REVIEW

Open Access



Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis

Aoife Stephenson^{1*}, Suzanne M. McDonough^{2,3,4}, Marie H. Murphy¹, Chris D. Nugent⁵ and Jacqueline L. Mair¹

Abstract

Background: High levels of sedentary behaviour (SB) are associated with negative health consequences. Technology enhanced solutions such as mobile applications, activity monitors, prompting software, texts, emails and websites are being harnessed to reduce SB. The aim of this paper is to evaluate the effectiveness of such technology enhanced interventions aimed at reducing SB in healthy adults and to examine the behaviour change techniques (BCTs) used.

Methods: Five electronic databases were searched to identify randomised-controlled trials (RCTs), published up to June 2016. Interventions using computer, mobile or wearable technologies to facilitate a reduction in SB, using a measure of sedentary time as an outcome, were eligible for inclusion. Risk of bias was assessed using the Cochrane Collaboration's tool and interventions were coded using the BCT Taxonomy (v1).

Results: Meta-analysis of 15/17 RCTs suggested that computer, mobile and wearable technology tools resulted in a mean reduction of -41.28 min per day (min/day) of sitting time (95% CI -60.99, -21.58, I2 = 77%, n = 1402), in favour of the intervention group at end point follow-up. The pooled effects showed mean reductions at short (\leq 3 months), medium (>3 to 6 months), and long-term follow-up (>6 months) of -42.42 min/day, -37.23 min/day and -1.65 min/day, respectively. Overall, 16/17 studies were deemed as having a high or unclear risk of bias, and 1/17 was judged to be at a low risk of bias. A total of 46 BCTs (14 unique) were coded for the computer, mobile and wearable components of the interventions. The most frequently coded were "prompts and cues", "self-monitoring of behaviour", "social support (unspecified)" and "goal setting (behaviour)".

Conclusion: Interventions using computer, mobile and wearable technologies can be effective in reducing SB. Effectiveness appeared most prominent in the short-term and lessened over time. A range of BCTs have been implemented in these interventions. Future studies need to improve reporting of BCTs within interventions and address the methodological flaws identified within the review through the use of more rigorously controlled study designs with longer-term follow-ups, objective measures of SB and the incorporation of strategies to reduce attrition.

Trial registration: The review protocol was registered with PROSPERO: CRD42016038187

Keywords: Sedentary behaviour, Behaviour change, Randomised-controlled trials, Systematic review, Digital technology

* Correspondence: stephenson-a@email.ulster.ac.uk

¹Shore Rd, Newtownabbey BT37 0QB, Northern Ireland

Full list of author information is available at the end of the article



© The Author(s). 2017 **Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated.

Introduction

Sedentary behaviour (SB) has been defined as any waking behaviour characterised by energy expenditure of 1.5 metabolic equivalents (METs) or less, undertaken while in a sitting or reclining posture [1]. Modern society provides many opportunities for prolonged sitting in leisure, work and commuting [2]. Data from a range of industrialised countries suggest that SB is highly prevalent with the majority of people's time (55–69% of the day) spent in sedentary pursuits [3–6].

Prolonged SB is positively associated with a range of health concerns including all-cause mortality, cardiovascular disease, type 2 diabetes, metabolic syndrome and several types of cancers [7]. Although the precise physiological mechanisms by which SB is detrimental to health are not fully known, a sedentary lifestyle is associated with cardiovascular morbidity and mortality, defects in lipoprotein metabolism, early atherosclerosis, insulin resistance, and development of the metabolic syndrome [2].

Previous systematic reviews and meta-analyses suggest that it is possible to intervene to reduce SBs in adults through activity permissive work stations, height adjustable desks, health coaching, activity monitors, and prompts to break up sitting [8, 9]. Pooled results from these interventions range from 22 to 91 min/day reduction in sedentary time in the intervention groups compared with the controls. While technological advancements have contributed to a rise in SB [10], these reviews [8, 9] have identified that they are also being harnessed to reduce SB. Digital tools such as mobile phones, internet, text-messaging and wearable sensors can provide a platform to intervene to change health behaviours, however, there is a lack of evidence examining their role in reducing SB. These have been successfully applied to improve diet/Physical Activity (PA) [11, 12], sexual health behaviours [13], weight management [14], alcohol reduction [12] and smoking cessation [15, 16]. One systematic review and meta-analysis investigated the use of mobile phone based interventions on outcomes of PA and SB [17]. The main findings were that these interventions targeting PA and SB promote small reductions in free-living individuals' sitting time. However, only 5 of the 21 included studies reported a measure of SB.

Recent recommendations on prevention and management of non-communicable diseases stressed the need for research focused on behaviour change as the core component [18]. The identification and characterisation of behaviour change techniques (BCTs) allows for an understanding of mechanisms of behaviour change, leading to enhanced replication and implementation of effective interventions [19]. Whilst reviews of SB interventions and the BCTs used within these interventions have started to emerge, they are scarce and have lacked a clear aim to reduce SB exclusively [8, 9, 17, 20]. The effectiveness of interventions supported by computer, mobile and/or wearable technology aimed specifically at reducing SB, and the BCTs used within, have not yet been explored. The objectives of this review are to evaluate the effectiveness of behaviour change interventions using computer, mobile and/or wearable technologies aimed at reducing SB in healthy adults and to identify the BCTs used within these interventions.

Methods

The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Guidelines and Cochrane Handbook for Systematic Reviews of Interventions were used as a methodological template for this review [21, 22] (Additional file 1).

Inclusion criteria

- Adults aged 18 years and over,
- Published RCTs of any duration with a main aim of reducing SB and with computer, mobile or wearable technology as any part of the intervention,
- RCTs with a comparison or control arm that consisted of no intervention control, usual care, or alternative treatment conditions,
- Pre-post objective, subjective or proxy measure of SB.

Exclusion criteria

- RCTs not published in English,
- Comparator intervention using computer, mobile or wearable technology to reduce SB or increase PA,
- RCTs where the main aim of the intervention was to increase PA,
- Interventions delivered in a hospital setting,
- Clinically diagnosed populations, with the exception of those who are overweight or obese.

Information sources and search strategy

Search strategies were developed for each electronic database; MEDLINE, EMBASE, CINAHL, PsycINFO and PubMed. The searches were based on the strategy developed for MEDLINE (Additional file 2) and revised appropriately for the other databases.

The search results were imported into EndNote X7 bibliographic software (Thompson Reuters, San Francisco, CA, USA) and duplicate studies were removed. The titles and abstracts of all identified studies were screened to identify potentially relevant papers. Studies that did not meet the inclusion criteria and titles/abstracts obviously not related to the topic of interest were excluded. Full text papers of potentially relevant studies were retrieved and assessed for eligibility by one member of the research team. Where uncertainties arose regarding study inclusion, consensus was achieved through discussion amongst the research team.

Data extraction

The following data were independently extracted from each article using a standardised form: author, year, study design, participants, intervention description, comparator description, SB outcome measures and longest follow-up.

Assessment of risk of bias in included studies

The risk of bias for each study was assessed using the Cochrane Collaboration's risk of bias tool [22]. Initially, a small sample of studies (n = 3) were assessed by two members of the research team, inconsistency in scoring was reviewed, and a consensus reached prior to the analysis of the remaining studies, by one author. The remainder of the risk of bias assessment was carried out independently by one member of the research team.

Studies that used an objective measure to assess SB were judged as being at low risk of bias for blinding of outcome assessment. Studies assessing SB with subjective and proxy measures were judged as being at high risk of bias, as there was potential for misreporting of time spent sitting. Where greater than 20% dropout in any group for outcomes up to one year and greater than 30% for outcomes greater than one year was reported, studies were judged as being at high risk of bias for incomplete outcome data. Studies were judged as being at low risk of bias for selective outcome reporting if the final publication of the trial followed what had been planned in a published protocol paper. In the case where no protocol paper was publicly available, studies were deemed as being at low risk for selective outcome reporting if they had reported all the outcomes mentioned in the methodology. A study was judged to be at low risk of bias overall when all domains had a low risk of bias. Conversely, a study was judged to have a high risk of bias when it reported a feature that would be judged as having a high risk of bias in any domain. As it is not possible to blind either in studies of this nature, we did not assess blinding of participants or personnel for overall risk of bias [23].

Coding of behaviour change techniques

All intervention procedures were coded using the BCT Taxonomy v1 [19]. Content was coded using the information reported within the methodology sections of identified studies and their protocol papers (where available) to identify the specific BCTs used in each intervention. BCTs targeting SB were coded for the entire intervention and then separately for the computer, mobile and wearable technology components. To minimise bias in interpretation of the tool, a small sample of studies were first assessed by two trained BCT coders (one coder was independent of the research team). Inconsistency in coding was reviewed and a consensus reached, prior to the analysis of the remaining studies, by one author. Where uncertainties later arose, the example was discussed with the wider remaining research team to achieve consensus.

Measures of treatment effect

Fifteen studies reported continuous outcomes for measures of SB across the same scale allowing meta-analysis of mean differences (MD). Statistical analysis was conducted in accordance with guidelines from the Cochrane Handbook for Systematic Reviews of Interventions [22]. SB data were transformed into minutes per day (e.g. 5 h/ day = 300 min/day). Data were pooled to compare the post intervention mean differences and 95% confidence intervals (CIs) in sitting time (min/day) between intervention and comparison groups. Authors of the studies included were contacted by email up to three times for further information where required. Studies where the information was unavailable or that reported units that could not be converted to min/day were not included in the meta-analyses.

Where studies reported multiple follow-up points of the same outcome, data were extracted for subgroup analyses at the following time points: short-term (≤ 3 months), medium-term (>3 to 6 months), and long-term follow-up (>6 months). In studies where two data sets fell within one of these time points, the longest time point was used for data extraction. Where more than one measure of SB was available, objective data were given priority over subjective or proxy data. If more than one proxy measure of SB was available, the measure most representative of overall SB was given preference. If a study focused on reducing workplace SB, workplace SB data were prioritised over SB in other domains or overall SB. Conversely, where an intervention targeted overall daily SB, full day SB data were used in the analysis. Separate subgroup analyses were run for interventions targeting workplace sitting and overall daily SB for short, medium and long-term follow-up periods. Subgroup analyses were also conducted for objective and subjective outcome measures. Data were assessed for statistical heterogeneity. Values of the I² statistic that were 30% to 60% were considered to represent moderate heterogeneity and 50% to 90% substantial heterogeneity. Studies were pooled using a random effects model where heterogeneity was moderate to substantial; otherwise a fixed effects model was used.

Results

Figure 1 displays the PRISMA flow diagram of the literature search. Inclusion criteria were met by 17 studies, 15 of which provided adequate data to be included in a meta-analysis.



Study characteristics

Study and participant characteristics are summarised in Table 1. Of the 17 included studies (n = 1967 participants), 1323 participants (67%) reported being female. Four studies stated the ratio of male to female participants for the sample analysed and not the sample randomised [24–27]. Fifteen studies were carried out in mixed gender populations. Two studies were carried out amongst female participants only [28, 29]. Thirteen studies included any participants aged 18 years or over. One study targeted females aged 55–70 years [29]. The target population in two studies were young adults with an age

range of 18–40 years [30, 31]. One study targeted undergraduate university students [25].

All studies were published between 2012 and 2016. Ten interventions were designed to reduce SB in the workplace and seven interventions aimed to reduce overall daily SB. Eleven studies were SB interventions alone [24–27 30, 32–37], and both PA and SB were targeted in three studies [29, 38, 39]. The remaining three were lifestyle interventions that included a SB reduction component [28, 31, 40].

All studies targeted SB using a mix of intervention approaches. Table 1 details the overall components of the interventions in addition to computer, mobile and wearable technology components. The studies targeting workplace SB utilised the following tools: software/ computer prompts were used in seven studies [24, 27, 28, 32, 34, 35, 39]; emails were used in five studies [26, 27, 36, 39, 40]; websites to relay information and provide feedback to participants were used in three studies [36, 37, 40]; and text messages were used in one study [36]. In those interventions targeting overall sitting, emails were used in three studies [25, 33, 38], websites were used in two studies [31, 33] and text messages were sent to participants in three studies [30-32]. Activity monitors with an online companion were used in three studies [29, 30, 38]. One study used a mobile application intervention, and this was an optional component of the intervention [29].

The duration and intensity of the interventions varied. The intervention time ranged from five days [24, 28] to 24 months [31]. The type of control groups also varied between studies. Two studies used a wait-list control [33, 37], seven studies used a no intervention control group [25, 26, 28, 32, 36, 38, 39] and one study compared a stand-up desk combined with prompts with a stand-up desk alone [27]. Seven studies provided their control group with basic health information [24, 29–31, 34, 35, 40].

