assessing Risk of Bias from the Cochrane Collaboration. Risk of bias was assessed as ‘high’, ‘unclear’ or ‘low’ for the following domains: (1) participant selection bias, (2) intervention performance bias, (3) effect detection bias, (4) outcome reporting bias, (5) attrition bias and (6) bias due to comparability of baseline groups.

Publication bias was examined using a funnel plot whenever meta-analyses included 10 or more studies. Quality of evidence for primary outcomes was assessed using the GRADEpro software developed by the Grading of Recommendations Assessment Development and Evaluation (GRADE) Working Group. An overall quality score is based on the assessment of risk of bias, indirectness, imprecision, inconsistency and publication bias of primary outcomes. The GRADE Working Group grades of evidence are high, moderate, low and very low quality.

Data synthesis and analysis
Studies reporting similar outcome measures were combined in meta-analyses using random effects models to account for intervention heterogeneity. Where suitable data were not reported, efforts were made to obtain the data from study authors. To account for variability between studies, inverse variance was used, giving more weight for studies with less variability. Effect sizes were estimated as mean differences (min/day) between the intervention and control groups. Review Manager 5.2 was used for quantitative analysis.

For cluster RCTs where control of clustering was missing, intervention effects were approximately corrected by reducing the sample size of each trial to its ‘effective sample size’. The sample size was divided by the design effect, which is \[1 + (M-1) \times ICC]\, where M is the average of cluster size and ICC is the intraclass correlation coefficient. An ICC of 0.01 was used.

Where suitable data were available, studies were combined in a meta-analysis regardless of whether missing data were imputed by authors. Variation in the degree of missing data was considered as a potential source of heterogeneity of results. A sensitivity analysis to examine the effect of inclusion of complete cases on robustness of intervention effects was performed.

Further heterogeneity of findings was assessed by comparing similarity of included studies in terms of study design, participants, interventions, outcomes and study quality. The cause of heterogeneity was evaluated by conducting subgroup and sensitivity analyses. Statistical heterogeneity was assessed by calculating the F statistic indicating the variability of the intervention effect due to heterogeneity. Variability of more than 50% may indicate moderate to substantial heterogeneity of intervention effects according to the Cochrane Handbook.

Subgroup analyses within this review focused on:
- Intervention type (SB, PA/SB or lifestyle which, in addition to PA/SB, also included a dietary/nutrition component)
- Gender (men, women, men and women)
- Intervention duration (<3 months, 3–6 months, >6 months)
- Follow-up duration (<3 months, 3–6 months, 7–12 months, >12 months)
- Intervention setting (work place vs home/community)
- Outcome measurement tool (objective measurement tool, sitting time self-report, proxy measurement tool)
- Study aim (SB as a primary vs secondary study aim)

Sensitivity analyses were used to test the effect of including studies which were cluster designs, used usual care or alternative treatment control groups, or were at ‘high risk’ of performance and attrition bias.

Included studies lacking data suitable for meta-analysis are described narratively.

RESULTS
Results of the literature search
Figure 1 displays the PRISMA diagram of the literature search. Inclusion criteria were met by 57 records which comprised 51 studies. Thirty-six studies provided adequate data to be included in meta-analyses.

Characteristics of included studies
Study and participant characteristics are summarised in table 1 of the online supplementary material. Of the 51 included studies (18 480 participants), 44 were RCTs and seven were cluster RCTs conducted in Europe (n=25), the USA (n=18), Australia (n=7) and China (n=1). The majority of studies were carried out in a mixed gender population (n=35); 13 studies...
targeted women only, and three studies targeted men only. Most studies included participants aged between 18–60 years (n=44), while seven studies included participants older than 60 years of age. Twenty-three studies were conducted in overweight or obese adults, five studies in participants with type 2 diabetes mellitus and three studies in participants with high levels of cardiovascular risk factors. Two studies were conducted in pregnant women.

Types of intervention and control conditions varied substantially between included studies (see online supplementary table S1). Three studies employed an intervention specifically to reduce SB, 16 studies aimed at increasing PA levels, 39 nine studies combined both approaches of reducing SB and increasing PA levels, 32 one study assessed the effect of a dietary intervention on SB, 63 and 22 studies (20 reports) applied a multicomponent lifestyle intervention and observed effects on sedentary behaviour (among other outcomes). 29, 30, 34, 37, 38, 42, 45, 47, 50–52, 54, 56, 57, 60, 67, 70, 74, 75 Twenty studies offered an alternative intervention, 30, 36, 39, 41, 46, 48, 49, 55, 58–60, 64, 66, 72, 78 nine studies combined both approaches of reducing SB and increasing PA levels, 32, 43, 53, 62, 63, 68, 70, 76, 77 one study assessed the effect of a dietary intervention on SB, 63 and 22 studies (20 reports) applied a multicomponent lifestyle intervention and observed effects on sedentary behaviour (among other outcomes). 29, 33, 34, 37, 38, 42, 45, 47, 50–52, 54, 56, 57, 60, 67, 70, 74, 75 Twenty studies offered an alternative intervention, 30, 36, 39, 41, 46, 48, 49, 55, 58–60, 64, 66, 72, 78 nine studies combined both approaches of reducing SB and increasing PA levels, 32, 43, 53, 62, 63, 68, 70, 76, 77 one study assessed the effect of a dietary intervention on SB, 63 and 22 studies (20 reports) applied a multicomponent lifestyle intervention and observed effects on sedentary behaviour (among other outcomes). 29, 33, 34, 37, 38, 42, 45, 47, 50–52, 54, 56, 57, 60, 67, 70, 74, 75

Risk of bias of included studies

Figure 2 shows each risk of bias item presented as percentages across all included studies.

Selection bias

Correct randomisation was used in 65% of the studies (33/51), and therefore there was low risk of bias in these studies. However, for the remaining studies, insufficient details were reported and thus assessed as ‘unclear’. In nearly 70% (35/51) of the studies, there was lack of reporting on whether or not participants knew in advance their group allocation, and thus there was an unclear risk of bias. For studies that provided information, studies were judged to be at low risk of allocation concealment bias.

Performance bias

It is recognised that in lifestyle interventions it is not possible to blind participants and researchers delivering the intervention to group allocation and this creates high risk of bias. However, 67% (34/51) of included studies were considered at low risk of performance bias because SB was not the primary outcome. A further 31% (16/51) of included studies were judged to be at high risk of performance bias because the participants and researchers delivering the intervention were not blinded to the purpose of the intervention, which was reducing SB. Risk of performance bias was unclear for one study due to insufficient information provided.

Detection bias

Sixty-one per cent of the studies (31/51) assessed SB through self-reports and thus were at high risk for detection bias. The risk of cross-contamination was ‘low’ in half of the studies and ‘unclear’ in the other half.

Attrition bias

The issue of incomplete outcome data was sufficiently addressed in 47% (24/51) of the studies, and thus these studies were at low risk of attrition bias. However, 43% (22/51) of the studies did not account for missing data and thus were at high risk of attrition bias. Five studies were at ‘unclear’ risk of attrition bias.

Comparability of baseline groups

Over 50% (29/51) of the studies were at low risk of bias. Apparent flaws in the randomisation process were found in
three studies and therefore assessed at high risk of bias related to the comparability of baseline groups. For the remaining studies, no formal assessment of the comparability of baseline groups was reported, and thus the risk of bias was ‘unclear’.

### Reporting bias

For half of the studies (26/51), access to a published study protocol or trial register was missing so that the risk of selective reporting was ‘unclear’. However, nearly 50% (24/51) of the studies were at low risk of selective outcome reporting. One study did not report all outcomes as stated in the study protocol and thus was at high risk of selective reporting.

### Publication bias

Lifestyle interventions were the only category of interventions where at least 10 studies were available and thus suitable for assessment of publication bias using the funnel plot (see online supplementary figure S1). The asymmetric distribution of effect sizes might indicate a publication bias towards studies with beneficial effects for reducing SB. However, an asymmetric funnel plot might be a study size effect.

## Effect of interventions

### Primary outcomes

The primary outcomes reported were overall time spent in SB as minutes per day (n=49) or percentage of assessed time period (n=3), number of sitting breaks (n=3) and number of prolonged sitting events (n=3).

Online supplementary table S1 summarises the original trial authors’ conclusions of study outcomes. Twenty studies indicated a beneficial effect of interventions for reducing SB in favour of the intervention group. Of these, 10 studies employed a lifestyle intervention, and six interventions targeted increased PA. Two studies were combined PA/SB interventions and two were SB interventions.

Two studies reported a beneficial intervention effect in favour of the control group; both studies were PA interventions. Control conditions were attention control and an alternative exercise treatment. Twenty-four studies suggested no evidence of a group difference in SB: 10 lifestyle interventions, seven PA interventions, seven PA/SB interventions and one SB intervention.

Four studies—two lifestyle, one PA/SBs, one dietary intervention—did not conclude on SB outcomes despite assessing SB.

A meta-analysis of 34 studies (5868 participants) suggested an overall reduction in sedentary time by mean differences (MD) of −22.34 min/day (95% CI −35.81 to −8.88, p=0.001, I²=71%) in favour of the intervention group. Figure 3 shows effect sizes of individual studies and pooled results by intervention type. Findings indicated a beneficial effect of interventions specifically targeting the reduction in SB as well as interventions employing a lifestyle intervention approach on reduced SB. Specific SB interventions (n=2, 62 participants) yielded an MD of −41.76 min/day (95% CI −78.92 to −6.60, p=0.003, I²=65%) and lifestyle

### Figure 2

Risk of bias item presented as percentages across all studies.
interventions (n=20, 3881 participants) an MD of −24.18 min/day (95% CI −40.66 to −7.70, p=0.004, I²=75%). There was no evidence of a statistically significant effect of PA interventions or combined PA/SB interventions for reducing SB.

Pooled intervention effects on SB patterns indicated no statistically significant effect for both the number of sitting breaks per hour or the number of prolonged sitting events of more than 30 min.

