We thank the reviewers for their detailed and thoughtful feedback, which has considerably strengthened this manuscript. The revised manuscript addresses all reviewer comments, as described in an itemized, point-by-point response (*in italics as to differentiate our responses*) to the original comments below.

Reviewer #1

Major comments:

1. Overall the authors provided a thorough review of the included interventions, but I would recommend an added narrative description of the setting/mode of the interventions. I recognize that there is a great deal of variability, but as currently written, the reader would not have a good understanding of the overall design and delivery methods of these interventions. This is important because "non-worksite interventions" is quite vague/broad, so some clear description of what these types of interventions entail will provide important context for readers. Were any targeting specific sedentary behaviors (e.g., TV watching) or specific settings (other than work), or were they more generally designed to reduce overall sitting throughout the day? Did participants meet for face-to-face workshops or receive information through some other means (print materials, website, etc.)?

The authors thank the reviewer for this comment. We agree that clarification may help to provide the reader with better understanding of our target intervention, as well as to provide important context as to intervention tools utilized by researchers. To that end, we have added text to the "Intervention Location" subheading in the methods to better describe our target intervention ("non-worksite interventions"). Further, in the results section, we go on to describe in more detail some of the specifics utilized by researchers in regards to technology applications, specific targets, and location information.

2. In reporting the efficacy/effectiveness outcomes, it would be helpful to include some data that reflect the magnitude of the effects if possible. Since sitting time seems to be the most commonly measured outcome across studies, can the authors present the range of effects in terms of minutes or percent reduction? Similarly, a range of effects could be reported for breaks in prolonged sitting. This would allow readers to better gauge and interpret the effectiveness of these interventions.

The authors thank the reviewer for this excellent consideration. We have included text in both the results and in the discussion that references the range of intervention effects by percent reduction in daily sedentary time and by reduction in minutes per day. We agree that this information will be of interest to readers and strengthens the paper.

Minor comments:

Abstract, line 5: Change "are not limited" to "is not limited"

Changed per request.

Line 43, inclusion criteria: Were any dissertations or theses included?

As the scope of this paper was to review the peer-reviewed literature, we did not include any theses or dissertations. We added a line in the text in the eligibility criteria for clarification.

Line 47: Change spelling to PsycINFO

Changed per request.

Line 115: What was the % cutoff to be considered "a majority"? >50%?

Information regarding how we defined a majority was added to line 115 per request.

Line 154: Consider using a word/descriptor in place of or in addition to "haptic," as this word may not be widely understood.

Clarification was added to the text per request.

Line 189: Consider changing "of" to "on" or "for"

Changed to "for" per request.

Line 210: Consider changing "as others" to "than others"

Changed per request.

Line 220: Change to "these data"

Changed per request.

Line 223: Does "small enough" pertain to classification as a pilot study?

Information was added to clarify how and why studies were classified as pilot studies.

Line 248: Considering changing "in" to "with"

Changed per request.

Line 249: Specify the number of studies that used an intent-to-treat analysis

Completed per request.

Line 261: A word like maintain seems more appropriate than adopt, which generally refers to the initial uptake of the behavior

We agree with this assertion and have changed this per your request.

Lines 268-9: Is the goal to make dose equal across studies, or to explicitly compare varying doses using experimental designs to replicate observational findings? It seems like the beginning of the paragraph suggests the latter.

Upon review, we agree with the reviewer that this is not initially clear. Text has been added to this paragraph to clarify the intent.

Lines 275-6: It is not immediately clear what the difference is between recommending reduced sitting vs. increased standing. Consider rephrasing - is this a matter of reducing duration of sitting vs. increasing frequency of breaks?

We appreciate this clarification. Our intention was to juxtapose considering the reduction of total time sitting with increasing standing breaks and have clarified this in the manuscript.

The authors might also consider adding that different intervention approaches (e.g., technology-based) may be better received by younger participants compared to their older counterparts.

We thank the reviewer for this excellent point. We have included text to reflect this.

Line 277: Consider replacing "couple" with "tailor" or similar word

Changed per request.

The tables are well organized and provide useful information. However, it would be helpful to include the reference number next to the author's name. This would allow for easier comparison with the text, since the studies are referenced by number in the narrative description of results.