A variety of SB measurement tools were used. Three studies used more than one measurement tool [26, 30, 37]. Eleven studies used objective measures including; accelerometers [26, 27, 29, 30, 33, 36, 39] and inclinometers [24, 28, 30, 32, 37]. Subjective questionnaires were used in five studies [25, 26, 30, 37, 38]. Four studies used proxy measures where participants were asked to record the time they spent in the domains they were interested in for example computer time, TV time [31, 34, 35, 40].

Risk of bias of included studies

The assessment for each risk of bias item across all included studies, plus the additional domains assessed for cross over and cluster RCTs are presented in Figs. 2 and 3.

Table 1 Su	ımmary	Table c	of includ	ed studies								
Author/Year	Study design	Sample Size	Gender	Age	Health Risk	Setting	Aim	Intervention	Technology tool(s)	Comparison group	Outcome Measure	Longest follow-up
Ashe 2015	Pilot RCT	25	25F 0M	All: 64.1 ± 4.6 l: 64.8 ± 4.6 C: 63.1 ± 4.8	Healthy, not meeting PA guidelines	Community/ home	SB + PA	Group health education, PA/ SB, PA prescription, online activity monitor (Fitbit), Fitbit app, public transport tickets	Activity monitor (Fitbit) with online companion and app	Health information	ActiGraph™	6 months
Barwais 2013	RCT	33	11F 22M	All:27 ± 4.0 1:9.0 ± 4.4 C:26.4 ± 3.0	Self-reporting >7 h per day sitting	Community/ home	SB + PA	Gruve activity tracker with online companion, motivational emails	Gruve activity tracker with online companion, motivational emails	No intervention	7-day SLIPA Log	4 weeks
Biddle 2015	RCT	187	128F 59M	All:32.8 ± 5.6 1:32.4 ± 5.4 C:33.3 ± 5.8	Obese/overweight plus additional risk factor for diabetes	Community/ home	ß	Group education, Gruve activity tracker with online companion, motivational texts/calls	Gruve activity tracker with online companion, motivational texts	Health information + SB information	ActiGraph ^m , ActivPAL ^m , IPAQ, Marshall sitting questionna- ire	12 months
Carr 2013	RCT	40	36F 4M	All:44.7 ± 9.6 1;47.6 ± 9.9 C:42.6 ± 8.9	Apparently healthy, Self-reporting <60 min of moderate to vigorous PA per week, overweight, reporting a minimum of 75% of their work day sitting	Workplace + community/ home	ß	Pedal machine, commercial website (Walker Tracker, Portland, Oregon, USA), pedometer, motivational emails	Commercial website (Walker Tracker, Portland, Oregon, USA), motivational emails	Waitlist	StepWatch [™]	12 weeks
Danquah ^a 2016	Cluster RCT	317	210F 107M	All:46 ± 10 1:46 ± 10 C:45 ± 11	Employees who sit most of the workday	Workplace	SB	Active meetings, lecture, workshop, educational emails/texts, project website	Emails/text, project website	No intervention	ActiGraph™	12 weeks
De Cocker ^a 2016	RCT	213	146F 67M	All:40.3 ± 9.1 1:40.5 ± 8.6 C:39.3 ± 9.0	All employees	Workplace	SB	Web based feedback from project website	Web based feedback from project website	Waitlist	ActivPAL [™] , WSQ	12 weeks
Donath ^a 2015	RCT	33	23F 8M 7 no data	All:42.42 I:45 ± 12 C:40 ± 10	Free from cardio-vascular disease	Workplace	SB	Standing desks, computer prompts	Computer prompts	Standing desk	ActiGraph™	12 weeks
Dutta ^a 2014	Cross- over RCT	29	19F 9M 1 no data	All: 40.4 (no SD reported)	Employees who sit most of the workday	Workplace	SB	Standing desks, reminder emails	Reminder emails	No intervention	Modular Signal Recorder 145, Gruve, OSPAQ	4 weeks
Evans ^a 2012	RCT	30	22F 6M 2 no data	All: 44 I:49 ± 8 C: 39 ± 10	Healthy employees	Workplace	SB	Individual education session, software prompts	Software prompts	Health information + SB information	ActivPAL TM	5 days
Judice 2015	Cross- over RCT	10	5F 5M	All:50.4 ± 11.5	BMI < 25.0 kg m – 2; not taking medication, not meeting PA guidelines, free from any major disease	Workplace + community/ home	ß	Computer prompts, step monitoring, motivational calls/texts	Computer prompts, motivational texts	No intervention	ActivPAL [™]	1 week
Laska 2016	RCT	441	298F 143M	All: 22.8 (no SD reported) I:22.9 C:22.8	BMI: 20–34.9 kg/m2	Community/home	Life style + SB	Educational course (online/ face to face/hybrid), project website, motivational texts/ calls	Educational course (online/ face to face/ hybrid), project website, motivational texts	Health information	Self- reported screen time behaviours	24 months

Table 1 Su	immary	. Table c	of includ	ed studies (Co	ontinued)							
Maher 2015	RCT	195	89F 95M 11 no data	All: 20.4 (no SD reported)	All undergraduates	Community/home	SB	SB planning via email	SB planning via email	No intervention	IPAQ	7 days
Mainsbridge ^a 2014	RCT	29	24F 5M	All: 40.10 l: 36.73 ± 12.38 C: 42.28 ± 9.59	Employees who sit most of the workday, medically deared to perform short bouts of PA	Workplace	SB	Group education, prompting software	Prompting software	Health information + SB information	Self- reported sitting	13 weeks
Pedersen ^a 2014	RCT	84 8	26F 8M	All: 43 1:41.50 ± 12.39 C: 43.88 ± 9.65	Employees who sit most of the workday, free from existing health conditions	Workplace	SB	Group education, prompting software	Prompting software	Health information + SB information	Self- reported SB	13 weeks
Schuna ^a 2014	RCT	4	40F 1M	All: 40.1 ± 10.1 1:40.0 ± 9.5 C: 40.3 ± 10.9	Overweight/obese office workers.	Workplace	SB + PA	Treadmill desk, computer prompts	Computer prompts, email	No intervention	ActiGraph™	12 weeks
Urda ^a 2016	RCT	48	48F 0M	All: 48 ± 10	Employees who sit most of the workday	Workplace	Life style + SB	Educational handout, computer prompt	Computer prompts	No intervention	ActivPAL [™]	5 days
Van Berkel ^a 2014	RCT	257	173F 84M	All: 45.5 1: 46.0 ± 9.4 C: 45.1 ± 9.6	All employees	Workplace	Life style + SB	Mindfulness sessions, nutrition support, e-coaching, intranet webpage	E-coaching (email), intranet webpage	Health information	Self- reported SB	12 months
PCT randomic	ad contra	leit belle	E famala	M mala + ctan	ituariation / intervention	an Crontrol CD rodontan	Thebaviour	DA shinital activity, 7 day CUD	ac included web 7 pol 1	d Linht Intoncit	to Dhurical Acti	vity, I oc

Intensity Physical Activity Log, RCT randomised controlled trial, F female, A male, ± standard deviation, I intervention, C control, SB sedentary behaviour, PA physical activity, 7-day SLPA Log 7-day Sedentary and Light IPAQ International Physical Activity Questionnaire, WSQ Workforce Sitting Questionnaire, OSPAQ Occupational Sitting and Physical Activity Questionnaire ^adenotes interventions targeting workplace sitting



Overall risk of bias assessment

Overall, 13 studies were judged to have a high risk of bias based on: allocation concealment [26] blinding of outcome assessment [25, 31, 34, 35, 37, 38, 40], incomplete outcome data [27, 29, 30, 33, 37, 39]. Three studies were deemed to be at an unclear risk of bias due to incomplete outcome data [28, 36], allocation concealment [28, 32]. One study was judged to be at a low risk of bias [24]. Due to only one study being at low risk of bias, it was not possible to conduct a sensitivity analysis. Refer to Figs. 2 and 3 for a graph and summary of judgements about each risk of bias item for each included study.

Behaviour change techniques

A total of 104 BCTs were coded in the 17 included studies (Table 2). 20/93 unique BCTs were coded representing 21.5% of the taxonomy. The range of BCTs coded per study was one to 15. The most frequently coded BCT was "instruction on how to perform a behaviour" which was coded 15 times, "social support

(unspecified)" (12 times), "prompts and cues" (11 times) and "adding objects to the environment" (11 times).

A total of 46 BCTs were coded in the 17 studies for the computer, mobile and wearable components of the interventions only. In these interventions, there were 14 unique BCTs coded, ranging from one to 10 per study. The most frequently coded BCTs were "prompts and cues" (10 times), "self-monitoring of behaviour" (7 times), "social support (unspecified)" (7 times) and "goal setting (behaviour)" (5 times).

Effects of intervention

Main analysis

Results of the main meta-analysis (n = 15; Fig. 4) suggest that SB reducing interventions incorporating computer, mobile and/or wearable technology tools resulted in a mean reduction of -41.28 min/day (95% CI -60.99, -21.58, $I^2 = 77\%$, n = 1402), in the intervention group at end point follow-up.

In the eight studies which reported objective measures of SB [24, 28–30, 32, 33, 36, 39], the pooled analysis

intervention group. The seven studies which reported subjective measures of SB [25, 31, 34, 35, 37, 38, 40] showed a mean reduction of -52.66 min/day (95% CI, -93.63, -11.69, $I^2 = 88\%$, n = 807). Ten of the 15 studies included in the meta-analysis

resulted in a mean reduction of -35.07 min/day (95%

CI -46.57, -23.57, $I^2 = 21\%$, n = 595) in favour of the

reported short-term measures (≤ 3 months) [24, 25, 28, 30, 32, 33, 36–39]. The pooled analysis showed a mean reduction of -42.42 min/day (95% CI -63.21, -21.63, I² = 61%, *n* = 760) in favour of the intervention group. Five interventions reported medium-term (>3 to 6 months) measures. The pooled effect showed a mean reduction of -37.23 min/day (95% CI -73.70, -0.75, I² = 85%, *n* = 691). Three studies reported long-term measures of SB (>6 months). The pooled analysis showed a mean reduction of -1.65 min/day (95% CI -14.77, 11.47, I² = 23%, *n* = 670).

Eight interventions included in the meta-analysis focused on reducing workplace SB [24, 28, 34–37, 39, 40] (Fig. 5). The pooled effect showed a mean reduction of -39.88 min/workday (time spent at work) (95% CI -59.58, -20.18, $I^2 = 65\%$, n = 762) in favour of the intervention group at end point follow-up.

Five workplace SB studies [24, 28, 36, 37, 39] reported short-term measures, showing a mean reduction of -35.23 min/workday (95% CI -47.60, -22.86, $I^2 = 0\%$, n = 477) in favour of the intervention group. Three workplace SB studies [34, 35, 40] included medium-term measures showing a mean reduction of -69.34 min/workday (95% CI -140.58, 1.91, I2 = 90%, n = 284). There were not enough data to conduct a meta-analysis on work place interventions with long-term measures.

There were seven interventions targeting overall daily sitting reporting measures of SB [25, 29–33, 38] (Fig. 6). Pooled effects showed a mean reduction of -45.11 min/ day (95% CI -86.63, -3.60, $I^2 = 82\%$, n = 640) favouring the intervention group at end point follow-up.

Five of these studies reported short-term measures [25, 30, 32, 33, 38] showing a mean reduction of -67.72 min/ day (95% CI -132.82, -2.62, $I^2 = 80\%$, n = 283) in favour of the intervention group. Two studies [29, 31] reported medium-term measures showing a mean reduction of -5.92 min/day (95% CI -21.32, 9.48, $I^2 = 0\%$, n = 413). Two studies [30, 31] reported long-term measures showing a mean reduction of -4.71 min/day (95% CI -32.81, 23.40, $I^2 = 55\%$, n = 448), with substantial heterogeneity in the observed effects studies.

Discussion

This systematic review and meta-analysis found that SB reduction interventions using computer, mobile and wearable technology resulted in a mean reduction of 41 min/ day in the intervention group at end point follow-up.