As indicated by the large I² statistic, the level of statistical heterogeneity between studies was high. Subgroup analyses were conducted (defined a priori) to assess potential reasons for heterogeneity (table 1). A significant subgroup difference between assessed groups was detected for gender and intervention duration. Studies in men-only (n=2; 434 men), but not women-only (n=10; 1541 women), resulted in significant intervention effects for reduced SB of intervention group participants (MD −57.94 min/day, 95% CI −86.14 to −29.74 min/day, p<0.001). The combined effects of mixed gender studies (n=22; 3393 participants) also showed benefit in favour of the intervention group (MD −25.32 min/day, 95% CI −42.94 to −7.69 min/day, p=0.005). Interventions of up to 3 months resulted in a significant reduction in sedentary time by an MD of −47.51 min/day (95% CI −76.57 to −18.46 min/day, p=0.001, 14 studies, 1474 participants) in favour of the intervention group, whereas longer intervention durations of more than 3 months did not show beneficial intervention effects (table 1). Heterogeneity between studies could not be explained by follow-up duration, intervention setting, type of assessment tool and whether reducing SB was a primary or secondary aim of the study. However, subgroup analysis revealed that long-term effects of interventions were evident up to 12 months. The beneficial intervention effects attenuated at a follow-up duration of 12 months.

Figure 3 Forest plot of the intervention effect for reducing sitting time in minutes/day in adults by type of intervention. PA, physical activity; SB, sedentary behavior.
of more than 12 months. All intervention settings except workplaces resulted in a significant reduction in SB in favour of the intervention group. Objective assessment of SB using an inclinometer and subjective assessment using proxy measure questionnaires resulted in a detection of a beneficial intervention effect. The overall intervention effect was not influenced by whether SB was a primary or secondary outcome (table 1).

Sensitivity analyses (see online supplementary tables S2–S5) show that results on SB for different types of interventions were not affected by inclusion of cluster RCTs, studies at high risk of attrition and performance bias, and studies with usual care or alternative treatment as the control group.

Secondary outcomes
Studies reported intervention effects on fasting blood glucose concentration,31 42 56 glycosylated haemoglobin levels,31 42 56 69 triglyceride levels,31 42 56 69 low-density lipoprotein levels,31 42 56 69 total cholesterol,31 42 56 69 high-density lipoprotein levels,31 42 56 69 blood pressure,31 38 43 57 59 65 70 BMI,39 33 36 37 42 55 56 57 58 59 62 64 69 74 waist circumference,31 42 53–59 62 64 69 74 76 percentage body fat32 53 56 58 62 64 and mental health outcomes.29 41 48 49 64 72

Sensitivity analyses (see online supplementary tables S2–S5) show that results on SB for different types of interventions were not affected by inclusion of cluster RCTs, studies at high risk of attrition and performance bias, and studies with usual care or alternative treatment as the control group.

Quality of evidence
Table 2 summarises the quality of evidence for reducing sedentary time by intervention type and duration. Owing to the intention of comparing different types of intervention with various control conditions, which was considered in the sensitivity analyses, the quality of evidence was not downgraded for indirectness or heterogeneity. Many plausible reasons for heterogeneity exist (eg, variation in population age, ethnicity, socioeconomic status).

Lifestyle interventions
The overall quality of evidence for lifestyle interventions was moderate with downgrading of the evidence by one level due to limitations in the design and implementation of the included studies.

PA/SB interventions
The overall quality of evidence of combined PA and SB intervention for reducing SB was moderate. The quality was downgraded by one level for high risk of bias in the majority of included studies.

PA interventions
Overall, the quality of PA intervention was moderate with the majority of studies having a high risk of detection and attrition bias.

SB interventions
The quality of evidence for reducing SB in adults was low based on the two studies available. The quality was downgraded twice for imprecision of results and high risk of performance bias. Participants and personnel were not blinded to the intervention intention.

DISCUSSION
Summary of main findings
There was clear evidence that it is possible to intervene to reduce SB in adults by 22 min/day in favour of the intervention group. Moderate to high-quality evidence on the efficacy of lifestyle interventions for reducing SB suggests that this may be a promising approach. Interventions focusing on SB only resulted in the greatest reduction in sedentary time (42 min/day); however, the quality of evidence was low and restricted to two studies only. Findings suggested that intervention durations up to 3 months and interventions targeting men and mixed genders can produce significant reductions in SB. There was no evidence that PA and combined PA/SB interventions reduced SB. Evidence of intervention effects on changes in patterns of accumulation of SB was limited. Encouragingly, intervention effects were evident up to 12 months. Interventions in any setting except the workplace resulted in a significant reduction in SB in favour of the intervention group.

This systematic review sought to evaluate the evidence of effects of interventions which included SB as an outcome measure on cardiometabolic risk factors, body composition and mental health outcomes. Studies reporting these outcomes were PA or lifestyle interventions, and thus it was unclear whether any intervention effect was due to reduction in SB. Furthermore, the majority of studies that assessed health-related outcomes did not show a reduction in SB. However, improvement of health outcomes due to reduction of SB has been demonstrated in laboratory-based studies29 and a recently published community-based RCT.

Comparison of the findings with the literature
Prince et al23 published a systematic review on the effects of interventions for reducing SB in adults. Our findings are consistent with those of Prince et al in relation to the effect of PA/SB interventions and interventions focusing on SB only, despite there being no overlap of included studies in the latter. The SB studies on which Prince et al based their main conclusion were excluded from this review because they either did not report a valid SB outcome measure,80 or the intervention was not independent of the outcome (measuring TV viewing time while blocking TV function).81 In contrast to Prince et al, we found no evidence of a beneficial effect on SB from interventions focused on increasing PA. This difference in findings may be explained by six studies in our review being classified as lifestyle interventions while Prince et al classed them as PA interventions and one study being classed as a PA/SB intervention while Prince et al classed it as a PA intervention. Authors of future reviews should use precise categories of intervention types to identify the potential of single or multicomponent interventions (eg, lifestyle intervention which, in addition to PA/SB, also included a dietary/nutrition component) to reduce SB.

Other systematic reviews have been conducted with a focus on the effect of workplace interventions for reducing sitting time.82–84 Some findings are consistent with the findings of this study on the effect of workplace interventions to reduce SB while others were not.81 84 Inconsistency can be explained by differences in inclusion criteria, since the majority of studies included in these reviews were not RCTs and thus did not qualify for our review. However, further high-quality RCTs investigating the effect of workplace interventions on sitting time are currently being conducted and publication of new evidence will follow shortly.

Implications for research and practice
Findings from lifestyle interventions and studies focusing on reducing SB are promising. While this is encouraging, SB are...
health-related behaviours and part of a pathway to better health outcomes. More high-quality research is needed that includes clinical health outcome measures. However, the findings of this review should encourage clinicians and public health practitioners to provide advice on how to reduce total volume of sitting time and breaking up long periods of sitting. This advice should not diminish or replace advice on achieving the recommended levels of MVPA. It is somewhat surprising that interventions that targeted PA alone, or even PA and SB, appeared to be less effective in reducing SB. This suggests that attention needs to be paid to the ways in which SB are targeted in these interventions. For example, it may be important to improve knowledge about the independent health risks of SB and to highlight the risk of compensatory behaviour (eg, a feeling that you have earned the right to be sedentary because you went for a brisk walk earlier). Given the evidence that increased breaks in SB are associated with improved health status, consensus is needed on the most appropriate SB patterning descriptors to use which are

Table 2  GRADE assessment of quality of evidence

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Illustrative comparative risks* (95% CI) Corresponding risk interventions for reducing sedentary behaviour</th>
<th>Number of Participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of lifestyle interventions</td>
<td>The mean effect of lifestyle interventions in the intervention groups was 24.18 min/day lower (40.66 to 7.70 lower)</td>
<td>3981 (20 studies)</td>
<td>⊕⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Intervention duration ≤3 months</td>
<td>The mean effect of lifestyle interventions—intervention duration ≤3 months in the intervention groups was 97.75 min/day lower (121.88 to 73.61 lower)</td>
<td>297 (5 studies)</td>
<td>⊕⊕⊕⊕ high</td>
</tr>
<tr>
<td>Intervention duration 3–6 months</td>
<td>The mean effect of lifestyle interventions—intervention duration 3–6 months in the intervention groups was 8.42 min/day lower (19.05 lower to 2.21 higher)</td>
<td>1664 (7 studies)</td>
<td>⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Intervention duration &gt;6 months</td>
<td>The mean effect of lifestyle interventions—intervention duration &gt;6 months in the intervention groups was 3.99 min/day lower (21.32 lower to 13.96 higher)</td>
<td>2040 (8 studies)</td>
<td>⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Effect of physical activity/ sedentary behaviour interventions</td>
<td>The mean effect of physical activity/sedentary behaviour interventions in the intervention groups was 32.51 min/day lower (106.52 lower to 41.50 higher)</td>
<td>471 (4 studies)</td>
<td>⊕⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Intervention duration ≤3 months</td>
<td>The mean effect of physical activity/sedentary behaviour interventions—intervention duration ≤3 months in the intervention groups was 54.69 min/day lower (166.60 lower to 57.22 higher)</td>
<td>214 (3 studies)</td>
<td>⊕⊕⊕⊕ very low§†</td>
</tr>
<tr>
<td>Intervention duration 3–6 months</td>
<td>The mean effect of physical activity/sedentary behaviour interventions—intervention duration 3–6 months in the intervention groups was 23.60 min/day higher (0.78 higher to 46.42 higher)</td>
<td>257 (1 study)</td>
<td>⊕⊕⊕ moderate**</td>
</tr>
<tr>
<td>Intervention duration &gt;6 months</td>
<td>No evidence available</td>
<td>0 (0)</td>
<td>No evidence available</td>
</tr>
<tr>
<td>Effect of physical activity interventions</td>
<td>The mean effect of physical activity interventions in the intervention groups was 6.08 min/day lower (38.00 lower to 25.84 higher)</td>
<td>1354 (8 studies)</td>
<td>⊕⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Intervention duration ≤3 months</td>
<td>The mean effect of physical activity interventions—intervention duration ≤3 months in the intervention groups was 10.43 min/day lower (49.85 lower to 28.98 higher)</td>
<td>935 (5 studies)</td>
<td>⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Intervention duration 3–6 months</td>
<td>The mean effect of physical activity interventions—intervention duration 3–6 months in the intervention groups was 21.52 min/day lower (103.55 lower to 60.51 higher)</td>
<td>184 (2 studies)</td>
<td>⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Intervention duration &gt;6 months</td>
<td>The mean effect of physical activity interventions—intervention duration &gt;6 months in the intervention groups was 48.60 min/day higher (1.66 to 95.54 higher)</td>
<td>235 (1 study)</td>
<td>⊕⊕⊕⊕ moderate†</td>
</tr>
<tr>
<td>Effect of sedentary behaviour interventions</td>
<td>The mean effect of sedentary behaviour interventions in the intervention groups was 41.76 min/day lower (78.92 to 4.60 lower)</td>
<td>62 (2 studies)</td>
<td>⊕⊕⊕ low§§</td>
</tr>
<tr>
<td>Intervention duration ≤3 months</td>
<td>The mean effect of sedentary behaviour interventions—intervention duration ≤3 months in the intervention groups was 41.76 min/day lower (78.92 to 4.60 lower)</td>
<td>62 (2 studies)</td>
<td>⊕⊕⊕ low§§</td>
</tr>
<tr>
<td>Intervention duration 3–6 months</td>
<td>No evidence available</td>
<td>0 (0)</td>
<td>No evidence available</td>
</tr>
<tr>
<td>Intervention duration &gt;6 months</td>
<td>No evidence available</td>
<td>0 (0)</td>
<td>No evidence available</td>
</tr>
</tbody>
</table>