We thank the reviewer for this observation. We agree that this would be helpful and have included these reference numbers per request.

Reviewer #2

Major comments:

Study eligibility criteria

1. Lines 36-43: The authors did not indicate whether an a priori review protocol was available and so it was unclear whether the eligibility criteria were pre-defined or changed post-hoc to yield more publishable results.

This point was clarified per request.

2. Line 36: Study population - additional details on the definition of 'clinical population' (acute vs chronic disease, under treatment or stable condition) and the rationale for including 'clinical populations' is needed. Comparing intervention effects in, for example stroke survivors, evidently will be difficult to compare to intervention effects in healthy young adults.

We agree with and thank the reviewer for this point. We have clarified "clinical populations" per request.

3. Lines 41-42: The outcome criteria are very ambiguous. The authors should specify the matrix and type of the sedentary behaviour outcomes that were eligible for inclusion (e.g. time spent

sitting, time spent in activities <1.5 METs, % of people breaking sitting bouts every 30 min, proxy measures like TV viewing, etc.) and provide examples of feasibility outcomes. Were both within and between group changes eligible efficacy outcomes?

We thank the reviewer for this comment and agree that the initial criteria were ambiguous. The section specific to outcomes has been updated to specify criteria for inclusion. Further, we added examples of feasibility outcomes to the outcomes section per request.

4. Line 43: The authors should provide a rationale why they restricted the eligibility to (published/peer-reviewed?) full-text articles written in English language.

Per other systematic reviews regarding physical activity and/or sedentary behavior interventions, including many of the reviews referenced in our paper (Martin et al, 2015, Gardner et al 2015, Prince et al, 2014), that delineated their searches based on language, we decided to only review peer-reviewed literature in English. This designation has been clarified in the text (eligibility criteria).

5. The authors did not specify the comparison or control condition or the study design eligible to be included in the review. If there was no restriction, the authors should state this and take their choice into consideration when it comes to comparing the between-group effect sizes.

Due to the limited number of studies, we did not limit based on study design. Per request, we have now explicitly stated this in the text.

Study identification and selection

1. Figure 1: The PRISMA diagram indicates that 543 studies were excluded before screening of abstracts. Judging the eligibility of a study sorely on the title introduces a high risk of missing eligible studies.

We thank the reviewer for this comment and, while we agree that there may be a risk of studies incorrectly being determined to be ineligible, we assure the reviewer that we were quite conservative with respect to checking the abstract for any situation where the title looked even remotely ambiguous. As noted in Figure 1, titles that contained words or phrases surrounding the terms "physical activity interventions, youth, workplace", etc., those not written in English, or were definitively not an intervention (review papers, titles using the descriptor "cross-sectional,"etc.) were excluded. All other studies moved to the next stage (abstract review) in determining eligibility.

2. Lines 57-58: It is unclear if the full-text articles were screened independently and in duplicate by 2 reviewers. Please add this detail.

Clarification was added to the text per request.

Quality assessment:

1. Lines 75-85: It is unclear to me why the authors have chosen a quality appraisal tool that is only suitable for RCTs if there was no restrictions of eligible studies to RCTs only. The authors decided not to assess the quality of the included quasi-experimental studies despite including those studies in the evidence synthesis. How can the authors judge the validity of the findings of both RCTs and non-RCTs without quality appraisal of all included studies? The authors should assess the quality of all included studies and put the quality rating in relation to the intervention effects.

We appreciate this comment and have added text to the manuscript explaining our rationale. As other systematic reviews evaluating sedentary behavior and physical activity interventions commonly utilized the Delphi criteria, we felt that being consistent with previous reviews would help our readers put our findings in proper context. However, while including non-randomized trials was justifiable in this particular analysis, we didn't feel that the Delphi criteria properly captured these methodological approaches. As such, we expanded this subsection of the results to better asses non-randomize trials.