	5																		
BCT LABEL	Ashe 2015	Barwais 2013	Biddle 2015	Carr 2013	Danquah 2016 ^a	de Cocker 2016 ^a	2015 ^a	2014 ^a 2	ul suns Ju 012 ^a 20	dice Las 15 20'	ka Mal 16 201	ber Mains 5 2014 ^a	oridge	Pedersen 2014 ^a	Schuna 2014 ^a	Urda 2016 ^a	Van Berkel 2014 ^a	Total coded (whole intervention)	Total coded (technology)
1. Goals and planning																		25	10
1.1. Goal setting (behaviour)		×I	×		×	×I				×	×I						×I	7	5
1.2. Problem solving	×		×		×				×	×					×		×I	6	2
1.4. Action planning	×		×			×I					×I							4	2
1.5. Review behaviour goal(s)	×		×														×I	4	Ļ
1.7. Review outcome goal(s)					×													1	0
2. Feedback and monitoring																		10	8
2.2. Feedback on behaviour			×			×												2	-
2.3. Self-monitoring of behaviour		×I	×I	×I					×	×I	×I	×I	-	×.				00	7
3. Social support																		13	8
3.1. Social support (unspecified)	×	×I	×	×I	×				×I	×							×ı	12	7
3.2. Social support (practical)															×I			1	1
4. Shaping knowledge																		15	4
4.1. Instruction on how to perform the behaviour	×		×	×I	×	×I		×	×	×I		×		ý		×		15	4
5. Natural consequences																		6	
5.1. Information about health consequences			×		×	×I		×	×			×		ž		×		6	-
6. Comparison of behaviour																		2	-
6.1. Demonstration of the behaviour														×				1	0
6.2. Social comparison										×I								1	1
7. Associations																		11	10
7.1. Prompts/cues			×	×	×		~	×	×I			×I	-	×I	×I	×		11	10
8. Repetition and substitution																		9	0
8.2. Behaviour substitution	×				×					×								m	0
8.7. Graded tasks	×				×		Â											m	0
9. Comparison of outcomes																		-	-
9.1. Credible source										×I								1	-
10. Reward and threat																		0	0
11. Regulation																		0	0
12. Antecedents																		12	3
12.3. Avoidance/reducing exposure to cues for the behaviour										×								-	0

Table 2 BCT coding and frequency

Table 2 BCT coding and frequency (Continued)

12.5. Adding objects to the environment	×ı ×ı	×I	×	×	×	×	×		×	11	ε
13. Identity										0	0
14. Scheduled consequences										0	0
15. Self-belief										-	0
15.1. Verbal persuasion about capability				×						-	0
16. Covert learning										0	0
BCT Behaviour change technique, a denotes interventions targeting w	coded as pa orkplace sitti	irt of the te ng	schnology	y aspect, x coo	ded as part of	interventio	on (non-tec	hnology aspects)			