GRADE Working Group grades of evidence.

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very unlikely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

*The basis for the assumed risk (eg, the median control group risk across studies) is provided in footnotes. The corresponding risk (and its 95% CI) is based on the assumed risk in the control group and the relative effect of the intervention (and its 95% CI).

†The majority of studies were of high risk of selection, performance or detection bias.

‡Half of the studies were of high risk for performance bias (no blinding of participants or personnel to the intervention intention).

§The wide CI indicates imprecision of results.

‖All studies were of high risk of performance bias and more than half showed high risk of attrition.

¶The study was of high risk of selection bias.

‖‖Studies were of high risk of detection or attrition bias.

‖‖‖The study was of high risk of detection bias.

‖‖‖‖The studies were of high risk of performance bias, that is, participants and personnel were not blinded.
sensitive to intervention (eg, ‘breaking rate’ or time spent/number of longer sedentary events). New interventions should also be developed around technologies that allow people to monitor their SB in addition to their physical activity to support them in setting goals to reduce their SB and increase PA.

The majority of studies included in the meta-analyses assessed intervention effects using self-report. While self-report measures are pragmatic and may provide contextual information, they have limitations in terms of accuracy. Subgroup analysis revealed that objective assessment of SB using a posture measurement tool such as the actiPAL and subjective assessment using proxy measure questionnaires (captures context specific sitting time) resulted in the detection of a beneficial intervention effect. Assessment tools that measure posture might be more valid and reliable in measuring SB and thus detecting intervention effects compared to estimation of SB via accelerometry (eg, ActiGraph). Therefore, researchers and practitioners should use posture measurement tools and context specific measurement tools which may prompt a reliable cognitive recall of sedentary behaviour.

Heterogeneity between studies was only partly explained by differences of studies in gender and intervention duration. Further work is warranted to identify the ‘active ingredients’ of the successful interventions and to explore the specific behaviour change techniques employed as well as barriers and facilitators of SB interventions. General principles for development of interventions to reduce SB have been established drawing from Behavioural research on physical activity.8 Examples include evaluating interventions designed for very specific contexts (work environments at home) and using behaviour change theory and associated techniques87 to systematically understand and change SB in different groups and settings.

Additionally, future studies should consider the influence of gender, given that some cohort studies suggested deleterious relationships of SB with health outcomes to be more pronounced in women than men. However, based on our review evidence, interventions with the potential to reduce SB showed limited effects when targeting women. Limited evidence was available on intervention effects on sedentary time in older adults.

Strengths and limitations
The systematic and transparent methods reported here reduce identification and selection bias. The inclusion criteria used for study designs (only RCTs) meant that the risk of bias was reduced. Overall, the robust methods used in this review ensure that the results and conclusions are likely to be as truly valid and replicable as possible. Subgroup and sensitivity analyses enabled a more nuanced understanding and interpretation of the results, as well as exploring the effect of potentially influential variables. Lastly, our exploration of the clinical outcomes was a strength, and led to the identification of research gaps which should be addressed in future RCTs.

One limitation was that no subgroup analysis for age was undertaken because there were too few studies in older adults.

CONCLUSION
There was evidence that it is possible to intervene to reduce SB in adults by around 22 min/day. Lifestyle interventions and those targeting SB only may be promising approaches, but more high-quality research is needed. More research is also needed to determine if SB interventions are sufficient to produce clinically meaningful and sustainable reductions in sedentary time. Further work is needed to identify the ‘active’ intervention components.

What are the new findings?
- Interventions targeting sedentary behaviour (SB) and lifestyle interventions can reduce sedentary time in adults.
- Interventions targeting an increase in physical activity and interventions combining an increase of physical activity with reducing sedentary behaviour did not reduce sedentary time in adults.
- We do not yet know if effective interventions for reducing sedentary behaviour result in clinically meaningful and sustained improvements in health outcomes.

How might it impact on clinical and public health practice in the near future?
- The findings of this study (together with the broader body of relevant evidence) do not point to specific recommendations on the degree of reduction in sitting time required to deliver significant health benefits. Nevertheless, the findings should encourage clinicians and public health practitioners to provide advice about reducing the total volume of sitting time and breaking up long periods of sitting by demonstrating that such advice can be effective. This advice should not diminish or replace advice on achieving recommended levels of physical activity.
- Interventions with a focus on physical activity should provide additional emphasis on the importance of and barriers to reducing SB. New technologies should be developed to allow self-monitoring and goal setting around SB as well as physical activity.
- Awareness will be raised on the topic of sedentary behaviour and its impact on health.
- Interventions that target sedentary behaviour will be developed and tested.
- Further research is needed to determine the clinical significance of changing patterns of sedentary behaviour.

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Acknowledgements The EuroFIT Consortium is acknowledged for their support and contribution in the development of this review. In particular, the authors thank Professor Sally Wyke and Dr Jason Gill for helpful comments on a preliminary report to the consortium. This manuscript also benefited from helpful reviewer comments.

Collaborators EuroFIT consortium.

Contributors AM, NM, DHS, RJ and CF led the review on behalf of the EuroFIT consortium. AM, NM, DHS, CF and RJ conceived of the systematic review strategy. AM wrote the protocol and all authors refined and approved it. AM conducted the review and screened the initial results. AM, DHS, RJ, CF and NM appraised and extracted data from the primary studies and analysed the findings. AM drafted the manuscript and all authors contributed to the critical revision of the manuscript and approved the final revised version. NM is the guarantor.

Funding This review was conducted on behalf of the EuroFIT consortium (see http://eurofit.eu). EuroFIT is funded by the European Community’s Framework Programme Seven (FP7) under contract No. 602170 ‘EuroFIT’.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.


60 Lane A, Murphy N, Bauman A, et al. Randomized controlled trial to increase physical activity among insufficiently active women following their participation in a mass event. *Health Educ J* 2010;69:287–96.


75 Adams MM. On our feet: feasibility trial of an intervention to reduce sedentary behavior and increase physical activity. *Dissertation Abstracts International: Section B: The Sciences and Engineering* 2013;73(10-E)(No Pagination Specified).


Interventions with potential to reduce sedentary time in adults – systematic review and meta-analysis

Online only supplementary material

Search strategy for Ovid Medline

1. exp adult/
2. exp men/
3. exp women/
4. adult*.tw.
5. (men or women).tw.
6. exp child/
7. or/1-5
8. 7 not 6
9. exp health promotion/
10. health education/
11. behavior therapy/
12. lifestyle/
13. Healthy People Programs/
14. (health$ adj3 (promot$ or educat$ or lifestyle)).tw.
15. lifestyle intervention*.tw.
16. behavi?r change.tw.
17. Health Knowledge, Attitudes, Practice/
18. exp physical activity/
19. (activ$ adj3 (break or breaks)).tw.
20. ((sitting or standing) adj3 break).tw.
21. active travel*.tw.
22. or/9-21
23. sedentary lifestyle/
24. (sedentary adj3 (behavi?$ or lifestyle or time)).tw.
25. "screen time".tw.
27. "media time".tw.
28. inactiv$.tw.
29. video games/
30. television/
31. (television or TV).tw.
32. (((computer or video) adj3 gam$)).tw.
33. ((sitting or screen or transport or indoor) adj3 time).tw.
34. "prolonged sitting".tw.
35. or/23-34
36. 8 and 22 and 35
37. perception/
38. belief/
39. view/
40. (belief$ or view$ or perception$ or experience$).tw.
41. acceptance.tw.
42. barrier$.tw.
43. or/37-42
44. randomized controlled trial.pt.
45. controlled clinical trial.pt.
46. randomi#ed.ab.
47. non-randomi#ed.ab.
48. quasi-random*.tw.
49. randomly.ab.
50. allocat$.ab.
51. trial.ab.
52. group.ab.
53. controlled trial.ab.
54. quasi-experiment$.tw.
55. exp animals/ not humans.sh.
56. or/44-54
57. 56 not 55
58. 36 and 57
59. qualitative research/
60. (qualitative adj3 (study or method or research or approach)).tw.
61. focus group/
62. interview/
63. focus group$.ab.
64. interview$.ab.
65. group discussion$.ab.
66. ethnography/
67. or/59-66
68. 36 and 43 and 67
69. 58 or 68
70. limit 69 to english language
71. remove duplicates from 70
### Table 1: Characteristics and authors’ conclusions of intervention effect of included studies