Data synthesis:

1. It was appropriate that the authors assessed the suitability of a meta-analysis. However, the presented rationale is rather poor and was not supported with a reference to the literature. Rightly, the authors decided not to include pilot trials in the meta-analysis of effect sizes. However, the authors stated "the majority of studies were small pilot trials" which suggests that not all included studies were pilot trials. The authors should assess the level of heterogeneity between non-pilot trials and so determine whether studies are suitable for being combined in a meta-analysis or not.

We appreciate this comment and would have liked to be able to conduct a meta-analysis. However our decision was informed by the PRISMA Statement (Moher 2010) and the Cochrane Handbook for systematic reviews (link below), "Meta-analysis should not be conducted when there are different comparisons being made or different outcomes being assessed or when there is significant risk of bias." As there is broad clinical diversity among the participants, methodological diversity among the study designs, and statistical heterogeneity among the studies, we feel that a systematic review without a meta-analysis is the most appropriate type of summary for this analysis. We have revised the manuscript to better explain the rationale for not using meta-analysis.

(http://handbook.cochrane.org/chapter_9/9_1_4_when_not_to_use_meta_analysis_in_a_review.htm)

2. From line 87: The narrative data synthesis approach shows strength in several aspects in terms of the type of data synthesised but it appears to be incomplete. The review's focus is on non-worksite intervention effects and so it would be important to report the intervention effects on non-work/leisure time and weekend sedentary behaviour. Considering the wide range of

population age, comparing intervention approaches and outcomes between age groups would provide important insight.

While we agree that further analysis of non-work, leisure time, and weekend sedentary behavior would be informative and interesting, the vast majority of studies reviewed do not provide this level of detail regarding the outcome data. While our review focuses on non-worksite interventions, it is important to note that these interventions can still encompass sedentary time reduction at the workplace within the confines of the study, just that they are not specifically designed to limit sedentary time at the workplace, but throughout daily living.

3. Table 3: The authors were cautious not to combined effect sizes of pilot trials but then report effect sizes including the level of significance of all studies. Since pilot trials are not intended to determine efficacy or effectiveness as they are not fully powered, the authors should only report mean differences and confidence intervals without reference to the significance level. Please report the unit of the sedentary measure (e.g. minutes/day, hours/week, etc)

The authors appreciate this distinction in the appropriate reporting of powered trials and pilot studies. Table 3 has been revised to include significance indications only for sufficiently powered trials (Otten, Gardiner, Aadahl, Bond, Biddle, Kendzor, Lewis). Units of measure have been indicated for each of the outcome changes and, in response to Reviewer #1, the range of changes in regards to both A) % reduction in daily sedentary time and B) reduction in daily minutes of sedentary time are now reported in the Methods and referenced in the Discussion.

4. Abstract, Line 178, Line 189: The reference to "significant reduction" in objectively measured sitting time should be restricted to fully powered trials only. Please be precise how many studies really support this conclusion.

Text was added per the request of the reviewer to clarify that only five trials were considered appropriately powered with regard to significance.

5. Line 151: In my opinion, extracting information about the use of technology as tool for behaviour change is the major strength of the paper as this has not been focused on in previous reviews on this topic. The authors could expand this section and report what the smartphone and PC-based application looked like and which behaviour change techniques were applied.

We very much appreciate this perspective from the reviewer. We agree that there is the potential of much information to be gained by discussing the actual technological components of these interventions. As such, we have expanded this section to greater degree outlining the technology being utilized.

6. Line 152-154: The authors should be more precise when reporting the feedback mechanisms of activity monitors. The information stated are misleading and partially incorrect. Neither of the reported devices has a display that can allow real-time behaviour tracking. If the devices are linked to a smartphone app, the authors should report this (potentially possible with the Shimmer?). Similarly, it might be that the study participants had access to a software to download the data collected by the devices to obtain feedback (real-time is unlikely) and self-monitor their behaviour or this information was provided by the interventionist. This detail

should be made clear in the description of the intervention. As for the haptic feedback, all three devices - activPAL, Gruve and Shimmer - provide this function.

We thank the reviewer for bringing this oversite to our attention. We corrected our terminology in the text in order to appropriately represent the intervention.

Discussion:

1. The authors should include a section about the limitation of the review and put the findings in relation to the limitations.

We thank the reviewer for this suggestion and have added a paragraph at the end of the discussion section describing the limitations of the study.