End point follow up

	Exp	erimenta	d	C	ontrol			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% C	IV, Random, 95% CI
Ashe 2015	517.37	54.77	12	522.81	35.77	7	7.1%	-5.44 [-46.21, 35.33]	-
Barwais 2013	516	102	18	672	90	15	4.8%	-156.00 [-221.53, -90.47]	
Biddle 2015	637.46	100.62	45	661.37	71.83	51	7.7%	-23.91 [-59.31, 11.49]	
Carr 2013	526.1	77.3	23	599.7	106.6	17	5.3%	-73.60 [-133.31, -13.89]	
Danguah 2016	310	71.03	173	349	79.2	144	9.6%	-39.00 [-55.71, -22.29]	-
De Cocker 2015	259	88	33	288	48	24	7.7%	-29.00 [-64.64, 6.64]	
Evans 2012	336	66	14	342	54	14	6.7%	-6.00 [-50.67, 38.67]	-
Judice 2015	573	108	10	684	88.8	10	3 4%	-111 00 [-197 66 -24 34]	
Laska 2016	78	80.27	170	72	78 92	173	9.6%	6 00 [-10 63 22 63]	+
Laska 2010	474 69	214 71	26	12 69	202 10	1/3	1 00/	28 00 [02 65 171 45]	
Mainehaidas 2014	011.01	120.45	11	433.00	203.10	44	2.0%	100 53 [030 07 01 70]	
Mainsbridge 2014	211.91	130.45	47	372.44	34.07	10	3.9%	-160.53 [-239.27, -81.79]	
Pedersen 2014	201.24	07.17	15	256 20	40.44	10	7.0%	-70.47 [-102.77, -36.17]	
Unde 2014	310.4	40.40	15	300.20	40.44	20	7.9%	-39.66 [-74.01, -5.75]	
Vice Deskel 2014	325.2	71.4	22	200 77	44.4	22	1.170	-37.60 [-72.93, -2.67]	
van Berkel 2014	301.03	97.84	112	309.77	105.44	110	6.0%	-8.74 [-35.51, 18.03]	
Total (0E% CI)			720			692	100.0%	41 29 1 60 00 21 691	•
10tal (55% CI)			120			002	100.076	-41.28 [-00.33, -21.38]	· · · · · · · · · · · · · · · · · · ·
Heterogeneity: Tau* =	982.95; 0	Chi* = 61.	54, df :	= 14 (P <	0.00001	(1^{*}) ; $1^{*} = 7$	1%		-200 -100 0 100 200
l est for overall effect:	Z = 4.11	(P < 0.00	01)					1	Favours [experimental] Favours [control]
Study or Subgroup Ashe 2015	Exp Mean 517.37	erimenta SD 54.77	Total	(Mean 522.81	Control SD 35.77	Total 7	Weight 8.0%	Mean Difference IV, Fixed, 95% Cl -5.44 (-46.21, 35.33	Mean Difference IV, Fixed, 95% Cl
Bladle 2015	637.46	100.62	45	661.37	/1.83	51	10.6%	-23.91 [-59.31, 11.49]	
Carr 2013	526.1	11.3	23	599.7	106.6	17	3.7%	-73.60 [-133.31, -13.89]	
Danquan 2016	310	/1.03	173	349	79.2	144	47.3%	-39.00 [-55.71, -22.29]	
Evans 2012	336	66	14	342	54	14	6.6%	-6.00 [-50.67, 38.67]	
Judice 2015	573	108	10	684	88.8	10	1.8%	-111.00 [-197.66, -24.34]	
Schuna 2014	316.4	48.45	15	356.28	48.44	16	11.4%	-39.88 [-74.01, -5.75]	
Urda 2016	325.2	71.4	22	363	44.4	22	10.7%	-37.80 [-72.93, -2.67]	
Test for overall effect:	Z = 5.98	(P < 0.00	001)						Favours (evnerimental) Favours (control)
Test for overall effect Subjective mea	z= 5.98 sures:	(P < 0.00 end p	ooint						Favours (experimental) Favours (control)
Test for overall effect Subjective mea	Z = 5.98 asures: Exp	(P < 0.00 end p erimenta	ooint		Control			Mean Difference	Favours [experimental] Favours [control] Mean Difference
Test for overall effect Subjective mea Study or Subgroup	Z = 5.98 SURES: Exp Mean	(P < 0.00 end p erimenta SD	ooint I Total	(Mean	Control SD	Total	Weight	Mean Difference IV, Random, 95% C	Favours (experimental) Favours (control) Mean Difference I IV, Random, 95% Cl
Test for overall effect: Subjective mea Study or Subgroup Barwais 2013	: Z = 5.98 ASURES: Exp Mean 516	(P < 0.00 end p erimenta SD 102	001) ooint I <u>Total</u> 18	(Mean 672	Control SD 90	Total 15	Weight 12.8%	Mean Difference IV, Random, 95% C -156.00 (-221.53,-90.47	Favours [experimental] Favours [control] Mean Difference I IV, Random, 95% CI I Image: Classical Statement
Test for overall effect: Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015	: Z = 5.98 ASURES: Exp Mean 516 259	(P < 0.00 end p erimenta <u>SD</u> 102 88	001) point I Total 18 33	672 288	Control SD 90 48	Total 15 24	Weight 12.8% 16.6%	Mean Difference N, Random, 95% C -156.00 (-221.53, -90.47 -29.00 (-64.64, 6.64	Favours [experimental] Favours [control] Mean Difference I I IV, Random, 95% CI
Test for overall effect: Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016	: Z = 5.98 ASURES: Exp Mean 516 259 78	(P < 0.00 end p erimenta SD 102 88 80.27	001) point I 18 33 179	Mean 672 288 72	Control SD 90 48 78.92	Total 15 24 173	Weight 12.8% 16.6% 18.4%	Mean Difference IV, Random, 95% C -156.00 [-221.53, -90.47 -29.00 [-64.64, 6.64 6.00 [-10.63, 22.63	Mean Difference
Test for overall effect: Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Maher 2015	Z = 5.98 asures: Exp Mean 516 259 78 474.58	(P < 0.00 end p erimenta 5D 102 88 80.27 314.71	001) point I Total 18 33 179 36	Mean 672 288 72 435.68	Control SD 90 48 78.92 283.18	Total 15 24 173 44	Weight 12.8% 16.6% 18.4% 6.4%	Mean Difference IV, Random, 95% C -156.00 [-221.53, -90.47 -29.00 [-64.64, 6.64 6.00 [-10.63, 22.63 38.90 [-39.65, 171.45	Mean Difference
Test for overall effect Subjective mea Barwais 2013 De Cocker 2015 Laska 2016 Maher 2015 Mainsbridge 2014	Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91	(P < 0.00 erimenta <u>SD</u> 102 88 80.27 314.71 130.45	001) 00int 1 18 33 179 36 11	Mean 672 288 72 435.68 372.44	Control 90 48 78.92 283.18 34.67	Total 15 24 173 44 18	Weight 12.8% 16.6% 18.4% 6.4% 11.2%	Mean Difference IV, Random, 95% C -156.00 [-221.53, -90.47 -290.00 [-64.64, 6.64 6.00 [-10.63, 22.63 39.90 [-93.65, 171.45 -160.53 [-23.027, -8.179	Mean Difference
Test for overall effect Subjective mean Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainer 2015 Mainsbridge 2014 Pedersen 2014	Exp Mean 516 259 78 474.58 211.91 291.24	(P < 0.00 erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17	001) 00int 1 18 33 179 36 11 17	Mean 672 288 72 435.68 372.44 361.71	Control SD 90 48 78.92 283.18 34.67 36.71	Total 15 24 173 44 18 17	Weight 12.8% 16.6% 18.4% 6.4% 11.2%	Mean Difference IV, Random, 95% C -156.00 [-221.53, -90.47 -29.00 [-64.64, 6.64 6.00 [-10.63, 22.63 38.90 [-93.65, 171.45 -160.53 [-239.27, -81.79 -70.47 [-10.77, -38.17]	Favours [experimental] Favours [control] Mean Difference I/V, Random, 95% CI
Test for overall effect Subjective meal Barwais 2013 De Cocker 2015 Laska 2016 Mains 2015 Mains bridge 2014 Pedersen 2014 Van Berkel 2014	Z = 5.98 ASURES: Exp Mean 516 259 78 474.58 211.91 291.24 301.03	(P < 0.00 erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17 97.84	001) 00int <u>Total</u> 18 33 179 36 11 17 112	Mean 672 288 72 435.68 372.44 361.71 309.77	Control SD 90 48 78.92 283.46 34.67 36.71 105.44	Total 15 24 173 44 18 17 110	Weight 12.8% 16.6% 18.4% 6.4% 11.2% 17.0%	Mean Difference IV, Random, 95% C -156.00 [+21:53.:90.47 -29.00 [+64.6, 664 6.00 [+10.63, 2263 38.90 [+33.65, 171.45 -160.53 [+239.27, -81.79 -70.47 [+102.77, -38.17] -8.74 [+35.11.803	Mean Difference
Test for overall effect Subjective mean Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Maher 2015 Mainsbridge 2014 Pedersen 2014 Van Berkel 2014	Z = 5.98 ASUTES: Exp Mean 516 259 78 474.58 211.91 291.24 301.03	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84	001) 00int 18 33 179 36 11 17 112	Mean 672 288 72 435.68 372.44 361.71 309.77	Control SD 90 48 78.92 283.18 34.67 36.71 105.44	Total 15 24 173 44 18 17 110	Weight 12.8% 16.6% 18.4% 6.4% 17.0% 17.6%	Mean Difference N, Random, 95% C 1-56.00 ; 221 : 5390.47 -29.00 ; 54.64, 56.4 6.00 ; 10.63, 22.3 38.90 ; [33.65, 171.45 -160.53 ; 223.92.7, -81.74 -70.47 ; 102.77, -38.17 -8.74 ; 53.51, 18.03	Mean Difference Image: Nr Random, 95% Cl
Test for overall effect: Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Pedersen 2014 Van Berkel 2014 Total (95% CI)	Z = 5.98 SUTES: Exp Mean 516 259 78 474.58 211.91 291.24 301.03	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84	001) 00int 1 18 33 179 36 11 17 112 406	Mean 672 288 72 435.68 372.44 361.71 309.77	Control SD 90 48 78.92 283.18 34.67 36.71 105.44	Total 15 24 173 44 18 17 110 401	Weight 12.8% 16.6% 18.4% 6.4% 11.2% 17.0% 17.6% 100.0 %	Mean Difference 1, Random, 95% C 1, Random, 95% C 1, Random, 95% C 4, 00 (1063, 2263 38.90 (93.65, 171.45 -160.33 (223) 27.41.79 -70.47 (102.77, -3817) -8.74 (-35.51, 18.03 -52.66 (-93.63, -11.69	Ravours [experimental] Favours [control]
Test for overall effect Subjective mea Barwais 2013 De Cocker 2015 Laska 2016 Mainer 2015 Mainsbridge 2014 Pedersen 2014 Van Berkel 2014 Total (95% CI) Heterogeneiky: Tau*=	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 ; Chi [≈] = 41	001) 00int 1 18 33 179 36 11 17 112 406 9.23, d	672 288 72 435.68 372.44 361.71 309.77 f= 6 (P <	Control SD 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401); I ² = 8	Weight 12.8% 16.6% 18.4% 6.4% 11.2% 17.0% 17.6% 100.0% 8%	Mean Difference N, Random, 95% C 165,001;27:53,-90.47 -29.00[:64.64, 64 6.00[:103,2263 38.90[:93.65,171,45 -160.53]:239.27,-91.77 -37.74[:35.51,18.03 -52.66[:93.63,-11.69	Mean Difference I IV, Random, 95% CI
Testfor overall effect: Subjective mea Study or Subgroup Barvais 2013 De Cocker 2015 Laska 2016 Mains 2014 Pedersen 2014 Van Berkel 2014 Total (95% CI) Heterogeneily: Tau ⁺ = Testfor overall effect	Z = 5.98 ASURES: ASURES: Asures: Area State 259 78 474.58 211.91 291.24 301.03 = 2296.90, Z = 2.52	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 ; Chi [≠] = 44 (P = 0.01)	001) 00int 1 18 33 179 36 11 17 112 406 9.23, d	(Mean 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P <	Control SD 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401); I ² = 8	Weight 12.8% 16.6% 6.4% 11.2% 17.0% 17.6% 100.0% 8%	Mean Difference N, Random, 95% C -156.00 [+21.53, -90.47 -29.00 [+64.6, 66 6.00 [+10.63, 228 38.90 [+33.65, 171.45 -160.63 [+23.927, -81.79 -70.47 [+102.77, -38.17 -8.74 [+35.51, 18.03 -52.66 [-93.63, -11.69	Revours [experimental] Favours [control]
Test for overall effect Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mains 2016 Mains 2014 Pedersen 2014 Van Berkei 2014 Total (95% CI) Heterogeneiky, Tau*= Test for overall effect	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.900 Z = 2.52	(P < 0.00 erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.73 97.84 ; Chi ² = 49 (P = 0.01)	001) 00int 1 18 33 179 36 11 17 112 406 9.23, d	(<u>Mean</u> 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P <	Control SD 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401); I ² = 8	Weight 12.8% 16.6% 6.4% 11.2% 17.0% 17.6% 100.0% 8%	Mean Difference N, Random, 95% C 156.001 (-21.53., -90.47 -29.00 [-64.64, 64 -0.01-106.3, 22.63 -160.53 [-230.27, -81.79 -70.47, [-10.277, -81.79 -8.74 [-35.51, 18.03 -52.66 [-93.63, -11.69	Mean Difference IV, Random, 95% CI Image: State S
Testfor overall effect: Subjective mea Subjective mea Barvais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Total (95% C) Heterogeneity: Tau [*] =	: Z = 5.98 ASUTES:	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 ; Chi ² = 41 (P = 0.01)	001) Total 18 33 179 36 11 17 12 406 9.23, d	<u>Mean</u> 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P <	Control SD 900 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401); I ² = 8	Weight 12.8% 16.6% 18.4% 6.4% 17.0% 17.6% 17.6% 8%	Mean Difference N, Random, 95% C -156.00 [+21:53, 90.47 -29.00 [+64.64, 664 6.00 [+10.63, 22:63 38.90 [=38.65, 171.45 -160.53 [+239.27, -81.77 -70.47 [+102.77, -38.17 -8.74 [+35.51, 18.03 -52.66 [-93.63, -11.69	Mean Difference IV, Random, 95% CI IV, Random,
Testfor overall effect Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Mainschidge 2014 Pedersen 2014 Van Berkel 2014 Total (95% C) Heterogeneily: Tau ^a = Testfor overall effect:	: Z = 5.98 ASUTES: ASUTES: ASUTES: AMAGENES: AMAGE	(P < 0.00 end p erimenta 88 80.27 314.71 130.45 57.17 97.84 ; Chi² = 49 (P = 0.01)	001) 0011 1 10 10 11 17 112 406 9.23, d	(<u>Mean</u> 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P <	Control 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401); I ² = 8	Weight 12.8% 16.6% 18.4% 6.4% 11.2% 17.0% 17.6% 100.0% 8%	Mean Difference - K, Random, 95% C - K, Random, 95% C - 50, 001 (-21 53, -90.47 - 29.00 [-64.64, 6.64 - 60.04 [-106.3, 22.63 - 38.09 [-93.65, 171.45 - 160.53 [-239.27, -81.79 - 70.47 [-102.77, -3817 - 8.74 [-35.51, 18.03 - 52.66 [-93.63, -11.69	Mean Difference IV, Random, 95% CI IV, Random,