<table>
<thead>
<tr>
<th>Study ID, Country, Funding source</th>
<th>Participant characteristic</th>
<th>Study design</th>
<th>Intervention</th>
<th>Intervention setting</th>
<th>Intervention duration</th>
<th>Control condition</th>
<th>Attrition rates</th>
<th>SB primary outcome</th>
<th>Author’s conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abascal 2008a, USA National Cancer Institute</td>
<td>N: I=153, C=155, Mean age across groups: 43.9 ± 8.0y, Gender: all males</td>
<td>RCT</td>
<td>“iPace Men in Motion”: Use of a pedometer, web-based activities which included learning about and applying new behavioral skills, and reading diet and physical activity topics. Encouragement to log on weekly to report weight and progress on goals (at least 10,000 steps (5-7 d/wk) and participating in strength training two times per week).</td>
<td>Home based</td>
<td>12 months</td>
<td>Waiting list: Access to an alternate website and encouragement to log on monthly. The control website contained general health information of interest to men but not likely to lead to changes in diet or physical activity behaviors.</td>
<td>I = 32%, C = 29%, Total = 30%</td>
<td>no - BMI change</td>
<td>Decreased sedentary behaviour in favour of the intervention group</td>
</tr>
<tr>
<td>Abascal 2008b, USA National Cancer Institute</td>
<td>N: I=140, C=146, Mean age across groups: 41.2 ± 8.7y, Gender: all females</td>
<td>RCT</td>
<td>“iPace Women in Balance”: Initial web-based assessment, health behavior counseling follow-up intervention via the web, and periodic phone and email interaction with a health counselor. Target behaviors for the intervention included increasing physical activity (30-60 minute goal), fruit and vegetable intake, fiber intake, and decreasing dietary fat.</td>
<td>General practise/home</td>
<td>12 months</td>
<td>Usual-care: Consisted of previously scheduled provider visits without health behavior counseling and a standard set of materials summarizing diet and activity recommendations</td>
<td>I= 32%, C= 25%, total = 29%</td>
<td>no - diet and PA behaviour change</td>
<td>No significant intervention effects on sedentary behaviour</td>
</tr>
<tr>
<td>Adams 2012, USA Funding source not reported</td>
<td>N: I=40, C=24, Mean age: 58.47±12.55y, Gender: all female</td>
<td>cluster RCT (cluster size: I=4, C=3)</td>
<td>“On our Feet”: face-to-face interactions and email messages. The content was intended to increase self-efficacy for reducing sedentary behaviour and for increasing light physical activity by highlighting mastery experiences related to both behaviors.</td>
<td>community</td>
<td>6 weeks</td>
<td>waiting list</td>
<td>I= 14%, C= 14%, Total = 18%</td>
<td>yes</td>
<td>No significant intervention effects on sedentary behaviour</td>
</tr>
<tr>
<td>Allen 2008, USA Funding source not reported</td>
<td>N: I=27, C=25, Mean age across groups: 57y, Gender: male+female,</td>
<td>RCT</td>
<td>Provision of an activity monitor at week 1. Participants received 90 min of individualized education and physical activity counselling. This counselling protocol was designed to change efficacy beliefs about physical activity</td>
<td>home/community</td>
<td>8 weeks</td>
<td>Alternative treatment: The control group received 90 min of individualized diabetes education based on major components from the International Diabetes Center curriculum</td>
<td>Not reported</td>
<td>no - PA and self-efficacy behavior</td>
<td>Decreased combined sedentary behavior and light physical activity in favor of the intervention</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Funding Source</td>
<td>Group Size</td>
<td>Mean Age</td>
<td>Gender</td>
<td>Study Type</td>
<td>Intervention Details</td>
<td>Follow-up</td>
<td>Comparator</td>
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<td>Anand 2007</td>
<td>Australia</td>
<td></td>
<td>I=88, C=86</td>
<td>I= 41y, C= 37y</td>
<td>not reported</td>
<td>cluster RCT (cluster size: I=29, C= 28)</td>
<td>“SHARE-AP ACTION”: The intervention consisted of a regular home visit by Aboriginal health counsellors who were trained to assess and set dietary and physical activity goals for each household member.</td>
<td>home based</td>
<td>6 months</td>
</tr>
<tr>
<td>Andersen 2012</td>
<td>Norway</td>
<td></td>
<td>I=76, C=50; N 12-months: I=59, C=38</td>
<td>I=35.7 ±6.1y, C=39.7 ±9.2y</td>
<td>all male</td>
<td>RCT</td>
<td>“Physical Activity and Minority Health”: The programme included structured group exercise sessions led by an exercise physiologist twice a week, two group lectures, one individual counselling session, written material and a phone call.</td>
<td>community</td>
<td>6 months</td>
</tr>
<tr>
<td>Baker 2010</td>
<td>UK</td>
<td>Scottish Government</td>
<td>I=39, C=40</td>
<td>I= 47.3 ±9.3y, C= 51.2 ±7.9y</td>
<td>20% men, 80% women</td>
<td>RCT</td>
<td>“Walking for Well-being in the West”: Physical activity consultation and pedometer-based walking program. The consultations were focused on promoting increases in walking. The overall goal was to increase mean daily step-count by 3,000 accumulated steps above baseline value on 5 days/week.</td>
<td>community</td>
<td>12 weeks</td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Country</td>
<td>Funding source</td>
<td>N: I=</td>
<td>C=</td>
<td>Mean age</td>
<td>Gender</td>
<td>Study design</td>
<td>Duration</td>
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<tr>
<td>Barwais 2013</td>
<td>Australia</td>
<td>Funding source not reported</td>
<td>Interaction with an online personal activity monitor. The device was designed to motivate a reduction in sedentary behavior and increase physical activity in the activities of daily living. Data subsequently provide the user with a visualization of daily activity patterns.</td>
<td>4 weeks</td>
<td>home based</td>
<td>No treatment: instructed to follow the normal, daily lifestyle patterns.</td>
<td>0%</td>
<td>yes</td>
<td>Decreased sedentary behaviour in favour of the intervention group</td>
</tr>
<tr>
<td>Burke 2013</td>
<td>Australia</td>
<td>Australian National Health and Medical Research Council grant</td>
<td>&quot;Physical Activity and Nutrition for Seniors&quot;: specially designed booklet that provided participants with information and promoted dietary and physical activity goal setting. Supplementary materials were an exercise chart, calendar, bi-monthly newsletters, resistance bands and pedometers. Trained group guides provided support for participants.</td>
<td>6 months</td>
<td>home based</td>
<td>no treatment</td>
<td>INT = 29%, CON = 13%</td>
<td>yes - (PA and nutrition behaviour)</td>
<td>Decreased sedentary behaviour in favour of the intervention group</td>
</tr>
<tr>
<td>Canuto 2012</td>
<td>Australia</td>
<td>Australian National Health and Medical Research Council grant</td>
<td>Women’s Fitness Program: structures 45-60min group aerobic and resistance exercise 2x/week, provision of pedometers and encouragement to reach 10,000 steps/week, 4 group nutrition and healthy lifestyle workshops</td>
<td>12 weeks</td>
<td>community</td>
<td>Waiting list</td>
<td>Not available for primary outcome</td>
<td>yes</td>
<td>Results on secondary outcomes available only</td>
</tr>
<tr>
<td>Carlson 2012</td>
<td>USA</td>
<td>Funding source not reported</td>
<td>An interactive web-based program to help participants set goals relative to their initial status on each of the behavioral targets. Goals: increasing fruit and vegetable intake to 5–9 servings/day; decreasing total fat to 30% of total calorie consumption; increasing PA to 30–60 min/day 5–7 days/week; increasing steps/day measured by pedometer to ≥10,000 (men only); and participating in</td>
<td>12 months</td>
<td>home based</td>
<td>Waiting list (women), attention control (men): In the men’s study, the control condition had access to a website that contained general health information topics (e.g., information on sun exposure protection and worksite injury prevention).</td>
<td>INT = 32%, CON = 23%</td>
<td>no - weight loss through dietary and physical activity changes</td>
<td>Decreased sedentary behaviour in favour of the intervention group</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Strength Training Target</td>
<td>Training Program Details</td>
<td>Control Group Details</td>
<td>Randomized Controlled Trial?</td>
<td>Length</td>
<td>Follow-Up Details</td>
<td>Interventions</td>
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<td>Chin A Paw 2006</td>
<td>The Netherlands</td>
<td>N: I=40, C=31</td>
<td>Twice/week targeting at least two body areas (upper-body, lower-body and core; men only).</td>
<td>Arm 1: The resistance training program was performed twice a week in groups. Resistance increased until two sets of 8–12 repetitions were possible. Resistance was to be increased after the participant could complete two sets of 12 repetitions for two consecutive sessions. Arm 2: The functional-skills training program was performed twice a week during six months in groups consisting of 5–10 min of warm-up activities, 30–35 min of skills training in game-like and cooperative activities and cool-down period (5–10 min). Arm 3: The combination group performed once weekly the resistance training and once weekly the allround functional-skills training protocol.</td>