2. Lines 211-217: Please revise the statements to avoid misleading conclusions. As mentioned under point 6 above, none of the activity trackers itself had a self-monitoring function unless the authors interpret prompts in form of a haptic feedback as self-monitoring. Inconsistency in the taxonomy of behaviour change techniques would introduce even more confusion.

We very much appreciate the reviewers concern in this matter. We agree that further confusion regarding the taxonomy of behavior change techniques could be detrimental. As the authors view haptic feedback as precipitating self-monitoring, in that it is alerting the user as to their accumulated time spent sedentary in the expectation that they alter their behavior, we did change the language used to clarify its use as a monitoring tool.

3. Lines 220-222: Rightly, the authors acknowledge the challenge of comparing intervention effects of different study designs. However, the conclusions do not consider the quality of the primary studies. The authors could include a sensitivity analysis, whereby only the findings of fully powered RCTs are synthesised, to determine the robustness of the review findings.

As discussed above, we did not conduct a meta-analysis as the literature did not support that type of summary. Note that there were just seven fully powered RCTs, each with a different intervention and various reported outcomes, further supporting our decision to not perform this type of analysis. Further, a sensitivity analysis would be inappropriate here as we are not working from a single quantitative outcome but are instead summarizing the information along a variety of outcomes. Still, as discussed in previous comments by the reviewer with regards to significance of under-powered trials, we have included in the text information to alert the reader as to the number of trials that were fully powered. The reviewer should note, however, that of the seven adequately powered trials, five reported significant findings, which is similar to the ratio found of thirteen total trials, ten of which reported significant findings, indicating similarity in the results across pilot and fully powered trials.

Minor comments:

1. Lines 11-13: The list of currently available systematic reviews on the effect of interventions to reduce sedentary behaviour is incomplete. The authors should add the following reference:

Martin, Anne, Claire Fitzsimons, Ruth Jepson, David H. Saunders, Hidde P. van der Ploeg, Pedro J. Teixeira, Cindy M. Gray, and Nanette Mutrie. "Interventions with potential to reduce sedentary time in adults: systematic review and meta-analysis." British journal of sports medicine (2015): bjsports-2014. http://bjsm.bmj.com/content/early/2015/04/23/bjsports-2014-094524.short

This reference has been added per request of the reviewer.

2. Abstract and Line 97: based on the PRISMA flow diagram, the authors screened 61 full-text articles. However, in the text the authors state that they reviewed 767 full-text articles. From the PRISMA diagram it is not clear what the number 767 refers to. Where perhaps 767 titles screened?

Clarification was added to both the text and Figure 1 (PRISMA flow diagram) per request.

3. Line 47: typo - should be changed to PsycINFO

Corrected.

4. Line 47: "Search filters" usually refer to publication date, language or publication type applied after the full search syntax made of subject headings and free-text terms was designed. When describing the search terms used for the electronic database search, the authors should refer to "Search strategy" or "Search terms".

Terminology has been changed per request.

5. Line 57: Please indicate if the title and abstracts were screened independently and in duplicate by two reviewers.

Clarified per request.

6. Line 76: The first sentence indicates the finding of the literature search and thus should be moved to the result section.

The first sentence has been changed per request such that it still provides insight into our analytic approach without indicating direct findings of our literature review.

7. Line 147: Please replace "count" with "quality assessment".

Replaced per request.

8. Line 149: Motivational interviewing can comprise a number of behaviour change techniques (BCTs). The sentence suggests that motivational interviewing is a BCT in itself.

Clarified per request.

9. Lines 147-151: Revision required. The authors mention three BCTs (motivational interviewing, goal-setting, prompts) but then refer to "a combination of the two".

Revised per request.

10. Line 162: Did the authors check subsequent papers or contacted the authors to obtain information about the feasibility outcomes?