Testfor overall effect Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Total (05% Ct) Heterogenelky, Tau ² Testfor overall effect Short term fol	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90 : Z = 2.52 Ilow u	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 (C hi ^p = 44 (P = 0.01)	001) 0011 1 1 1 1 3 3 1 7 9 3 6 11 17 112 406 9.9.23, d	(Mean 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P <	Control 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	<u>Total</u> 15 24 173 44 18 17 110 401); ² = 8	Weight 12.8% 16.6% 18.4% 6.4% 11.2% 17.0% 17.6% 100.0%	Mean Difference N. Random, 95% C 156,001;221;53,-904 - 29,001;64,64,64 60,01;1063,2263 38,901;93,65,171,45 - 160,531;239,271,-98,17 - 70,47;102,77,-98,17 - 8,74[-35,51,18,03 - 52,66[-93,63,-11,69]	Mean Difference IV, Random, 95% Cl IV, Random,
Testfor overall effect: Subjective mea Subjective mea Barvais 2013 De Cocker 2015 Laska 2016 Mainstratoridge 2014 Van Berkel 2014 Van Berkel 2014 Total (95% Ct) Heterogeneily: Tau [*] = Testfor overall effect: Short term fol	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.900 : Z = 2.52 Ilow u	(P < 0.00 end p erimenta 5D 102 88 80.27 314.71 130.45 57.17 97.84 ;Chi ² = 44 (P = 0.01)	001) Docint Total 18 33 179 36 11 177 112 406 9.23, d	Mean 672 288 722 435.68 372.44 361.71 309.77 f= 6 (P <	Control 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401 401); ² = 8	Weight 12.8% 16.6% 18.4% 6.4% 17.0% 17.6% 100.0% 8%	Mean Difference 14, Random, 95% C 156.00 +221 53.9047 -29.00 [64.64, 64 6.00 (+106.3, 22.63 -38.90 [63.65, 171.45 -160.53 +223.27, 48.79 -70.47 (+102.77, -38.17 -8.74 (+35.51, 18.03 -52.66 [-93.63, -11.69	Favours [experimental] Favours [control]
Test for overall effect: Subjective mean Study or Subgroup Barwais 2013 De Cocker 2015 Lasika 2016 Mainsbridge 2014 Van Berken 2014 Van Berken 2014 Van Berken 2014 Total (95% CI) Heterogeneik, Tau*= Test for overall effect: Short term fol	:Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90 ;Z = 2.52 Ilow u	(P < 0.00 end p erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17 97.84 (Chi ² = 44 (P = 0.01) P erimenta	001) 0011 1 10 10 11 179 36 11 179 36 11 179 36 11 179 36 11 179 36 11 179 36 11 12 12 12 12 12 12 12 12 12	Mean 672 288 722 435.68 372.44 361.71 309.77 1= 6 (P <	Control SD 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	<u>Total</u> 15 24 173 44 18 17 110 401 401 }; ² = 8	Weight 12.8% 16.6% 18.4% 6.4% 11.2% 17.0% 17.6% 100.0%	Mean Difference -1,56,001;221;53,-90,47 -29,001;64,64,64 6,001;106,32,263 -38,901;93,65,171,46 -160,53;2263 -160,53;2263,27,-81,79 -70,47;102,77,-38,17 -8,74;33,51,18,03 -52,66[-93,63,-11,69 Mean Difference	Favours [experimental] Favours [control]
Testfor overall effect: Subjective mea Study or Subgroup Barvais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Total (05% Ct) Heterogeneity: Tau [*] = Testfor overall effect: Short term fol Study or Subgroup	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90; Z = 2.52 Ilow u Exp Mean	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 (Chi ² = 44 (P = 0.01)	0001) Total 18 33 179 36 11 17 112 406 9.23, d) Total	Mean 672 288 372,44 361,71 309,77 f= 6 (P <	Control 90 48 78.92 283.18 34.67 36.71 105.44 0.00001	Total 15 24 173 44 18 17 110 401); I ^a = 8	Weight 12.8% 16.6% 18.4% 6.4% 17.0% 17.0% 100.0% 8%	Mean Difference N, Random, 95% C -156.00 ; 221.5390.47 -29.00 ; 64.64, 664 6.00 ; 10.63, 222.65 38.90 ; [33.65, 171.45 -160.53 ; 223.927, -81.77 -8.74 ; 53.51, 18.03 -52.66 [.493.63, -11.69 Mean Difference IV. Random, 95% C	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI IV, Random, 95% CI Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI
Test for overall effect Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mains 2015 Mains 2015 Mains 2014 Pedersen 2014 Van Berken 2014 Van Berken 2014 Total (95% CI) Heterogeneiky, Tau*= Test for overall effect Short term fol Study or Subgroup Barwin 2013	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90; Z = 2.52 Ilow u Exp Mean 54	(P < 0.00 end p erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17 97.84 (Chi ² = 4! (P = 0.01) P erimenta <u>SD</u> 100 100 87 88 80.27 130.45 57.17 97.84	0001) Total 18 18 33 179 36 11 17 112 406 9.23, d 1 Total	(Mean 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P < C Mean 672 288 72 435.68 372.44 361.71 309.77 f= 6 (P < C Mean C Mean C C C C C C C C C C C C C	Control SD 90 48 78.92 283.18 34.67 36.71 105.44 0.00001 Control SD 90 90 90 90 90 90 90 90 90 90	<u>Total</u> 15 24 173 44 17 110 401 401 401 1€ 5	Weight 12.8% 16.6% 18.4% 6.4% 17.0% 17.0% 100.0% 8% Weight	Mean Difference N, Random, 95% C 156.001 ; 221 ; 390 47 - 29.001 ; 64.64, 64 6 0.01 (106.3, 22.63 38.900 ; 93.65, 171.46 - 160.53 ; 223.927, - 81.79 - 70.47 ; 102.77, - 38.17 - 3.74 ; 33.51, 18.03 - 52.66 [-93.63, -11.69 Mean Difference IV, Random, 95% C - 10.20 ; 21.20	Mean Difference IV, Random, 95% CI
Testfor overall effect: Subjective mea Study or Subgroup Barvais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Heterogeneity: Tau ⁺ = Testfor overall effect: Short term fol Study or Subgroup Barvais 2015	:Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 :Z = 2.52 Ilow u Exp Mean	(P < 0.00 end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 (P = 0.01) (P p terimenta SD 102 96.24	0001) Total 1 1 1 1 1 1 1 1 1 1 1 1 1	(<u>Mean</u> 672 288 72 435.68 372.44 309.77 f= 6 (P < <u>C</u> <u>Mean</u> 672 <u>672</u>	Control SD 900 48 78.92 283.18 36.71 105.44 0.00001 0.000000 0.0000000 0.000000 0.00000000	Total 15 24 173 44 18 17 110 401 20 10 5 7	Weight 12.9% 18.6% 18.4% 1.2% 17.0% 17.6% 100.0% 8%	Mean Difference N. Random, 95% C 156.00 / 27.153.90.47 -29.00 [64.64, 64 6.00 (10.63, 22.63 -38.90 [93.65, 171.45 -160.53 [2232, 24.17 -70.47 [102.77, -38.17 -8.74 [-35.51, 18.03 -52.66 [-93.63, -11.69 Mean Difference IV. Random, 95% C -156.00 [221.53, -90.47]	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: Control of the second s
Test for overall effect: Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Lasika 2016 Mainsbridge 2014 Van Berken 2014 Van Berken 2014 Van Berken 2014 Total (95% CI) Heterogeneity, Tau*= Test for overall effect: Short term fol Study or Subgroup Barwais 2013 Biddle 2015	:Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90 :Z = 2.52 Ilow u Exp Mean 516 652.82 529 528 528 528 528 528 528 528 528	(P < 0.00 end p erimenta 5D 102 88 80.27 314.71 130.45 57.17 97.84 (P = 0.01) (P (P = 0.01) (P 102 86.31 77.02	001) Total 18 33 179 366 11 177 112 406 9.23, d 18 53 20 18 53 20 18 53 20 18 19 10 10 11 10 10 10 10 10 10 10	((((((((((((((Control 90 48 78.822 283.18 34.67 36.71 105.44 0.000001 0.000001	<u>Total</u> 15 24 173 4 18 17 110 401 401 5 57 57 7	Weight 12.8% 16.6% 11.2% 11.2% 17.0% 17.6% 100.0% 8% Weight 6.6% 3.7%	Mean Difference N, Random, 95% C 156.001 ; 221 ; 3904 - 29.00 ; 64.64, 64 6.00 [106.3, 2263 38.90 [93.65, 171.46 - 160.53 ; 2233 27, 81.79 - 70.47 [102.77, -38.17 - 8.74 ; 35.51, 18.03 - 52.66 [-93.63, -11.69 Mean Difference N, Random, 95% C - 156.00 [-21.53, -90.47] - 11.41 [-42.27, 19.45]	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: State of the s
Testfor overall effect: Subjective mea Stuby or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Total (0%: C) Heterogenety, Tau ⁺ = Test for overall effect: Short term fol Study or Subgroup Barwais 2013 Bidde 2015 Carr 2013	: Z = 5.98 asures: Exp Mean 516 259 78 474.58 211.91 291.24 301.03 = 2296.90, Z = 2.52 Ilow U Exp Mean 516 652.82 526.1 	end p erimenta <u>SD</u> 102 80 80 80 814.71 130.45 67.17 97.84 (P=0.01) p f 102 80 80.31 77.3 78 97.84 20 97.84 10 97.84 10 97.84 100 97.84 10 97.84 100 97.84 1	0001) Total 18 33 179 36 111 177 112 406 9.23, d 1 Total 18 53 233 233 179 102 102 102 102 102 102 102 102	<u>Mean</u> 672 288 372 435.68 372 44 361.71 309.77 1 = 6 (P < C <u>Mean</u> 672 € 664.23 599.7	Control SD 90 48 34.67 36.71 105.44 0.00001 control SD 90 90 106.6 27.8.23	Total 15 24 173 4 18 17 110 401 401 15 57 17 17 17	Weight 12.8% 16.6% 18.4% 17.0% 100.0% 8% Weight 6.6% .7.5% .7.5%	Mean Difference N. Random, 95% C 1.16.00 / 221.5390.47 -29.00 [64.64, 64 6.00 (1.106.3, 22.63 -38.90 [93.65, 171.46 -160.53 223.27, 41.79 -70.47 [102.77, -38.17 -8.74 [-35.51, 18.03 -52.66 [-93.63, -11.69 Mean Difference IV. Random, 95% C -156.00 (221.53, -90.47) -11.41 [-42.27, 19.45] -73.60 [-13.33, -13.89]	Favours [experimental] Favours [control]
Test for overall effect Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Lasika 2016 Mainsbridge 2014 Pedersen 2014 Van Berken 2014 Van Berken 2014 Total (95% CI) Heterogeneiky, Tau ⁺ = Test for overall effect Short term fol Study or Subgroup Barwais 2013 Biddle 2015 Carr 2013 Danguah 2016	Z = 5.98 sures: Exp Mean 516 2599 78 474.58 211.91 221.24 201.24 201.24 201.24 201.24 201.24 201.24 201.24 201.24 201.24 201.24 201.25 201	end p erimenta <u>SD</u> 102 880.27 314.71 130.45 57.17 97.84 (P=0.01) p normerimenta <u>SD</u> 02 88.31 77.3 71.03 77.3 71.03 77.3	0001) Total 18 33 179 36 11 177 112 406 9.23, d 1 Total 18 53 23 173 173 179 112 112 112 112 112 112 112 11	(<u>Mean</u> 672 288 372.44 361.71 309.77 f= 6 (P ≪ <u>C</u> <u>Mean</u> 672 664.23 349 349	Control 90 48 34.67 36.71 105.44 0.000001 control 90 78.23 90 78.23 90 78.23	<u>Total</u> 15 24 173 44 18 173 110 401 30 401 30 71 10 57 17 144	Weight 12.9% 16.6% 11.2% 11.2% 11.2% 17.0% 17.6% 8% Weight 6.6% 13.7% 7.5% 7.7%	Mean Difference 1, Random, 95% C 1, Random, 95% C 1, Random, 95% C 1, Random, 95% C 1, Random, 2, Random, 95% C 1, Random,	Mean Difference IV, Random, 95% CI Image: State Sta
Testfor overall effect: Subjective mea Stuby or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Total (95% Ct) Heterogenety, Tau ⁺ = Testfor overall effect: Short term fol Study or Subgroup Barwais 2013 Biddle 2015 Carr 2013 Danquah 2016 De Cocker 2015	Z = 5.98 ASURES: Exp Mean 616 616 6259 78 474,58 2219.31 221.24 301.03 221.24 301.03 221.24 201.24 301.03 201.24 Mean 516 652.82 526.13 10 259 257 257 257 257 257 257 257 257	end p erimenta SD 102 88 80.27 314.71 130.45 57.17 97.84 (Chi= 41 (P= 0.01) p terimenta SD 102 88.31 77.33 71.03 88.31	001) Total 179 18 33 179 36 11 177 112 406 9.23, d 173 173 173 33 33	<u>Mean</u> 672 288 372.43 361.71 309.77 f= 6 (P < <u>C</u> <u>Mean</u> 664.23 599.7 249 664.23 599.7 349 288	Control SD 90 482 283.18 34.67 36.71 105.44 0.00001 0.00001 SD 90 78.23 106.6 79.2 48	<u>Total</u> 155 24 173 44 17 110 401 10 401 10 ; ² = 8 57 15 57 17 17 144 24	Weight 12.8% 18.4% 17.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 10.0% 17.5% 10.0% 17.5% 10.0% 17.5% 10.7% 17.4% 12.4%	Mean Difference 1, Random, 95% C 1, Random, 95% C 1, Random, 95% C 4, 00 (1-053, 2283 38.90 (93.65, 171.45 160.53 (2283 160.53 (2282, 21.47 -70.47 (102.77, -381, 11.69 -52.66 (-93.63, -11.69 Mean Difference IV, Random, 95% C -156.00 (-221.53, -90.47) -11.41 (-42.27, 19.45) -32.60 (-53.1, -13.89 -39.00 (-55.71, -22.29) -39.00 (-55.71, -22.29)	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: Standard S
Test for overall effect: Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkeil 2014 Van Berkeil 2014 Total (95% CI) Heterogeneiky, Tau*= Test for overall effect: Short term fol Study or Subgroup Barwais 2015 Barwais 2015 Barwais 2015 Danguah 2015 Danguah 2015 Danguah 2015 De Cocker 2015 De Cocker 2015	Z = 5.98 asures: Exp Mean 516 259 78 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2215	end p erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17 97.84 ; Chi ^p =44 ; Chi ^p =4 ; Chi ^p =4 ; Chi ^p =4 ; Thi ^p =4 ; Chi	001) Docint Total 18 33 179 36 11 17 172 4066 9.23, d 9.23, d 11 18 18 33 36 9.23, d 11 18 17 10 10 10 10 10 10 10 10 10 10	(Mean 672 288 772 435.68 373.44 3361.71 309.77 1 = 6 (P < C Mean 672 664.23 599.7 349 288 349 288 349 288 342 288 342 342 342 342 342 342 342 342	Control SD 78.92 283.18 34.67 34.67 34.67 30.00001 105.44 0.00001 50 78.23 90 78.23 90 78.23 90 78.23 106.6 79.2 48 54	Total 15 24 173 44 18 17 173 401 401 401 57 17 15 57 17 144 4 15 24 14 14 15 17 17 17 17 17 17 17 17 17 17	Weight 12.8% 16.6% 6.4% 11.2% 17.0% 17.0% 100.0% 8% Weight 6.6% 13.7% 7.5% 17.4% 12.4% 10.3%	Mean Difference 1, Random, 95% C 1, Random, 95% C 1, Random, 95% C 1, Random, 95% C 1, Random, 2, 263 3, 800 [-33, 65, 171, 46 1, 80, 32, 233 27, 417 9 -10, 37, 243 27, 417 9 -10, 37, 243 27, 417 9 -10, 37, 243 27, 417 9 -52, 266 [-93, 63, -11, 69 Mean Difference IV, Random, 95% C -156, 00 [-21, 33, -00, 47] -11, 41 [-42, 27, 19, 45] -39, 00 [-55, 71, -22, 29] -23, 00 [-65, 71, -22, 29] -23, 00 [-63, 73, 857]	Mean Difference IV, Random, 95% CI IV, Random, 95% CI IV, Random, 95% CI IV, Random, 95% CI