<td>N: I=45, C=47. Mean age: I=46.6±10.9y C=47.7±11.4y Gender: I= 38% men, 62% women, C=45% men, 55% women</td>
<td>RCT</td>
<td>6 months</td>
<td>Home based</td>
<td>Resistance training 30%, functional-skills training 27%, combined training 21% and control group 39%. 8 participants discontinued the intervention because they found the exercise program too intensive.</td>
</tr>
<tr>
<td>De Cocker 2012</td>
<td>Belgium</td>
<td>N: I=28, C=35</td>
<td>No specified</td>
<td>Pedometer intervention supplemented with computer-tailored step advice.</td>
<td>Alternative treatment: pedometer provision</td>
<td>RCT</td>
<td>3 months</td>
<td>Home based</td>
<td>No -effect on habitual PA and constipation</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Funding source</td>
<td>N</td>
<td>Mean age</td>
<td>Gender</td>
<td>Study design</td>
<td>Intervention</td>
<td>Follow-up</td>
<td>Dropout</td>
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<tr>
<td>De Greef 2010</td>
<td>Belgium</td>
<td>Funding source not reported</td>
<td>I=21, C=20</td>
<td>I=61.3±6.3y, C=61.3±6.9y</td>
<td>I=62%, 38% women, C=75% men, 25% women</td>
<td>RCT</td>
<td>Lifestyle intervention (dietary and physical activity) that consisted of five cognitive-behavioural group sessions of 90 min. In addition participants received a pedometer and a pedometer diary as motivational tools.</td>
<td>Commonly/home</td>
<td>12 weeks</td>
</tr>
<tr>
<td>De Greef 2011</td>
<td>Belgium</td>
<td>Funding source not reported</td>
<td>I=60, C=32</td>
<td>Mean age for both groups: 62±9y</td>
<td>Gender for both groups: 69% men, 31% women</td>
<td>RCT</td>
<td>Consisted of a face-to-face session, a pedometer and telephone support. 30 min face-to-face sessions started with a motivational interview phase. The psychologist together with the participants made an individualized lifestyle plan. After this session patients started the telephone support program given by the psychologist.</td>
<td>Hospital/home based</td>
<td>24 weeks</td>
</tr>
<tr>
<td>Dunn 1998</td>
<td>USA</td>
<td>National Institute of Health</td>
<td>I=121, C=114</td>
<td>I=45.9±6.8y, C=46.2±6.5y</td>
<td>Gender: I= 50% men, 50% women, C= 49.1% men, 50.9% women</td>
<td>RCT</td>
<td>&quot;Project Active&quot;: Lifestyle physical activity programme: Encouragement to engage in daily 30 min MVPA, behaviour change methods (e.g. problem solving) applied in group sessions</td>
<td>Community (Fitness centre)</td>
<td>24 months</td>
</tr>
<tr>
<td>Evans 2012</td>
<td>UK</td>
<td>Funding source not reported</td>
<td>I=14, C=14</td>
<td>I=49±8y, C= 39±10y</td>
<td>Gender:</td>
<td>RCT</td>
<td>Education programme (see control group) and Point of Choice PC software: advice window that reminded participants to take a break appeared on the monitor for 1 minute every 30 minutes from work place</td>
<td></td>
<td>5 days</td>
</tr>
<tr>
<td>Study</td>
<td>Year</td>
<td>Country</td>
<td>Funding source</td>
<td>N: I1 = 60, I2 = 59, C = 60</td>
<td>Mean age: I1 = 42 ± 9.2 years, I2 = 41 ± 9.7 years, C = 40 ± 11.4 years</td>
<td>Gender: I1 = 25% men, 75% women, I2 = 25% men, 75% women, C = 20% men, 80% women</td>
<td>RCT</td>
<td>Pedometer use and weekly group emails as a motivational and self-regulatory tool, participants with &gt; 10,000 daily steps at pre-intervention were encouraged to maintain this level of workday walking and add additional steps where possible. Arm 3: directed to achieve step workplac e - white-collar univer sit y employees</td>
<td>10 weeks</td>
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<td>Fitzsimons 2009</td>
<td>UK, Australia</td>
<td>Funding source not reported</td>
<td>N: I1 = 39, C = 40</td>
<td>Mean age: I = 47 ± 9.3 years, C = 51 ± 7.9 years</td>
<td>Gender: I = 21% men, 79% women, C = 20% men, 80% women</td>
<td>RCT</td>
<td>&quot;Walking for Well-being in the West&quot;: Following the 12 week walking programme (Baker 2010), participants received a second individual physical activity consultation focusing on relapse prevention strategies, encouragement and maintenance of activity. At 24 weeks participants received a written physical activity advice leaflet and at 36 weeks remote support in the form of a short telephone consultation.</td>
<td>12 months</td>
<td>Alternative treatment: individualised 12 week walking programme five minutes of brief advice and a pedometer</td>
</tr>
<tr>
<td>Gilson 2009</td>
<td>UK</td>
<td>UK, Australia</td>
<td>N: I1 = 29%, men, 71% women, C = 29%, men, 71% women</td>
<td>the time the PC was started. The window could not be minimized or moved, but participants could work in any opened windows around it.</td>
<td>Gender: all female</td>
<td>RCT</td>
<td>The first 90-min weekly meeting was divided into a 45-min interactive didactic component and a 45-min exercise component (structured aerobics and walking). The second weekly meeting consisted of a 45-min exercise session.</td>
<td>commu ni ty based</td>
<td>20 weeks</td>
</tr>
<tr>
<td>Fitzgibbon 2005</td>
<td>USA</td>
<td>National Cancer Institute and Postdoctoral Research Supplement for Underrepr esented Minorities</td>
<td>N: I1 = 12, I2 = 14, C1 = 13, C2 = 18</td>
<td>Mean age for both groups in each cohort: Cohort 1 = 44 ± 7.9 years, Cohort 2 = 45 ± 6.9 years</td>
<td>Gender: all female</td>
<td>RCT</td>
<td>The first 90-min weekly meeting was divided into a 45-min interactive didactic component and a 45-min exercise component (structured aerobics and walking). The second weekly meeting consisted of a 45-min exercise session.</td>
<td>commu ni ty</td>
<td>20 weeks</td>
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<tr>
<td>Fitzsimons 2012</td>
<td>UK</td>
<td>Scottish Government</td>
<td>N: I = 39, C = 40</td>
<td>Mean age: I = 47 ± 9.3 years, C = 51 ± 7.9 years</td>
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<td>RCT</td>
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<td>commu ni ty based</td>
<td>12 months</td>
</tr>
<tr>
<td>Gilson 2009</td>
<td>UK</td>
<td>UK, Australia</td>
<td>N: I1 = 60, I2 = 59, C = 60</td>
<td>Mean age: I1 = 42 ± 9.2 years, I2 = 41 ± 9.7 years, C = 40 ± 11.4 years</td>
<td>Gender: I1 = 25% men, 75% women, I2 = 25% men, 75% women, C = 20% men, 80% women</td>
<td>RCT</td>
<td>Pedometer use and weekly group emails as a motivational and self-regulatory tool, participants with &gt; 10,000 daily steps at pre-intervention were encouraged to maintain this level of workday walking and add additional steps where possible. Arm 3: directed to achieve step workplac e - white-collar univer sit y employees</td>
<td>10 weeks</td>
<td>Waiting list: Control group participants were asked to maintain their normal behavior over a ten-week period</td>
</tr>
<tr>
<td>Study</td>
<td>Participants</td>
<td>Interventions</td>
<td>Follow-up</td>
<td>Outcomes</td>
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</table>
| Hansen 2012 | N: I=4435, C=4509  
Mean age: I= 50.7±13.6y, C=50.4±13.7y  
Gender: I=35% men, 65% women, C=35% men, 65% women | Automated web-based physical activity intervention: The website was structured as three major parts: (1) a personal page, which included individually tailored PA advice and a personal profile, (2) a page with training programs and general recommendations, and (3) a forum and discussion page for questions from participants.  
Arm 1: asked to engage in brisk, sustained, route-based walking during work breaks campus walks supported by maps, times (10- to 45 minutes) and step count.  
Arm 2: asked to engage in incidental walking and accumulate step counts during working tasks (e.g. walking and talking to colleagues)  
Goal through brisk, sustained, route-based walking during work breaks campus walks supported by maps, times (10- to 45 minutes) and step count.  
Route-based walking during work breaks campus walks supported by maps, times (10- to 45 minutes) and step count. | 3 months?  
no treatment | 43.80% participation rate. Attrition rates in the 3-month questionnaire were I=42%; C=33%. Attrition rate at 6 months follow-up: I=41%, C=33% |
| Hu 2012 | N: I=192, C=212  
Mean age: I= 32.3±3.5y, C=32.4±3.6y  
Gender: All females | A 2-week “run-in” period with 2 classes on general principles of lifestyle intervention for the prevention of type 2 diabetes and obesity. Dietary intervention: one-on-one meetings with a dietitian and provision of daily menu for 5 days. The physical activity goal is to gradually increase the physical activity from 15 to 30 min/day over the first 4 weeks. The level of physical activity increased to at least 30 min/day, 7 days/week over the whole trial.  
Physical activity goal is to gradually increase the physical activity from 15 to 30 min/day over the first 4 weeks. The level of physical activity increased to at least 30 min/day, 7 days/week over the whole trial.  
Usual care: Education regarding general principles of healthy lifestyle that benefits type 2 diabetes and obesity prevention, and information about the current evidence showing that the lifestyle intervention is effective in women at high risk for type 2 diabetes. | 1 year, year 2 maintenance period | I=67%, C=64% |