The intention of this review is to summarize the peer-reviewed published literature. As such, we chose not to contact authors to provide additional non-published information. While we realize that author contact after publication is not uncommon, as suggested in Mullen et al, 2009 (Mullan RJ, Flynn DN, Carlberg B, et al., systematic reviewers commonly contact study authors but do so with limited rigor. J Clin Epidemiol 2009;62:138–42.), and this practice is not a universal feature of reviews in top journals or the Cochrane Library. Further, in those who have done it, there is not a standardized in approach in conduct or reporting. While we realize that it is possible that authors may have information regarding feasibility of their interventions that they did not choose to publish, this review aims to provide a summary of reported outcomes and intentionally includes only that information that has been published.

Manuscript

Non-worksite interventions to reduce sedentary behavior among adults: A systematic review

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Abstract

Purpose Sedentary behavior has been identified as a major health risk. While interventions to reduce time spent sedentary have become increasingly prevalent, the vast majority of this work in adults has been focused on workplace sedentary behavior, and often pairs sedentary reduction interventions with increasing physical activity. As research designed to specifically decrease sedentary time that is not limited to the workplace becomes available, identifying strategies and approaches, along with feasibility and efficacy of these interventions, is warranted.

Methods Electronic databases were searched for sedentary interventions with eligibility criteria including: (a) interventions designed to explicitly reduce sedentary behavior that were not limited to the workplace, (b) outcomes specific to sedentary behavior, (c) adults aged at least 18 years, and (d) written in English.

Results A total of 767 full-text manuscripts were identified, with thirteen studies meeting all eligibility criteria. While intervention characteristics and methodological quality varied greatly among studies, ten of the thirteen studies observed a significant reduction in objectively measured sitting time post-intervention. In those studies that collected participant feasibility/acceptability data, all reported that the intervention was viewed as "favorable to very favorable," would use again, and that participant burden was quite low, suggesting that these interventions were feasible.

Conclusion Sedentary behavior interventions not limited to the workplace appear to be largely efficacious. While results varied with respect to the magnitude of the decrease in time spent sedentary, they are encouraging. However, due to the small body of evidence and the variability of study designs, our ability to make overarching statements regarding "best practices" at this

time is limited. Well-controlled trials of longer duration with larger samples, using theoretically-based interventions with consistent prescriptions for limiting sedentary time are needed.

Keywords: sitting; health promotion; adults; behavior change

Sedentary behavior, defined as waking activities performed while sitting or reclining that do not substantially increase energy expenditure above resting (6), has gained increased attention in the research community as an important predictor of health outcomes. Prolonged time spent sedentary is associated with an increased risk of obesity, metabolic syndrome, type II diabetes, cancer, depression and anxiety disorders, and all-cause mortality (27-29). Further, there is evidence that the health consequences of accumulating large amounts of sedentary time may be independent of the risks associated with inadequate physical activity (8) and the benefits of achieving physical activity recommendations (24). As such, interventions specifically targeted at decreasing sedentary time are warranted.

Sedentary interventions conducted to date in adults have utilized a variety of approaches and techniques with varying levels of success in their feasibility and effectiveness, as documented in previous review papers (7, 13, 19, 25, 26). These reviews have addressed contexts including (a) worksite interventions specifically targeting sedentary time, (b) non-worksite interventions addressing physical activity and sedentary time, and (c) non-worksite interventions that addressed physical activity but also measured sedentary behavior as a secondary outcome. Given that adults spend much of their leisure time in sedentary pursuits (20), non-worksite interventions are of substantial public health importance. This is particularly true given that sedentary time increases as people age and retire from the workforce (20). Thus, information is needed regarding best practices specific to limiting sedentary time across domains. Further, reviews by both Gardner et al. (13) and Prince et al. (25) suggest that interventions focusing solely on sedentary time may be more efficacious for reducing sitting compared to those that target both physical activity and sedentary behavior. Until quite recently, however, few of these

interventions had been published outside of the context of worksites. As such, this review focuses on interventions specifically designed to decrease sedentary time that are not limited to the workplace. The purpose of this review is to discuss the characteristics, strategies, and approaches of existing sedentary interventions as well as the associated feasibility, acceptability, and efficacy of these interventions.

Methods

Study Selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (21) statement guided this systematic review. Studies were eligible for inclusion if they met the specific a priori criteria related to study population, design, intervention, and outcomes as detailed below.