Testfor overall effect: Subjective mea Stuby or Subgroup Barwais 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Total (95% Ct) Heterogenely, Tau ⁺ = Test for overall effect: Short term fol Study or Subgroup Barwais 2013 Biddle 2015 Car 2013 Danquah 2016 De Cocker 2015	Z = 5.98 SUIPES: Exp Mean 516 259 78 291.24 301.03 2296.90 VZ = 2.52 100 VZ = 2.52 VZ = 2.52 100 VZ = 2.52 VZ =	end p erimenta <u>SD</u> 102 882.7 314.71 130.45 57.17 97.84 (P=0.01) P eerimenta <u>SD</u> 102 (P=0.01) P 102 86.31 77.3 888 86.31 77.3 103 102 80.31 77.3 77.3 77.3 77.3 77.3 77.3 77.3 7	001) Docint Total 18 33 179 36 11 177 112 406 9.23, d 9 Total 18 53 23 173 33 173 33 173 33	(<u>Mean</u> 72 288 72 435.68 372.44 3372.44 3309.77 f= 6 (P < <u>C</u> <u>C</u> <u>C</u> <u>C</u> <u>C</u> <u>C</u> <u>C</u> <u>C</u>	Control SD 90 978,92 283,18 36,71 105,44 0.000001 50 0.000001 50 78,23 106,6 90 78,23 106,6 8,8 8,8,8	Total 15 24 173 44 17 110 401 401 15 57 17 144 24 14 10	Weight 12.8% 16.6% 13.4% 17.0% 17.7% 100.0% 8% Weight 6.6% 6.5% 10.3% 7.5% 12.4% 10.3%	Mean Difference IV, Random, 95% C IV, Random, 95% C 45, 001 (-21, -3, -90, 47 -29,001 (-54, -46, -64, -64, -64, -64, -64, -64, -6	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: Standard S
Test for overall effect: Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Lasika 2016 Mainsbridge 2014 Pedersen 2014 Van Berkeil 2014 Total (95% CI) Heterogeneiky, Tau ⁺ = Test for overall effect: Short term fol Study or Subgroup Barwais 2013 Biddle 2015 Carr 2013 Biddle 2015 Card 2015 Danguah 2016 De Cocker 2015 Haher 2015	Z = 5.88 asures: Exp Mean 516 517 299 299 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 292.24 295.25 295.	end p erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17 97.84 (P = 0.01) p (P = 0.01) p 102 86.31 71.03 88 81.71 102 86.31 88 86 60 88 314.71	001) point Total 18 33 179 36 111 17 112 406 9.23, d 9.23, d 18 53 23 173 173 33 141 36 33 174 179 179 179 179 179 179 179 179	(Mean 672 2888 372.44 361.71 309.77 f= 6 (P < C Mean 672 664.23 664.23 664.23 664.23 664.23 829.288 342 4435.68	Control SD 78.92 283.18 34.67 36.71 105.44 0.00001 \$0.0000000000	<u>Total</u> 15 24 173 44 18 17 110 401 401 10 15 57 17 14 24 14 14 10 0 0 44	Weight 12.8% 18.8% 6.4% 17.2% 17.8% 100.0% 8% Weight 6.6% 13.7% 7.5% 10.3% 4.4%	Mean Difference N, Random, 95% C 156.001;2215390.47 -29.001;64.64, 64 60.01(1063,2263 38.901;93.65, 171.45 -70.47,[102.77,-3817 -8.74 [-35.51,18.03 -52.66 [-93.63,-11.69 Mean Difference N, Random, 95% C -73.60 [-133.31,-13.89] -73.60 [-133.31,-13.89] -73.60 [-133.31,-13.89] -73.60 [-133.31,-13.89] -73.60 [-133.31,-13.89] -73.60 [-133.31,-13.89] -73.60 [-133.67,-38.77] -111.00 [-197.66,-23.43]	Mean Difference IV, Random, 95% CI IV, Random, 95% CI IV, Random, 95% CI IV, Random, 95% CI
Testfor overall effect: Subjective mea Study or Subgroup Barwais 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Total (6% ct) Heterogeneity, Tau ⁺ = Test for overall effect: Short term fol Study or Subgroup Barwais 2013 Biddle 2015 Car 2013 Dançuah 2016 De Cocker 2015 Evans 2012 Judice 2015 Maher 2015 Schung 2014	Z = 5.98 BUTCS:: Exp Mean 516 259 78 2211.91 2211.91 2211.91 2211.91 2211.91 2211.91 2219.24 301.03 2296.90 0.03 2296.90 0.03 2296.90 0.03 2295.25 2.52 1.03 2.52 2.52 1.03 2.52	(P < 0.00 end p solution (P < 0.00 erimenta 880.27 314.71 130.45 57.17 97.84 (P = 0.01) (P = 0.01)	001) point Total 18 33 179 366 179 366 9.23, d Total 18 53 23 173 33 173 33 14 10 36 53 23 173 33 179 9.23, d 10 10 10 10 10 10 10 10 10 10	(Control SD 900 48 78.92 283.18 34.67 36.77 105.44 0.000001 50 90 78.23 106.6 90 78.23 106.8 48.84	Total 15 24 173 44 173 44 17 110 401 401 15 57 17 144 24 14 10 44 14 10 44 14 16 16 16 16 16 17 17 17 10 10 10 10 10 10 10 10 10 10	Weight 12.8% 16.6% 17.0% 17.0% 100.0% 8% Weight 6.6% 13.7% 7.5% 10.3% 4.4% 12.4% 12.8%	Mean Difference IV, Random, 95% C IV, Random, 95% C 45, 001 (-21, 53, -90, 47 -29,001 (-54, 46, 64 6, 00 (-10, 63, 22, 63 -38, 90 (-33, 65, 17, 14) -160, 53 (-23, 23, 27, -18, 78 -160, 53 (-23, 23, 27, -18, 78 -160, 53 (-23, 23, -11, 18) -52,66 (-93, 63, -11, 18) -52,66 (-93, 63, -11, 18) Mean Difference IV, Random, 95% C -156,00 (-22, 153, -90, 47) -11,41 (-42, 27, 194, 55) -39,00 (-55, 71, -22, 29) -20,00 (-64, 64, 64, -64) -600 (-90, 67, 38, 67) -11,100 (-197, 66, -24, 34) 39,80 (-93, 65, 77), 45) -39,88 (-14, 01, -5, 75) -39,88 (-14, 01, -5, 75)	Favours [experimental] Favours [control] Mean Difference Image: State of the state of th
Test for overall effect: Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Mainsbridge 2014 Pedersen 2014 Van Berkeil 2014 Total (95% CI) Heterogeneilty, Tau ² = Test for overall effect: Short term fol Study or Subgroup Barwais 2013 Bidde 2015 Carr 2013 Danguah 2016 De Cocker 2015 Schuna 2014 Unda 2016	Z = 5.98 Hear SUPES: Exp Mean 516 259 78 229.91 24 291.24 301.03 291.24 2	end p erimenta <u>SD</u> 102 88 80.27 314.71 130.45 57.17 97.84 (P = 0.01) P p to 2 (P = 0.01) P to 2 (P = 0.01) P to 2 (P = 0.01) P to 2 (P = 0.01) P to 2 (P = 0.00) P to 2 (P = 0.00) P (P = 0.00) P (P = 0.00) P (P = 0.00) P (P = 0	001) point Total 18 33 179 36 117 177 112 406 9.23, d 9 1 18 53 23 173 33 31 40 6 5 22 173 36 173 36 173 31 173 173 173 173 173 173	(<u>Mean</u> 672 288 72 435.68 372.44 361.71 309.77 1= 6 (P < <u>C</u> <u>Mean</u> 672 664.23 425 664.23 342 288 342 288 342 355.88 342 355.88 355.88 363 363 363 363 363 363 363 3	Control 90 48 78 922 283.18 36.71 36.71 105.44 0.00001 50 78.23 78.23 78.23 78.23 78.23 78.23 78.23 78.23 78.23 78.23 78.23 88.8 88.8 88.8 84.4 44.4	<u>Total</u> 15 24 173 44 18 17 110 401 401 401 (); ² = 8 57 7 7 144 24 14 10 44 10 44 122	Weight 12.8% 18.6% 18.4% 6.4% 17.7% 8% Weight 100.0% 8% Weight 100.0% 2.7% 7.5% 13.7% 12.8% 2.2%	Mean Difference N, Random, 95% C 16.00 221 5390.47 -29.00 64.64, 64 6.00 10.63, 22.63 38.90 63.65, 171.45 -160.53 223 2781 78 -70.47 102.77, -381 -52.66 -93.63, -11.69 Mean Difference N, Random, 95% C -155.00 c421.53, -90.477 -11.41 -42.27, 19.45] -73.60 1-23, -90.477 -11.41 -42.27, 19.45] -73.60 1-23, -90.477 -11.41 -42.27, 19.45] -73.60 1-23, -90.477 -11.41 -42.27, 19.45] -73.60 1-23, -90.477 -11.00 -197.66, -23.38] -73.80 7-29, -27.77 -37.80 7-29, -27.77 -	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: Standard S
Testfor overall effect: Subjective measures Suby or Subgroup Barwais 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Van Berkel 2014 Total (05% Ct) Heterogeneity, Tau*= Testfor overall effect: Short term fol Study or Subgroup Barwais 2013 Bidde 2015 Carr 2015 De Cocker 2015 Evans 2012 Judice 2015 Maher 2015 Schuna 2014 Urda 2018	Z = 5.98 Hear States Z = 5.98 Key States Z = 2.98 Key States Z = 2.92 Key States Z = 2.92 Key States Z = 2.92 Key States S = 2.92 Key States Key States S = 2.92 Key States Key States	(P < 0.00 end p so 102 88 80.27 97.84 57.17 97.84 (P = 0.01) (P = 0.01) 02 86.31 77.3 88 86 61 08 86 61 14.71 77.3 814.71	001) Total 1 1 1 1 1 3 3 1 1 1 1 1 1 2 3 6 1 1 1 1 1 2 3 3 6 1 1 1 1 1 2 3 3 6 1 1 1 1 1 2 3 3 6 1 1 1 1 1 2 3 3 6 1 1 1 1 1 1 2 3 6 6 1 1 1 1 1 1 1 1 2 3 6 6 1 1 1 1 1 1 1 1 1 1 1 1 1	(0 Mean 672 288 372 435.68 372.44 361.71 309.77 f= 6 (P < C C Mean 672 664.23 599.7 349 288 342 684 435.68 342 684 435.68 342 684 345 685 345 285 345 345 345 345 345 345 345 34	Control 90 48 78.92 283.18 34.67 36.71 105.44 0.00001 0.000001 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.000000 0.000000 0.00000000	<u>Total</u> 15 24 173 44 18 17 110 401 15 57 17 144 14 10 22 44 14	Weight 12.8% 16.6% 11.2% 17.0% 17.0% 100.0% 8% Weight 6.6% 13.7% 7.4% 12.4% 12.8% 12.8% 12.8%	Mean Difference IV, Random, 95% C IV, Random, 95% C 40, 00 [-10.53, 29.04 -29.00 [-64.64, 6.64 6.00 [-10.63, 22.63 -38.90 [-33.65, 171.45 -10.53, 12.93, 27, 41.79 -70.47 [-102.77, -38.17] -8.74 [-35.51, 18.03 -52.66 [-93.63, -11.69 Mean Difference IV, Random, 95% C -156.00 [-221.53, -90.47] -11.41 [-42.27, 18.45] -39.00 [-55.71, -22.29] -28.00 [-64.6, 6.44] -6.00 [-93.65, 171.452] -39.88 [-74.01, -5.75] -37.80 [-72.93, -2.67] -37.80 [-72.93, -2.67]	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: Standard S
Test for overall effect: Subjective meas Study or Subgroup Barwais 2013 De Cocker 2015 Mainsbridge 2014 Pedersen 2015 Mainsbridge 2014 Pedersen 2014 Van Berkel 2014 Total (95% CI) Barwais 2013 Biddle 2015 Carr 2013 Danquah 2016 De Cocker 2015 Schuna 2014 Unda 2016 Total (95% CI)	Z = 5.98 Mean 516 259 74 301.03 229.24 301.03 229.24 291.24 301.03 291.24 301.03 292.29 291.24 301.03 291.24 291.24 301.03 292.29 295.27 295.27 295.27 205.27	(P < 0.00 end p 102 88 80.27 97.84 130.45 57.17 97.84 (P = 0.01) (P = 0.01) p erimenta 102 86.31 77.3 88 66 108 314.71 48.45 71.4	001) Total 1 1 1 1 1 1 1 1 1 1 1 1 1	(<u>Mean</u> 672 372,44 361,71 309,77 41 = 6 (P < <u>C</u> <u>Mean</u> 672 288 342 288 342 288 342 288 342 288 356,28 363 363 363	Control 90 48 78,922 283,18 34,67 36,71 105,44 0,000001 0,00000000	Total 15 24 173 44 18 17 110 401 401 401 15 57 17 144 24 10 44 41 16 22 363	Weight 12.9% 16.6% 11.2% 17.0% 100.0% 8% Weight 6.6% 7.5% 7.5% 7.74% 7.5% 12.4% 12.2% 10.3%	Mean Difference N, Random, 95% C 16.00 221 5390.47 -29.00 64.64, 64 6.00 10.63, 22.63 38.90 93.65, 171.45 -160.53 2238 2781 78 -70.47 102.773817 -8.74 -35.51, 18.03 -52.66 [-93.63, -11.69 Mean Difference N, Random, 95% C -156.00 -21.53, -90.477 -11.41 [-42.27, 19.45] -36.00 [-50.67, -38.67] -36.00 [-50.67, -38.67] -111.00 [-197.66, -23.43, -174.65] -38.88 [74.01, -5.75] -37.80 [72.93, -2.67] -42.42 [-63.21, -21.63]	Favours [experimental] Favours [control] Mean Difference IV, Random, 95% CI Image: Standard S
Testfor overall effect: Subjective mea Study or Subgroup Barwais 2013 De Cocker 2015 Laska 2016 Mainsbridge 2014 Van Berkel 2014 Van Berkel 2014 Van Berkel 2014 Total (95% C) Heterogeneiky: Tau* = Schort term fol Study or Subgroup Barwais 2013 Bidde 2015 Carr 2013 Danquah 2016 De Cocker 2015 Schuna 2014 Urda 2016 Total (95% C) Heterogeneiky: Tau* =	Z = 5.88 SUPERS: Expression 259 747458 279.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 291.24 301.03 2296.90 Kannon 506 652.82 575.31 305.2 575.35 575.35 575.5	(P < 0.00 end p erimenta SD 102 88 88 88 87.1 97.84 (P = 0.01) P p p p p p p p p p p p p p	001) Total 1 1 1 1 3 3 1 1 1 1 1 2 4 0 9 2 3 6 9 2 3 1 1 1 1 7 9 3 6 9 9 2 3 6 1 1 1 1 7 9 9 2 3 6 6 9 9 2 3 6 1 1 1 1 7 9 9 2 3 6 6 9 9 2 3 6 1 1 1 7 9 9 2 3 6 6 9 9 2 3 6 1 1 1 7 9 9 2 3 6 6 9 9 2 3 6 1 1 1 7 9 9 2 3 6 6 9 9 2 3 6 1 1 1 7 9 9 2 3 6 1 1 1 7 9 9 2 3 6 1 1 1 7 1 1 2 3 6 1 1 1 1 7 1 1 1 1 1 1 1 1 1 1 1 1 1	(<u>Mean</u> 672 728 728 728 728 728 737 435.68 372.44 3372.44 3361.71 309.77 (= 6 (P < C <u>Mean</u> 672 664.23 599.7 288 342 664 445.68 342 368 342 368 342 368 342 368 342 368 342 345 345 345 345 345 345 345 345	Control SD 900 48 78,92 283,18 34,67 105,44 0,00001 105,44 0,00001 90 78,23 106,6 90 78,23 106,6 88,4 48,44 48,44 44,4	Total 15 24 173 44 18 17 10 401 10 10 15 57 17 14 14 15 57 17 14 24 14 16 57 17 14 44 16 25 26 26 26 26 26 26 26 26 26 26	Weight 12.8% 18.4% 18.6% 17.0% 17.0% 100.0% 8% Weight 6.6% 13.7% 7.7% 12.4% 12.8% 12.8% 12.8%	Mean Difference IV, Random, 95% C IV, Random, 95% C 40, 80 (-1053, 2263 38.90 (-33.65, 171, 45 -160, 33, 2263 -160, 33, 2263 -160, 33, 2263 -160, 33, 223 -52,66 (-93,63, -11,89 -52,66 (-93,63, -11,89 Mean Difference IV, Random, 95% C -156,00 (-221,53, -90,47] -11,41 (-42,27, 194,5) -39,00 (-55, 71, -22,29) -28,00 (-46, 6, 64) -60,0 (-30,67, 38,67) -39,88 (-74,01, -5,75) -37,80 (-72, 93, -2,67) -42,42 (-63,21, -21,63)	Mean Difference Image: Nr, Random, 95% CI