No intervention effects on sedentary behaviour
<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Study Title</th>
<th>Design</th>
<th>Sample Size</th>
<th>Gender</th>
<th>Mean Age</th>
<th>Intervention Description</th>
<th>Follow-up</th>
<th>Interventions</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jago 2013</td>
<td>UK</td>
<td>British Heart Foundation</td>
<td>RCT</td>
<td>1st follow-up: INT = 23; 2nd follow-up: INT = 22</td>
<td>Gender: I=100% women, C=97.5% women, 2.5% men</td>
<td></td>
<td>“Teamplay”: parenting program, The content drew heavily on key issues that affected parental PA and SV behaviors. A Teamplay leader manual was produced which gave detailed session plans for the 8-week course in order to ensure consistency of delivery across groups and the meeting of learning objectives.</td>
<td>8 weeks, + 2 months follow up</td>
<td>no treatment: provided with written materials summarizing the intervention content at the end of the study</td>
<td>INT = 13%, CON = 7%</td>
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<tr>
<td>Judice 2013</td>
<td>Portugal</td>
<td>Portuguese Institute of Hydration and Health</td>
<td>RCT (crossover)</td>
<td>N:I=10, C=11?</td>
<td>Gender: all male</td>
<td>Mean across groups: 24.3 ± 4.5y</td>
<td>5 mg of caffeine per kg of body mass per day was administered. The dose of caffeine was divided into two equal parts (2.5 mg kg⁻¹) to be orally consumed through capsules in the morning and after lunch.</td>
<td>4 days</td>
<td>placebo controlled: maltodextrin as placebo, dose (5 m kg⁻¹day⁻¹) and number of placebo capsules, of the same color as the caffeine capsules, containing maltodextrin were provided for the placebo condition.</td>
<td>yes</td>
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<tr>
<td>Kallings 2009</td>
<td>Schweden</td>
<td>Swedish National Institute of Public Health, The Swedish Heart and Lung Foundation, Swedish National Centre for Research in Sports, Tormspiran Foundation, Karolinska Institutet Founds</td>
<td>RCT</td>
<td>N: I=47, C=54</td>
<td>Gender: I=43% men, 57% women, C=43% men, 57% women</td>
<td>Mean age in both groups: 68y</td>
<td>“Physical Activity on Prescription (PAP)”: 30 minutes of patient centred counselling and individualized written prescription of PAP. Participants in the intervention group were encouraged to reduce their time spent in sedentary behaviour.</td>
<td>6 months</td>
<td>Alternative treatment: low-intensity intervention, with one page of written general information about the importance of PA for health.</td>
<td>INT = 13%, CON = 7%</td>
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<tr>
<td>Study</td>
<td>Year</td>
<td>Country</td>
<td>Collaboration</td>
<td>Group</td>
<td>Age</td>
<td>Gender</td>
<td>Study Details</td>
<td>Intervention</td>
<td>Outcome</td>
<td>Notes</td>
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<tr>
<td>Katzmarzyk 2011</td>
<td>USA</td>
<td>ARS/USDA cooperative agreement, Louisiana Public Facilities Authority Endowed Chair in Nutrition</td>
<td>RCT</td>
<td>Education + pedometer: physical activity brochure (for description see control group) and pedometer. Walking with an interventionist for approximately 10 minutes to build self-efficacy for walking at MVPA and to observe how quickly steps accrued. Specific strategies discussed and encouragement to increase steps/day by an amount that would approximate USDA guidelines for the prevention of weight gain.</td>
<td>home</td>
<td>1 week</td>
<td>Alternative treatment: brochure detailing the importance of physical activity for maintaining health, the physical activity guidelines, and strategies to increase physical activity levels</td>
<td>INT = 23%, CON = 18%</td>
<td>no - increase in MVPA</td>
<td>No intervention effects on sedentary behaviour</td>
</tr>
<tr>
<td>Lakerveld 2013</td>
<td>The Netherlands</td>
<td>Netherlands Organization for Health Research and Development</td>
<td>RCT</td>
<td>“Hoorn Prevention Study”: In a maximum of six individual 30-min counseling sessions, followed by 3-monthly sessions by phone, an innovative combination of motivational interviewing and problem solving treatment were used. The participants were free to choose which lifestyle component(s) (smoking, physical activity or diet) they wanted to change.</td>
<td>GP practice</td>
<td>6 months</td>
<td>Alternative treatment: health brochure with information and guidelines with regard to healthy physical activity levels, a healthy diet and smoking cessation.</td>
<td>6month: INT = 15%, CON = 13%, 1 year: INT = 21%, CON = 18%, 2 years: INT = 23%, CON = 19%</td>
<td>yes</td>
<td>No intervention effects on sedentary behaviour. Stratified analyses for educational attainment revealed a small and temporary between-group difference in favour of the intervention group, in those who finished secondary school.</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Funding source not reported</td>
<td>N: I=55, C=57</td>
<td>Age: 84% were aged between 21y and 49y</td>
<td>Gender: all female</td>
<td>RCT</td>
<td>The intervention consisted of two print booklets, specific to initial and later stages of motivational readiness. The booklets contained information and strategies designed to alter self-efficacy, social support, outcome expectancy and barriers to physical activity.</td>
<td>home</td>
<td>6 weeks</td>
<td>Attention control: Healthy eating and nutrition booklet developed by the Irish Heart Foundation, An Bord Bia and the Health Promotion Unit.</td>
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<td>Lane 2010</td>
<td>Ireland</td>
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<td>RCT</td>
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<tr>
<td>Lioret 2012</td>
<td>Australia</td>
<td>Funding source not reported</td>
<td>N: I=179, C=178</td>
<td>Mean age: I=32.5±4.2y, C=32.0±4.4y</td>
<td>Gender: all female</td>
<td>cluster RCT</td>
<td>&quot;Melbourne InFANT Program&quot;: focused on parenting skills and behaviors that aimed to promote the development of healthy eating and physical activity behaviors in infants, along with reduced sedentary behaviors. This dietician-delivered intervention comprised six 2-hour sessions delivered quarterly during the regular meeting time of the first-time parents’ group. Intervention materials incorporated six key messages within a DVD and written handouts.</td>
<td>home based</td>
<td>18 months</td>
<td>Usual care/attention control: newsletters regarding generic issues in child health</td>
</tr>
<tr>
<td>Lopez-Fontana 2009</td>
<td>Spain</td>
<td>Navarra Government, CIBEROnb, and the Special Research Line of Nutrition, Obesity and Health of the University of Navarra, Friend’s</td>
<td>N: I=19, C=21</td>
<td>Mean age: I=34.2±6.2y, C=34.5±7.9y</td>
<td>Gender: all female</td>
<td>RCT</td>
<td>Low-CHO–high-fat diet. Each volunteer received a plan detailing the food distribution, quantities of each food, weekly meal menu, quantity of oil permitted per day, recipes and cooking techniques, and specific suggestions.</td>
<td>10 weeks</td>
<td>Sedentary behaviour assessment after 5 weeks</td>
<td>Alternative treatment: high-carbohydrate–low-fat diet. Each volunteer received a plan detailing the food distribution, quantities of each food, weekly meal menu, quantity of oil permitted per day, recipes and cooking techniques</td>
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<tr>
<td>Study Authors</td>
<td>Year</td>
<td>Country</td>
<td>Funding</td>
<td>N: I=</td>
<td>N: C=</td>
<td>Description</td>
<td>Setting</td>
<td>Duration</td>
<td>Alternative Treatment</td>
<td>Intervention Effect</td>
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<tr>
<td>Marshall et al.</td>
<td>2003</td>
<td>Australia</td>
<td>National Heart Foundation of Australia</td>
<td>I=327, C=328</td>
<td>Mean age: I=43±10y, C=43±11y</td>
<td>RCT</td>
<td>PA program delivered via an interactive stage-targeted website and e-mail. The “Active Living” website was based on the content of the “Active Living” booklets. The website included interactive and animated features, stage-based quizzes with feedback on responses, as well as personalized sections on goal setting, activity planning, determining target heart rates, and a PA readiness questionnaire.</td>
<td>home-based</td>
<td>8 weeks</td>
<td>Alternative treatment: Physical activity program delivered via print. The print intervention included the previously tested “Active Living” booklets, additional behavioral reinforcement letters were sent to participants every 2 weeks</td>
</tr>
<tr>
<td>McGuire et al.</td>
<td>2001</td>
<td>USA</td>
<td>Funding source not reported</td>
<td>I=306, I2=305, C=613</td>
<td>Mean age across groups: 35.2±6.3y</td>
<td>RCT</td>
<td>Arm 1: Education only group which received monthly newsletters that emphasized self-weighing, increased servings of fruits and vegetables, decreased servings of high-fat foods, and walking. The monthly newsletters were mailed to participants for the 3y of the intervention. Arm 2: Education plus lottery incentive group. This group received the same monthly newsletters as the education-only group but, in addition, they were entered into a lottery drawing for $100 if they returned their adherence postcard.</td>
<td>community</td>
<td>3 yrs</td>
<td>no treatment</td>
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<tr>
<td>Morrison et al.</td>
<td>2013</td>
<td>UK</td>
<td>Henry Dryerre Scholarship,</td>
<td>I=16, C=12</td>
<td>Mean age for groups: 44.8 y</td>
<td>RCT</td>
<td>Children, parents and the pet dog being physically active together by providing information on dog walking routes and promoting various forms of active play with the dog both indoors and outdoors. Intervention families received</td>
<td>family</td>
<td>10 weeks</td>
<td>no treatment</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Funding source</td>
<td>Study design</td>
<td>Phase</td>
<td>Interventions</td>
<td>Effect size</td>
<td>Notes</td>
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<tr>
<td>Mutrie 2012</td>
<td>UK</td>
<td>Chief Scientist Office [CSO] Scotland NHS Research and Development from Greater Glasgow and Clyde and the Scottish Primary Care Research Network.</td>
<td>RCT</td>
<td>12 weeks</td>
<td>Two 30-minute physical activity consultations were delivered individually to each participant by a practice nurse. The consultations followed recommended guidelines. The initial consultation aimed to increase walking participation. A 12-week individualized graduated walking programme in the form of a specially designed booklet and pedometer was given to participants.</td>
<td>N: I=20, C=19</td>
<td>Waiting list: asked to continue normal PA for the first 12 weeks</td>
<td>INT = 0%, CON 1st follow-up = 10%, 2nd follow-up = 19%</td>
<td>Decrease of sedentary behaviour in favour of the intervention group</td>
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<tr>
<td>Opdenacker 2008</td>
<td>Belgium</td>
<td>Funding source not reported</td>
<td>RCT</td>
<td>3 months</td>
<td>Alternative treatment: coach designed an individualized physical activity program in accordance with the preferences and habits of the participant. <strong>The main goal was to attain the recommended ACSM/CDC amount of physical activity.</strong> The coach further provided a brochure that included information, tips, and examples on how to increase physical activity participation.</td>
<td>N: I=33, C=33</td>
<td>Alternative treatment: coach designed an individualized physical activity program in accordance with the preferences and habits of the participant in a face-to-face session. The coach further provided the employee with a 20-page colorful brochure that included information, tips, and examples on how to increase physical activity participation.</td>
<td>both groups 27%</td>
<td>No - effect on PA and mental health</td>
<td>Reduced sitting time in both groups with no significant group differences</td>
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<tr>
<td>Study</td>
<td>Design</td>
<td>Interventions</td>
<td>Outcomes</td>
<td>Notes</td>
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<tr>
<td>Ostbye 2009 USA</td>
<td>RCT</td>
<td>Eight healthy eating sessions (Mom’s Time Out [MTO] classes); ten physical-activity group sessions (ACTIVMOMS classes); and six telephone-counseling sessions (20 minutes). They were also provided with a study notebook with exercises, recipes, and other intervention-related information; and a pedometer. Given the intervention’s strong emphasis on walking, a sport stroller was provided to encourage walking for exercise outside of class and after the end of the intervention.</td>
<td>Commun ity</td>
<td>Usual care: received biweekly newsletters with general tips for postpartum mothers</td>
<td>INT = 18%, CON = 23%</td>
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<tr>
<td>Papalazarou 2010 Greece</td>
<td>RCT</td>
<td>Instruction to follow a liquid diet of very low calorie content for 4 weeks. Following this period, soft and solid foods were gradually introduced to the diet of both groups. Additional 40min of individual counseling: Aim of the intervention was to help patients to overcome barriers and regulate their body weight by adopting healthier eating habits and a less sedentary lifestyle.</td>
<td>Dietetics Departm ent</td>
<td>Usual care: Instructed to follow a liquid diet of very low calorie content for 4 weeks. Following this period, soft and solid foods were gradually introduced to the diet of both group. During these assessment sessions general information was provided on adopting healthier eating and physical habits.</td>
<td>Not reported</td>
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<tr>
<td>Parry 2013 Australia</td>
<td>cluster RCT</td>
<td>Arm 1: ‘active office work’ intervention - access to a single ‘Active Workstation’ which consisted of an electronically height adjustable desk with integrated treadmill or a treadmill plus a stationary cycle ergometer. It was recommended that the Active Workstation be used for short periods several times a day, starting at 10 minutes and building up to 30 minutes per session.</td>
<td>work place - office workers (clerical, data entry and call centre workers) from 3 governm ent</td>
<td>Alternative treatment /attention control: ‘office ergonomics’ intervention which focused on computer workstation setup, ‘active’ sitting (moving whilst in the chair) and breaking up computer tasks</td>
<td>INT 1 = 61%, INT 2 = 53%, Con = 46%</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Intervention</td>
<td>Duration</td>
<td>Usual care</td>
<td>Actigraph data</td>
<td>Notes</td>
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<td>Pederson 2013</td>
<td>N: I=17, C=17</td>
<td>Arm 2: traditional physical activity' intervention - focused on strategies to promote light to moderate activity in breaks between productive work times and increasing the use of active transport before and after work. Participants were all provided with a pedometer to use as a motivational tool.</td>
<td>13 weeks</td>
<td>Alternative treatment/waiting list: 15-minute educational session on the negative health effects associated with prolonged sitting, general instructions on performing appropriate workplace physical activity (20 minutes), and an information session on using the Exertime software (30 minutes). No e-health software loaded on their computers for a 13 week period.</td>
<td>INT = 0%, CON = 0%</td>
<td>yes Decreased sitting behaviour at work in favour of the intervention group</td>
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<tr>
<td>Poston 2013</td>
<td>N: I= 56, C=54</td>
<td>Participants attended a one-to-one appointment where women were provided with a participant handbook, a pedometer, a log book for weekly SMART goals and related behaviours (steps, PA and diet) and a DVD of a specially devised pregnancy exercise regime and were invited to weekly group sessions for 8 consecutive weeks from approximately 19 weeks’ gestation. All women attended routine antenatal care appointments and received hospital and community children’s centre visits.</td>
<td>28 weeks</td>
<td>Usual care: routine antenatal visits</td>
<td>INT = 62%, CON = 56%</td>
<td>no - changes in diet and physical activity behaviours No significant intervention effect on sedentary behaviour</td>
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</table>