Study Population: Adults over the age of 18. As this was the only eligibility criteria designated for inclusion, both "healthy" populations and populations with defined comorbidities (specifically, those identified as overweight, obese, and/or diagnosed with diabetes) were included in this review.

Interventions: Interventions designed to explicitly reduce sedentary behavior; those attempting to reduce time spent sedentary by increasing physical activity, solely or in conjunction with limiting sedentary time were excluded.

Intervention location: Interventions that were not specifically designed to limit sedentary time in the workplace were included. Of note, interventions could still incorporate strategies to limit occupational sedentary behavior, but those could not be the focus of the intervention. Rather,

interventions included here were specifically designed to limit sedentary time throughout the day, regardless of the setting.

Outcomes: All interventions that measured sedentary behavior as an outcome (primary or secondary) were included. As such, sedentary behavior could be quantified in a number of ways, including (but not limited to): total time (minutes) spent in sedentary activities (metabolic equivalents, [or METs] ≤ 1.5), number of breaks interrupting prolonged sitting time (typically defined as $\geq$30 minutes), sedentary time accrued in prolonged bouts (typically defined as $\geq$30 minutes), sit-to-stand transitions, and percentage of daily waking hours spent sedentary. Assessment of sedentary behavior could be either self-reported or objectively measured. Feasibility (including enrollment, retention, reach, acceptability, participant satisfaction, and preference of the intervention,) efficacy, and effectiveness outcomes were all included.

Study Design: There were no restrictions specifically placed on study design. All methodological approaches were included as long as all other eligibility criteria were met.

Other Inclusion Criteria: Studies had to be be peer-reviewed, full-text articles and written in English.

Data Sources and Search Criteria

An electronic search was performed using the following databases: PubMed, Web of Science, Google Scholar, PsycINFO, and SPORTDiscus. The search strategy applied to these databases included "adult", "intervention" studies (pre-post, quasi-experimental or randomized designs) to "reduce sedentary behavior", "sedentary lifestyle", or "sitting time", and "health behavior." No date limits were set. Complete search terms used for each database are provided in the Supplemental Material. Reference lists of recent sedentary behavior reviews and relevant studies

were also individually cross-referenced by research staff to identify studies that may have been missed by the electronic searches (7, 13, 25).

Study Selection

Two reviewers independently screened all titles and abstracts for initial inclusion. After this initial review, full text of all articles determined to be eligible were screened for inclusion. An additional independent reviewer was consulted with any eligibility disagreements.

Data Extraction

Using the PRISMA checklist as a reference (21), data from the following categories were extracted:

General: Author, date

Study Population: Number of participants, baseline demographic characteristics (i.e., age, gender, health status)

Intervention: Characteristics of intervention including: setting, length, mode of intervention, mention of specific behavioral theory, technological component of intervention

Study Design & Analyses: Treatment allocation, specified eligibility criteria, if intention-to-treat analyses were used

Outcome measures: Primary outcomes, secondary outcomes, if point estimates and measures of variability were presented, feasibility, acceptability, measurement of sedentary behavior (objective vs. self-report)

Data Synthesis and Quality Assessment

The studies included in this analysis were quite diverse in regards to their methodological and analytical approaches, study design, population, and intervention characteristics. In keeping with recommendations by the PRISMA statement (21), we concluded that meta-analysis was not appropriate. Rather, we addressed the methodological merit of these works using two separate strategies. First, we used a quality rating adapted from the Delphi list (as described in Table 3 of Verhagen et al. (30)) to quantitatively analyze the randomized controlled trials in our study, as this metric has been used in previous sedentary behavior intervention reviews (7, 13). Briefly, the Delphi list consists of a series of criteria specific to the design of a study as it relates to the external and internal validity, validity of the outcome, and of the statistical model used (30). Criteria were given a score based on answers to the associated questions ("yes"=1, "no" or "don't know" (insufficient information present) =0). A total quality score ranging from 0-7 was then generated for each study. A second reviewer independently scored each study. In instances where consensus was not met between reviewers, a third reviewer was consulted. Second, as the Delphi criteria were designed to specifically evaluate the methodological quality of randomized controlled trials, questions on the metric were not always applicable to the other study designs included in this review. Therefore, we describe the merit of non-randomized trials in the context of, and relation to, randomized controlled trials.