-200 -100 0 100 200 Favours [experimental] Favours [control]

Medium term follow up

	Exp	erimenta	al	(Control			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% (CI IV, Random, 95% CI
Ashe 2015	517.37	54.77	12	522.81	35.77	7	19.5%	-5.44 [-46.21, 35.33	1
Laska 2016	84	83.57	194	90	83.57	194	24.5%	-6.00 [-22.63, 10.63	1 -
Mainsbridge 2014	211.91	130.45	11	372.44	34.67	18	11.7%	-160.53 [-239.27, -81.79	· · · · · · · · · · · · · · · · · · ·
Pedersen 2014	291.24	57.17	17	361.71	36.71	17	21.5%	-70.47 [-102.77, -38.17	·
Van Berkel 2014	296.96	97.76	112	300.17	103.45	109	22.7%	-3.21 [-29.76, 23.34	i —
Total (95% CI)			346			345	100.0%	-37.23 [-73.70, -0.75]	•
Heterogeneity: Tau ² =	1339.86;	Chi ² = 2	6.28, df	= 4 (P <	0.0001);	l ² = 85	%		200 100 0 100 200
Test for overall effect:	Z = 2.00	(P = 0.05	5)						Favours [experimental] Favours [control]

Long term follow up

	Exp	erimenta	al	c	ontrol			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% C	I IV, Fixed, 95% CI
Biddle 2015	637.46	100.62	45	661.37	71.83	51	13.7%	-23.91 [-59.31, 11.49]	
Laska 2016	78	80.27	179	72	78.92	173	62.2%	6.00 [-10.63, 22.63]	
Van Berkel 2014	301.03	97.84	112	309.77	105.44	110	24.0%	-8.74 [-35.51, 18.03]	
Total (95% CI)			336			334	100.0%	-1.65 [-14.77, 11.47]	+
Heterogeneity: Chi ² = Test for overall effect:	2.60, df = 7 = 0.25	2(P = 0) P = 0.81	.27); l ²	= 23%					-200 -100 0 100 200
			/						Favours [experimental] Favours [control]

Fig. 4 Effects of intervention versus control on SB



Interventions focusing on workplace SB showed a mean reduction of 40 min/workday in the intervention group at end point follow-up. Interventions focusing on overall daily SB showed a mean reduction of 45 min/day in the intervention group at end point follow-up. Due to risk of bias issues, caution should be taken whilst interpreting these results. Nevertheless, these reductions are encouraging as it has previously been reported that every 30 min of SB reallocated to light PA results in a 2-4% improvement in triglycerides, insulin, beta-cell function biomarkers [41], suggesting clinically meaningful health outcomes.

The magnitude of the mean reduction in sedentary time in this review (41 min/day) is in line with a previous meta-analysis reporting a 42 min/day reduction [9], however, is well below the 91 min/day reduction reported by Prince et al. [8]. This inconsistency may be explained as Prince et al. included non-randomised trials and focused on any intervention that targeted PA and/or SB [8].

The reduction of approximately 40 min/workday in intervention group in this review echoes results from a similar meta-analysis which also showed a reduction of 40 min/workday in favour of the intervention group [42]. Other systematic reviews have shown slightly higher reductions in SB among intervention participants. For example, activity permissive workstation interventions have been reported to contribute to a reduction of 77 min/ workday in favour of the intervention group [43]. It is likely that this larger reduction is due to intervention type investigated. These interventions allow participants to stand but also continue working. Although this represents a higher reduction than seen in our review, these work stations are costly to provide and their widespread deployment may not be feasible. From a public health perspective computer, mobile and wearable technology may hold promise for large-scale, cost-effective interventions [17, 44, 45].

The inconsistencies in the above comparisons may be explained by differences in inclusion criteria, as most of these reviews included studies that aimed to increase PA, and/or reduce SB or addressed interventions that reported on SB outcomes, however, did not necessarily target SB in the intervention [8, 9, 17, 20, 23, 42, 46, 47]. This may be relevant as intervention components that successfully increase PA, may not effectively reduce SB, and vice versa [20]. Furthermore, many of the studies in these other reviews were composed of small sample sizes, used different study designs and intervention durations, used a range of SB measurement tools and varying comparator groups.



Results from the meta-analysis suggest that SB interventions have the greatest effect on sitting in the short-term, with results lessening over time. Interventions targeting overall daily sitting time also follow this trend. The attenuation of the effects on sitting reported by Martin et al. [9], is similar to that reported in our results, with the greatest impact on SB reduction (42 min/day) in the short-term $(\leq 3 \text{ months})$ follow-up declining to 3 min/day at longterm follow-up (>12 months). These results suggest that maintaining long-term behaviour change is challenging, possibly due to the wearing off of the initial "novelty" of technology mediated behaviour change interventions [48, 49]. It must be noted that only three studies reported long-term follow-up measures of SB highlighting a lack of evidence for long-term SB reductions. It was also not possible to analyse interventions targeting workplace sitting at long-term follow-up points as there was insufficient data to conduct a meta-analysis. This lack of long-term evidence is seen in other reviews exploring interventions to reduce SB [42, 46, 50]; where they also did not or could not evaluate long-term effectiveness. Given the importance of sustained behaviour change for health effects, this lack of data highlights the need for studies to examine the effects of longer term SB interventions and over longer follow-up periods.

Greater reductions in SB were found in studies where self-report/proxy measures (53 min/day) of SB were used compared to objective measures (35 min/day). This was also seen in a similar meta-analysis on interventions to reduce SB [9]. This may be due to the subjective assessment of SB being limited by the ubiquitous nature of the behaviours, which may be unremarkable, intermittent and incidental and therefore difficult to accurately recall [51]. Objective measures are also not without limitations. It was not possible to compare cut points and wear time algorithms used in studies, it should be noted that these differences may introduce differences in the scale observed. The development and refinement of valid and reliable objective measures of SB which can incorporate the type and contextual factors, as well as clear guidelines on wear time and cut points are required [52]. This is the first review to collate BCTs used in SB change interventions using computer, mobile or wearable technology in adults. The aim was not to provide definitive conclusions regarding the most effective behaviour change intervention components, but code to identify which techniques have been used to reduce SB. It is, however, difficult to conceptually separate PA promotion and SB reduction components within an intervention [20]. In typical applications of BCT taxonomies in other literatures, a single behaviour is defined and targeted by the intervention, and the link to BCTs can be assumed to be explicitly related to changing that single behaviour [53]. The reality of the design and reporting of many interventions within this review is that they target multiple behaviours and outcomes. Thus, making it more difficult to link BCTs to specific behaviours. Moreover, there was a lack of clear and consistent reporting of which BCTs were undertaken within each intervention making classification of BCTs difficult [54]. Research is warranted to identify the 'active ingredients' of successful interventions to refine the design of optimal BCT use and produce an evidence base upon which SB interventions can be developed. In order to assess the impact of BCTs, the reporting of intervention content must be improved. Researchers should "clearly define and provide a rationale for all BCTs that have been included" with full intervention manuals being provided as supplementary electronic files [55]. In complex interventions, clearer delineation of strategies used to change PA and SB, respectively, in intervention reports is required.

The most frequently coded BCTs to reduce SB across the interventions as a whole were "instruction on how to perform a behaviour" "social support (unspecified)", "prompts and cues" and "adding objects to the environment". Whereas, the most frequently coded BCTs for computer, mobile and wearable components of the interventions were "prompts and cues", "self-monitoring of behaviour", "social support (unspecified)" and "goal setting". These differences suggest some BCTs may lend themselves well to certain modes of delivery and that the BCTs identified in the technology components might fruitfully be incorporated into future technology based interventions to reduce SB.

When comparing the computer, mobile and wearable components in workplace interventions and overall daily interventions, "prompts and cues" was more frequently coded in workplace interventions and "social support (unspecified)" was more frequently coded in overall daily interventions. This reflects the results in Gardner et al. [20] where it is suggested that workplace SB may be more receptive to planning and routinisation than non-workplace SB, which occurs in less predictable and structured contexts. This highlights the need for interventions to be chosen on the basis of what is most appropriate and feasible in the specific setting [56]. The high usage of the BCT 'prompts/cues' identified in this review and that of Direito et al. [17] illustrates that technology may be harnessed to facilitate intervention delivery, however, also to conduct intervention "top-ups" beyond the intervention core duration. This may be a vital component for interventions to prevent relapse.

This study has a number of strengths, including a comprehensive search strategy in multiple databases and the adherence to methodological criteria for high qualitysystematic reviews and meta-analysis. In addition, the systematic detailing of BCT coding procedures using the most recent BCT taxonomy (v1), allows future researchers to replicate and review methods used in detail. However, non-English publications were excluded from review and the search was limited to peer reviewed publications. There was considerable heterogeneity of included studies with regard to intervention type, sample size, follow-up duration, type and outcome estimates and no metaregression was performed. Baseline sitting levels varied across the studies, the scope for change post intervention may be influenced by how much participants sat pre intervention. It must also be noted that how central technology was to each intervention varied greatly. 13/17 included studies were of high risk of bias, with particular concerns in the areas of detection and attrition bias. Six studies were at high risk of attrition bias due to high dropout levels. SB measures used to determine intervention effects in this analysis were measured through subjective measures in seven studies and thus were at high risk for detection bias. These identified methodological flaws present a problem when trying to draw conclusions and evidence presented in the current review should be interpreted with caution. This review also included 'active' comparator groups which may contribute to smaller intervention effects. It was not possible to statistically analyse the individual effectiveness of BCTs or to assess the effectiveness of different combinations of behaviour techniques due to the number of different combinations of BCTs present within studies. In order to address this, future study designs could consider using adaptive interventions such as sequential multiple assignment trials (SMART) or multiphase optimization strategy (MOST) designs. Finally, technology development often outpaces academic research [57] and this review includes two studies using the Gruve activity monitor which is no longer commercially available.

This systematic review provides a useful overview of the effectiveness of computer, mobile and wearable technology interventions in reducing SB and has exposed important gaps in the current evidence base which warrant further attention. Future research should focus on attrition rates to reduce drop out and improve engagement. Such studies may consider using technology to refresh the intervention, varying the approach or introduce a new intervention as time passes to encourage long-term maintenance of SB reductions. Furthermore, research should aim to improve detection bias by using objective measurement tools of SB e.g. accelerometer/ inclinometer, in order to better detect intervention effects. The lack of long-term follow-up highlights the need for extended follow-up in future studies to examine potential long-term impacts of SB interventions. We also recommend including outcome measures that will be of interest to workplaces and policy makers to determine efficient use of resources such as the cost-effectiveness of technology supported strategies to reduce SB.

Conclusion

This review provides new knowledge regarding technology interventions incorporating BCTs for reducing SB. Our findings suggest that computer based, mobile and wearable technologies appear to be promising approaches to reduce SB. However, due to risk of bias issues, caution should be taken whilst interpreting these results. The reduction in sitting time appeared to be most prominent at short-term follow-up and attenuated over time, with the exclusion of interventions targeting work place sitting, where results were most prominent at medium-term follow-up. A range of BCTs were implemented in these interventions. Future studies need to improve reporting of BCTs within interventions and address the methodological flaws identified within the review through the use of more rigorously controlled study designs with longer-term follow-ups, objective measures of SB and the incorporation of strategies to reduce attrition.

Additional files

Additional file 1: PRISMA checklist (DOC 62 kb) Additional file 2: Search strategy (DOCX 14 kb)

Abbreviations

7-day SLIPA Log: 7-day Sedentary and Light Intensity Physical Activity Log; AMSTAR: Assessment of multiple systematic reviews; BCT: Behaviour change technique; CI: Confidence interval; Hr/day: Hours per day; IPAQ: International Physical Activity Questionnaire; MD: Mean difference; MET: Metabolic equivalent; Min/day: Minutes per day; NICE: National Institute for Health and Care Excellence; OSPAQ: Occupational Sitting and Physical Activity Questionnaire; PA: Physical activity; PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses; RCT: Randomised-controlled trial; SB: Sedentary Behaviour; WSQ: Workforce Sitting Questionnaire

Acknowledgements

We would like to thank Mary Rose Holman for her assistance with the search process and Sarah Howes for assistance with BCT coding.