**Arm 2:** traditional physical activity' intervention - focused on strategies to promote light to moderate activity in breaks between productive work times and increasing the use of active transport before and after work. Participants were all provided with a pedometer to use as a motivational tool.
advice regarding diet and physical activity (PA) in accordance with local policies, which draw on UK NICE guidelines.

Reynor 2013a  
USA  
Feasibility grant from the University of Tennessee Obesity Research Center  
N: I=12, C=12  
Mean age: I= 53.3±8.0y C=51.7±10.0y  
Gender: I=10% men, 90% women C=20% men, 80% women  
RCT  
Energy restriction + TV decrease: Participants were instructed to consume a standard energy- and fat-restricted diet. Intervention consisted of 8, 60-minute group meetings. Participants were instructed to gradually reduce their TV watching time to 10 hours per week.  
research centre/home  
8 weeks  
Alternative treatment: Energy restriction and instruction to gradually increase MVPA to at least 40 minutes per day, 5 days per week. Participants were encouraged to do brisk walking and accumulate time spent in MVPA. 8 group meetings  
I = 25%, C = 17%  
Yes  
No significant intervention effect for TV viewing time

Reynor 2013b  
USA  
Feasibility grant from the University of Tennessee Obesity Research Center  
N: I=14, C=14  
Mean age: I= 54.9±7.4y C=53.3±9.1y  
Gender: I=27% men, 73% women C=27% men, 73% women  
RCT  
Energy restriction + TV decrease + PA increase: Intervention consisted of 8, 60-minute group meetings. Participants were instructed to consume a standard energy- and fat-restricted diet, to reduce TV watching to 10 hours/week and to gradually increase MVPA to at least 40 minutes per day, 5 days/week. Participants were encouraged to do brisk walking and accumulate time spent in MVPA. Participants were given a pedometer. Home visits occurred so that the code that the participants used to watch TV on the TV Allowances was set to limit TV watching accordingly to meet target.  
research centre/home  
8 weeks  
Alternative treatment: Energy restriction and instruction to gradually increase MVPA to at least 40 minutes per day, 5 days/week. Participants were encouraged to do brisk walking and accumulate time spent in MVPA. Provision of a pedometer.  
I= 36%, C = 14%  
Yes  
Reduced TV viewing time in favour of the intervention group
| Study | Year | Country | Funding | N: I= | C= | Mean age: I= | C= | Gender: | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Robertson 2013 | USA | Funding source not reported | RCT | Ergonomics training: sit-stand workstation, 1.5 h group coaching and mandatory experiential practice period, where participants were asked to stand once for 5 min in the middle of the 50 min session, and three days later to stand once for 20 min in the middle of the 50 min session. Reminders were also presented once every three days in the morning and they contained three helpful tips regarding office ergonomics principles. | workplac | 4 weeks | Alternative treatment: Sit-stand workstation with separate adjustments for the monitor and main table work surface. Group received no coaching, ergonomics reminders, or mandatory sit/stand periods. | Not reported | no - musculo-skeletal discomfort | Reduced sitting time at work in favour of the intervention group |
| Rosenberg 2010 | USA | Funding source not reported | cluster RCT; (ICC for sedentary behaviour = 0) | Provision of pedometer, Information provided in print materials included: safe walking tips, benefits of walking, overcoming barriers to walking, and summaries of recommendations for walking with health conditions. Group meetings lasted approximately 30 minutes and included a check-in with residents to share any relevant walking stories from the previous week, a brief didactic on the weekly topic, and time for residents to problem-solve difficulties as a group. To deliver individualized feedback and assistance, brief (5-10 minutes) biweekly individual telephone counseling. Provision of walking maps. | Retirement community | 12 weeks | Alternative treatment: handouts on goal-setting so participants could set their own step goals. | I=22%, C=32% | No - increased walking | No intervention effect on sedentary behaviour |
| Slootmaker 2009 | The Netherlands | The Netherlands Organization for Health Research and | RCT | The intervention group received the Personal Activity Monitor (PAM) and was provided with Web-based tailored physical activity advice (PAM COACH). Based on the user’s uploaded PAM score for the first week, the PAM COACH assigns a lower goal that increases daily until the PAM goal score is reached at the end of the intervention period. | work place - office workers | 3 months | Alternative treatment: single written information brochure with brief general PA recommendations and health benefits of PA. | I=6%, C=2%; 8 months: I=25%, C=18% | yes | No intervention effect on sedentary behaviour |
### Development