Funding

AS is supported by a Vice Chancellor's Research Scholarship from Ulster University.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

AS, SMD, MM, CN and JM formulated the research question and defined the search terms. AS carried out the electronic searches and carried out the search process. AS, MM, SMD finalised study inclusion. AS carried out the risk of bias assessment with assistance from MM. AS carried out the BCT coding, data extraction and meta-analysis. All authors were involved in writing, reviewing and providing feedback on the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹Shore Rd, Newtownabbey BT37 0QB, Northern Ireland. ²Centre for Health and Rehabilitation Technologies, Institute of Nursing and Health Research, Faculty of Life and Health Sciences, Ulster University, Shore Rd, Newtownabbey BT37 0QB, Northern Ireland. ³UKCRC Centre of Excellence for Public Health (Northern Ireland), Belfast, Northern Ireland. ⁴School of Physiotherapy, University of Otago, Dunedin, New Zealand. ⁵Computer Science Research Institute, Faculty of Computing and Engineering, Ulster University, Shore Rd, Newtownabbey BT37 0QB, Northern Ireland.

Received: 23 May 2017 Accepted: 4 August 2017 Published online: 11 August 2017

References

- SBRN: Letter to the editor. Standardized use of the terms "sedentary" and "sedentary behaviours." Applied Physiology, Nutrition, and Metabolism 2012, 37:540–542.
- Same RV, Feldman DI, Shah N, Martin SS, Al Rifai M, Blaha MJ, Graham G, Ahmed HM. Relationship between sedentary behavior and cardiovascular risk. Current Cardiology Reports. 2015;18
- Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, Troiano RP. Amount of time spent in sedentary behaviors in the United States, 2003-2004. Am J Epidemiol. 2008;167:875–81.
- Healy GN, Wijndaele K, Dunstan DW, Shaw JE, Salmon J, Zimmet PZ, Owen N. Objectively measured sedentary time, physical activity, and metabolic risk: the Australian diabetes, obesity and lifestyle study (AusDiab). Diabetes Care. 2007;31:369–71.
- Hansen BH, Kolle E, Dyrstad SM, Holme I, Anderssen SA. Accelerometerdetermined physical activity in adults and older people. Med Sci Sports Exerc. 2012;44:266–72.
- Colley R, Garriguet D, Janssen I, Craig C, Clarke J, Tremblay M. Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian health measures survey. Health Rep 2011, 22.
- de Rezende LFM, Rodrigues Lopes M, Rey-López JP, VKR M, do Carmo Luiz O. Sedentary behavior and health outcomes: An overview of systematic reviews. PLoS ONE. 2014;9:e105620.
- Prince SA, Saunders TJ, Gresty K, Reid RD. A comparison of the effectiveness of physical activity and sedentary behaviour interventions in reducing sedentary time in adults: a systematic review and meta-analysis of controlled trials. Obes Rev. 2014;15:905–19.
- Martin A, Fitzsimons C, Jepson R, Saunders DH, van der Ploeg HP, Teixeira PJ, Gray CM, Mutrie N. Interventions with potential to reduce sedentary

time in adults: systematic review and meta-analysis. Br J Sports Med. 2015; 49:1056–63.

- Inyang M, Stella O. Sedentary lifestyle: health implications. J Nursing Health Sci. 2015;4:20–5.
- Broekhuizen K, Kroeze W, van Poppel MN, Oenema A, Brug J. A systematic review of randomized controlled trials on the effectiveness of computertailored physical activity and dietary behavior promotion programs: an update. Ann Behav Med. 2012;44:259–86.
- Oosterveen E, Tzelepis F, Ashton L, Hutchesson MJ. A systematic review of eHealth behavioral interventions targeting smoking, nutrition, alcohol, physical activity and/or obesity for young adults. Prev Med. 2017;
- 13. Noar SM, Black HG, Pierce LB. Efficacy of computer technology-based HIV prevention interventions: a meta-analysis. AIDS. 2009;23:107–15.
- Neve M, Morgan PJ, Jones PR, Collins CE. Effectiveness of web-based interventions in achieving weight loss and weight loss maintenance in overweight and obese adults: a systematic review with meta-analysis. Obes Rev. 2010;11:306–21.
- Free C, Phillips G, Galli L, Watson L, Felix L, Edwards P, Patel V, Haines A. The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. PLoS Med. 2013;10:e1001362.
- Whittaker R, McRobbie H, Bullen C, Rodgers A, Gu Y. Mobile phone-based interventions for smoking cessation. Cochrane Database Syst Rev. 2016;4
- Direito A, Carraça E, Rawstorn J, Whittaker R, Maddison R. MHealth technologies to influence physical activity and sedentary behaviors: behavior change techniques, systematic review and meta-analysis of randomized controlled trials. Ann Behav Med. 2016;
- Matheson GO, Klügl M, Engebretsen L, Bendiksen F, Blair SN, Börjesson M, Budgett R, Derman W, Erdener U, Ioannidis JPA, Khan KM, Martinez R, van Mechelen W, Mountjoy M, Sallis RE, Schwellnus M, Shultz R, Soligard T, Steffen K, Sundberg CJ, Weiler R, Ljungqvist. Prevention and management of non-communicable disease: the IOC consensus statement, Lausanne 2013. Sports Med 2013, 43:1075–1088.
- Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, Eccles MP, Cane J, Wood CE. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46:81–95.
- Gardner B, Smith L, Lorencatto F, Hamer M, Biddle S. How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. Health Psychol Rev. 2015:1–24.
- 21. Moher D. Preferred reporting items for systematic reviews and metaanalyses: the PRISMA statement. Ann Intern Med. 2009;151:264.
- Higgins JPT, Green S. Cochrane handbook for systematic reviews of interventions. United States. John Wiley & Sons: New York, NY; 2011.
- Shrestha N, Kukkonen-Harjula K, Verbeek J, Ijaz S, Hermans V. Bhaumik S. Cochrane Database of Systematic Reviews: Workplace interventions for reducing sitting at work; 2016.
- 24. Evans R, Fawole H, Sheriff S, Dall P, Grant P, Ryan C. Point-of-choice prompts to reduce sitting time at work. Am J Prev Med. 2012;43:293–7.
- Maher J, Conroy D. Habit strength moderates the effects of daily action planning prompts on physical activity but not sedentary behavior. J Sport Exercise Psychology. 2015;37:97–107.
- Dutta N, Koepp G, Stovitz S, Levine J, Pereira M. Using sit-stand workstations to decrease sedentary time in office workers: a randomized crossover trial. Int J Environ Res Public Health. 2014;11:6653–65.
- Donath L, Faude O, Schefer Y, Roth R, Zahner L. Repetitive daily point of choice prompts and occupational sit-stand transfers, concentration and neuromuscular performance in office workers: an RCT. Int J Environ Res Public Health. 2015;12:4340–53.
- Urda J, Lynn J, Gorman A, Larouere B. Effects of a minimal workplace intervention to reduce sedentary behaviors and improve perceived wellness in middle-aged women office workers. J Phys Act Health. 2016;13:838–44.
- Ashe M, Winters M, Hoppmann C, Dawes M, Gardiner P, Giangregorio L, Madden K, McAllister M, Wong G, Puyat J, Singer J, Sims-Gould J, McKay H. "not just another walking program": everyday activity supports you (EASY) model—a randomized pilot study for a parallel randomized controlled trial. Pilot sFeasibility Studies. 2015;1
- 30. Biddle S, Edwardson C, Wilmot E, Yates T, Gorely T, Bodicoat D, Ashra N, Khunti K, Nimmo M, Davies M. A randomised controlled trial to reduce

sedentary time in young adults at risk of type 2 diabetes mellitus: project STAND (sedentary time ANd diabetes). PLoS One. 2015;10:e0143398.

- Laska M, Lytle L, Nanney M, Moe S, Linde J, Hannan P. Results of a 2-year randomized, controlled obesity prevention trial: effects on diet, activity and sleep behaviors in an at-risk young adult population. Prev Med. 2016;89:230–6.
- Júdice P, Hamilton M, Sardinha L, Silva A. Randomized controlled pilot of an intervention to reduce and break-up overweight/obese adults' overall sitting-time. Trials. 2015;16
- Carr L, Karvinen K, Peavler M, Smith R, Cangelosi K. Multicomponent intervention to reduce daily sedentary time: a randomised controlled trial. BMJ Open. 2013;3:e003261.
- Mainsbridge C, Cooley P, Fraser S, Pedersen S. The effect of an e-health intervention designed to reduce prolonged occupational sitting on mean arterial pressure. J Occup Environ Med. 2014;56:1189–94.
- Pedersen S, Cooley P, Mainsbridge C. An e-health intervention designed to increase workday energy expenditure by reducing prolonged occupational sitting habits. Work. 2014;49:289–95.
- Danquah I, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll A, Tolstrup J. Take a Stand!-a multi-component intervention aimed at reducing sitting time among office workers-a cluster randomized trial. Intern J Epidemiol. 2016:dyw009.
- De Cocker K, De Bourdeaudhuij I, Cardon G, Vandelanotte C. The effectiveness of a web-based computer-tailored intervention on workplace sitting: a randomized controlled trial. J Med Internet Res. 2016;18:e96.
- Barwais F, Cuddihy T, Tomson L. Physical activity, sedentary behavior and total wellness changes among sedentary adults: a 4-week randomized controlled trial. Health Qual Life Outcomes. 2013;11:183.
- Schuna J, Swift D, Hendrick C, Duet M, Johnson W, Martin C, Church T, Tudor-Locke C. Evaluation of a workplace treadmill desk intervention. J Occup Environ Med. 2014;56:1266–76.
- van Berkel J, Boot C, Proper K, Bongers P, van der Beek A. Effectiveness of a worksite mindfulness-based multi-component intervention on lifestyle behaviors. Int J Behav Nutr Phys Act. 2014;11:9.
- Burnan M, Winkler E, Kurka J, Hekler E, Baldwin C, Owen N, et al. Reallocating time to sleep, sedentary behaviors, or active behaviors: associations with cardiovascular disease risk biomarkers, NHANES 2005-2006. Am J Epidemiol. 2013;179(3):323–34.
- Chu A, Ng S, Tan C, Win A, Koh D, Müller-Riemenschneider F. A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. Obes Rev. 2016;17:467–81.
- Neuhaus M, Eakin E, Straker L, Owen N, Dunstan D, Reid N, Healy G. Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations. Obes Rev. 2014;15:822–38.
- Lyons E, Lewis Z, Mayrsohn B, Rowland J. Behavior change techniques implemented in electronic lifestyle activity monitors: a systematic content analysis. J Med Internet Res. 2014;16:e192.
- 45. Thomas J, Bond D. Review of innovations in digital health technology to promote weight control. Current Diab Reports. 2014;14
- Chau J, der Ploeg H, van Uffelen J, Wong J, Riphagen I, Healy G, Gilson N, Dunstan D, Bauman A, Owen N, Brown W. Are workplace interventions to reduce sitting effective? A systematic review. Prev Med. 2010;51:352–6.
- Schoeppe S, Alley S, Van Lippevelde W, Bray N, Williams S, Duncan M, Vandelanotte C. Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: a systematic review. Int J Behav Nutr Phys Act. 2016;13
- Yardley L, Spring B, Riper H, Morrison L, Crane D, Curtis K, Merchant G, Naughton F, Blandford A. Understanding and promoting effective engagement with digital behavior change interventions. Am J Prev Med. 2016;51:833–42.
- 49. Eysenbach G. The law of attrition. J Med Internet Res. 2005;7:e11.
- Commissaris D, Huysmans M, Mathiassen S, Srinivasan D, Koppes L, Hendriksen I. Interventions to reduce sedentary behavior and increase physical activity during productive work: a systematic review. Environment & Health: Scandinavian Journal of Work; 2015.
- Shephard R, Tudor-Locke C. The objective monitoring of physical activity: contributions of Accelerometry to epidemiology, exercise science and rehabilitation. 1st ed. Switzerland: Springer; 2016. p. 192.
- Atkin A, Gorely T, Clemes S, Yates T, Edwardson C, Brage S, Salmon J, Marshall S, Biddle S. Methods of measurement in epidemiology: sedentary behaviour. Int J Epidemiol. 2012;41(5):1460–147.
- 53. Presseau J, Ivers N, Newham J, Knittle K, Danko K, Grimshaw J. Using a behaviour change techniques taxonomy to identify active ingredients

within trials of implementation interventions for diabetes care. Implement Sci. 2015;10

- Soltani H, Arden M, Duxbury A, Fair F. An analysis of behaviour change techniques used in a sample of gestational weight management trials. J Pregnancy. 2016;2016:1–15.
- NICE, Behaviour change: individual approaches | Guidance and guidelines | NICE [https://www.nice.org.uk/guidance/ph49/resources/behaviour-changeindividual-approaches-pdf-1996366337989].
- Michie S, Atkins L, West R. The behaviour change wheel. 1st ed. London: Silverback Publishing; 2014.
- Agarwal S, LeFevre A, Lee J, L'Engle K, Mehl G, Sinha C, Labrique A. Guidelines for reporting of health interventions using mobile phones: mobile health (mHealth) evidence reporting and assessment (mERA) checklist. BMJ 2016; i1174.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at www.biomedcentral.com/submit