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<tr>
<th>Study Details</th>
<th>Sample Size</th>
<th>Gender Distribution</th>
<th>Intervention</th>
<th>Duration</th>
<th>Alternative Treatment</th>
<th>Findings</th>
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<tbody>
<tr>
<td>Spring 2012, USA</td>
<td>N: I= 53, I2= 44, C= 47, C2=48</td>
<td>61% women, C= 41% men, 59% women</td>
<td>The uploaded PAM scores are automatically accompanied by tailored physical activity advice and motivational tips for increasing physical activity.</td>
<td>RCT</td>
<td>Make better choices: (behavioural choice theory) ARM 1 - ↓Fat ↓Sedentary behaviour: decrease saturated fat consumption to &lt; 8% per day and decrease targeted sedentary leisure activity to &lt; 90 minutes/day; ARM 2 - ↑Fruits &amp; Vegetables (FV) ↓Sedentary behaviour: increase FV consumption to &gt; 5/day and decrease sedentary leisure activity to &lt; 90 min/day. For the first week of treatment, daily goals were set midway between the baseline behavior and the ultimate daily goal. Beginning the second treatment week, full goals were set for the 2 targeted behaviors. During the 3 treatment weeks, participants uploaded data daily (PDA) and communicated as needed with their coaches via telephone or e-mail, per preference, to overcome challenges.</td>
<td>home based, 3 weeks</td>
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<tr>
<th>Study Details</th>
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<th>Alternative Treatment</th>
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<tbody>
<tr>
<td>Steeves 2012, USA</td>
<td>N: I=29, C=29</td>
<td>Gender: I=23% men, 77% women; I2=25% men, 75% women; C1=17% men, 83% women; C2=29% men, 71% women</td>
<td>Instructed to stand and “briskly” step in place, or “briskly” walk continuously around the room/ house for the duration of each commercial break during at least 90 min of TV programming at least 5 d/wk. Participants were instructed to step in place at a “moderate pace” (e.g., 100–120 steps per minute), Participants reviewed appropriate stepping-in-place or walking around the room pace and technique during each of the first 3 face-to-face meetings.</td>
<td>RCT</td>
<td>Instructed to stand and “briskly” step in place, or “briskly” walk continuously around the room/ house for the duration of each commercial break during at least 90 min of TV programming at least 5 d/wk. Participants were instructed to step in place at a “moderate pace” (e.g., 100–120 steps per minute), Participants reviewed appropriate stepping-in-place or walking around the room pace and technique during each of the first 3 face-to-face meetings.</td>
<td>home based, 6 months</td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Sample Size</td>
<td>Mean Age</td>
<td>Gender</td>
<td>Intervention</td>
<td>Duration</td>
</tr>
<tr>
<td>-------</td>
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</tr>
<tr>
<td>Sternfeld 2009 USA Centre for Disease Control</td>
<td>USA</td>
<td>N: I=351, C=436</td>
<td>I=44.8±10.0y, C=43.5±11.0y</td>
<td>Gender: I=27% men, 73% women, C=25% men, 75% women</td>
<td>cluster RCT: ALIVE - designed to increase both the consumption of fruits and vegetables and physical activity and to decrease the consumption of saturated fats, trans fats, and added sugars. Participants choose to work on one of three paths (increasing physical activity; increasing fruits and vegetables [fruits/vegetables]; or decreasing fats and sugars [fats/sugars]); the messages they subsequently receive are specific to the chosen path. The participant chooses one or two of those goals for the week; once a selection is made, a personal home page opens with tips for achieving the selected goal(s), along with other modules.</td>
<td>16 weeks</td>
</tr>
<tr>
<td>Thompson 2008 USA Funding source not reported</td>
<td>USA</td>
<td>N: I=100, C=100</td>
<td>I=29.6±6.6y, C=28.9±6.7y</td>
<td>Gender: All female</td>
<td>RCT: The final intervention consisted of five discussion-format group sessions (one per month for five months). Sessions lasted 2 to 2.5 hours and included learning to read food labels, strategies for choosing healthier foods when eating out or snacking, taste-testing of healthy meals, and dissemination of inexpensive recipes for at-home preparation of foods to increase vegetable and fruit intake and decrease saturated fats. Weather permitting, the facilitator led a 15-minute outdoor walk at the beginning of each session.</td>
<td>18 months</td>
</tr>
<tr>
<td>van Berkel 2014</td>
<td>N: I=129, C=128</td>
<td>RCT</td>
<td>The Mindful VIP intervention comprised 8 weeks of in company mindfulness training with homework exercises, followed by 8 sessions of e-coaching. The weekly mindfulness training sessions took 90 minutes and were held in a room at the worksite in a group setting. The homework exercises comprised a variety of meditation and informal exercises such as breathing exercises when starting up the computer, and grocery shopping mindfully and took approximately 30 min/day on 5 days/week. Materials for this training consisted of 2 cd’s with guided meditation exercises and a booklet with examples of workplace situations, background and (workplace) exercises. Lunch walking routes, and a buddy-system were offered as supportive tools.</td>
<td>work site - employees from two Dutch research institutes</td>
<td>6 months</td>
<td>no treatment</td>
</tr>
<tr>
<td>---</td>
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</tr>
<tr>
<td>The Netherlands Nuts Ohra Foundation</td>
<td>Mean age: I=46.0±9.4y C= 45.1±9.6y</td>
<td>Gender: I= 37% men, 63% women, C=29% men, 71% women</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Verweij 2012 | N: I=210, C=206 | cluster RCT | Guideline based care: Prevention at the environmental level (advice for the employer), (b) prevention at the individual level (advice for the employee) and (c) evaluation and maintenance of a) + b). Physician led behaviour change counselling to promote employees' healthy lifestyle in five 20-30 min counselling sessions. In the first counselling session, employees could choose which target behaviour they would like to discuss (increasing physical activity, decreasing sedentary behaviour, increasing fruit consumption or reducing the energy intake derived from snacks). Employees were provided with a toolkit containing a waist | work site - Employees of Occupational Physicians | 6 months | Usual care: health risk appraisal with anthropometric measurements and a subsequent health advice | 6 months: I = 23%, C = 17% | yes | Reduced sedentary behaviour at work in favour of the intervention group but not during leisure time |
| The Netherlands Organisation for Health Research and Development | Mean age: I= 46±8y, C=48±9y | Gender: I=62%men, 38% women C=65% men, 35% women | cluster size = 16 practices of occupational physician | | | | |
circumference measure tape, a pedometer, leaflets on physical activity and nutrition from the Dutch Heart Foundations and the Netherlands Nutrition Centre
Supplement figure 1: Funnel plot of the intervention effect for reducing sitting time in minutes/day in adults by type of intervention
Sensitivity analyses for effect of interventions with the potential to reduce sedentary behaviour in adults

Sensitivity analyses were used to test the influence of study characteristics on the robustness of the review results. The effect of the following characteristics was explored: ‘high risk’ of performance and attrition bias (Tables 2 and 3), cluster designs (Table 4), usual care or alternative treatment control groups (Table 5). The tables show the pooled intervention effects when studies meeting the above characteristics were excluded from the analyses.

Table 2: Sensitivity analysis for studies of ‘high’ risk of performance bias

<table>
<thead>
<tr>
<th>Outcome or Subgroup</th>
<th>n Studies</th>
<th>n Participants</th>
<th>Statistical Method</th>
<th>Effect Estimate [min/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>All interventions</td>
<td>20</td>
<td>3818</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-17.38 [-35.55, 0.80]</td>
</tr>
<tr>
<td>Physical activity</td>
<td>9</td>
<td>1729</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-6.60 [-33.27, 20.07]</td>
</tr>
<tr>
<td>Sedentary behaviour</td>
<td>0</td>
<td>0</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>Not estimable</td>
</tr>
<tr>
<td>Physical activity &amp; sedentary behaviour</td>
<td>1</td>
<td>257</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>23.60 [0.78, 46.42]</td>
</tr>
<tr>
<td>Lifestyle interventions</td>
<td>10</td>
<td>1832</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-35.48 [-65.26, -5.69]</td>
</tr>
</tbody>
</table>

Table 3: Sensitivity analysis for studies of ‘high’ risk of attrition bias

<table>
<thead>
<tr>
<th>Outcome or Subgroup</th>
<th>n Studies</th>
<th>n Participants</th>
<th>Statistical Method</th>
<th>Effect Estimate [min/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>All interventions</td>
<td>21</td>
<td>3054</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-28.32 [-47.06, -9.58]</td>
</tr>
<tr>
<td>Physical activity</td>
<td>5</td>
<td>1050</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-0.16 [-42.91, 42.59]</td>
</tr>
<tr>
<td>Sedentary behaviour</td>
<td>2</td>
<td>62</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-41.76 [-78.92, -4.60]</td>
</tr>
<tr>
<td>Physical activity &amp; sedentary behaviour</td>
<td>2</td>
<td>290</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-63.46 [-239.39, 112.46]</td>
</tr>
<tr>
<td>Lifestyle interventions</td>
<td>12</td>
<td>1652</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-34.22 [-59.12, -9.31]</td>
</tr>
</tbody>
</table>
Table 4: Sensitivity analysis for cluster RCTs

<table>
<thead>
<tr>
<th>Outcome or Subgroup</th>
<th>n Studies</th>
<th>n Participants</th>
<th>Statistical Method</th>
<th>Effect Estimate [min/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>All interventions</td>
<td>30</td>
<td>4861</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-25.91 [-41.29, -10.53]</td>
</tr>
<tr>
<td>Physical activity</td>
<td>10</td>
<td>1849</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-8.45 [-32.16, 15.26]</td>
</tr>
<tr>
<td>Sedentary behaviour</td>
<td>2</td>
<td>62</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-41.76 [-78.92, -4.60]</td>
</tr>
<tr>
<td>Physical activity &amp; sedentary behaviour</td>
<td>2</td>
<td>290</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-63.46 [-239.39, 112.46]</td>
</tr>
<tr>
<td>Lifestyle interventions</td>
<td>16</td>
<td>2660</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-33.55 [-55.90, -11.20]</td>
</tr>
</tbody>
</table>

Table 5: Sensitivity analysis for studies with usual care and alternative treatment as control condition

<table>
<thead>
<tr>
<th>Outcome or Subgroup</th>
<th>n Studies</th>
<th>n Participants</th>
<th>Statistical Method</th>
<th>Effect Estimate [min/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>All interventions</td>
<td>12</td>
<td>1898</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-30.17 [-51.79, -8.54]</td>
</tr>
<tr>
<td>Physical activity</td>
<td>5</td>
<td>772</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-32.14 [-61.49, -2.80]</td>
</tr>
<tr>
<td>Sedentary behaviour</td>
<td>0</td>
<td>0</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>Not estimable</td>
</tr>
<tr>
<td>Physical activity &amp; sedentary behaviour</td>
<td>2</td>
<td>290</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-63.46 [-239.39, 112.46]</td>
</tr>
<tr>
<td>Lifestyle interventions</td>
<td>5</td>
<td>836</td>
<td>Mean Difference (IV, Random, 95% CI)</td>
<td>-17.62 [-36.94, 1.70]</td>
</tr>
</tbody>
</table>
References

REFERENCES


32. Barwais FA, Cuddihy TF, Tomson LM. Physical activity, sedentary behavior and total wellness changes among sedentary adults: A 4-week randomized controlled trial. Health and Quality of Life Outcomes 2013;11(1).


60. Lane A, Murphy N, Bauman A, et al. Randomized controlled trial to increase physical activity among insufficiently active women following their participation in a mass event. Health Education Journal 2010;69(3):287-96.