Interventions were also assessed based on characteristics likely to be important in changing behavior, including the use of behavioral theory in designing the intervention, as well as the total duration of the intervention. Additionally, we also assessed the use of objective measures of sedentary time, as well as integration of a technological component to the intervention. Finally,

data regarding efficacy and effectiveness for reducing sedentary time, along with feasibility and acceptability data, were discussed when available.

Results

Study Characteristics & Design

The results of our literature search using a PRISMA-style flow diagram (21) can be found in Figure 1. A total of 767 full-text manuscripts were initially identified for eligibility assessment. After removing duplicate studies (n=1) and excluding studies from the analysis which: were in non-adult populations (n=151), were not interventions (n=207), specifically targeted physical activity (n=329), were workplace-based interventions (n=38), did not incorporate a measure of sedentary behavior (n=26), or were not written in English (n=2), thirteen studies met all eligibility criteria and were included in this review. Full study characteristics for these interventions are detailed in Table 1. Of the thirteen studies, seven were randomized controlled trials (1, 3, 9, 14, 16, 17, 22), five utilized a single-sample 'pre-post' design (4, 10, 11, 18, 23), and one used a quasi-experimental (non-randomized) design consisting of a post hoc addition to a larger observational study (15).

Samples

Sample sizes ranged from n=9 (23) to n=819 (17). Although only adults were included, some studies focused specifically on either younger (18-40 years) (3, 9) or older adults (≥60 years) (10, 11, 18); therefore, mean age ranged greatly between studies (mean ages: 20.1 years to 74.3 years). Further, five studies focused specifically on healthy adults (1, 9-11, 15), four on overweight and obese adults (BMI ≥25 kg/m^2) (3, 4, 14, 22), and two on adults with either

diabetes (23) or risk factors for diabetes (3). All studies included both males and females, although eight of the included 13 interventions had a majority (>50%) of female participants (1, 3, 4, 11, 15, 16, 18, 22, 23).

Methodological Quality Assessment for Randomized Controlled Trials

Strong inter-rater agreement (94%) was observed. Study characteristics for the randomized controlled trials (n=7) as they relate to the Delphi scale can be found in Table 2. While no trial received a score of 7 out of 7, four received a score of 6 out of 7 (1, 3, 16, 22), two scored a 4 out of 7 (9, 14), and one received a score of 2 out of 7 (17).

Methodological Quality Assessment for non- Randomized Controlled Trials

In regards to the non-randomized controlled trials reviewed in this analysis (n=6) (4, 10, 11, 15, 18, 23), it should be noted that these studies should be considered to have lower methodological quality to that of the randomized controlled trials. Specifically, we note that potential biases are likely to be greater for these studies when compared with the randomized trials, regardless of the latter's score on the Delphi scale as described above. However, with regards to specific Delphi criteria, we did observe that all six studies had defined and specified eligibility criteria, had systematically collected outcome data and provided appropriate point estimates and validity measures for primary outcomes, with five (4, 10, 11, 18, 23) utilizing study designs that were prospective in nature.

Intervention Characteristics and Quality

All interventions included were intended to decrease time spent sedentary, whether discussed as a primary (n=12) or secondary outcome (n=1) (22). Of these, nine studies (1, 3, 4, 9, 10, 14, 16, 18, 23) also specifically incorporated adding breaks in prolonged sitting time with sit-to-stand transitions. However, the prescription/goals for sedentary time reduction, as well as the number of breaks in sedentary time, differed between studies. The majority of studies (n=8) did not utilize specific goals regarding time spent sedentary or number of breaks. Of the studies that did specifically give participants explicit time targets, they varied from reducing TV viewing time by 50% (22), interrupting sitting time every 20 (23), 30 (1, 4) , or 60-120 minutes (4), accumulating 30 additional sit-to-stand transitions per day (16), to two (16) or three hours (14) of total daily sedentary reduction. The duration of these interventions also varied greatly among studies, ranging from one study utilizing a one-time, one hour session (17), four studies with interventions lasting one week (11, 14, 15, 18), and one study lasting 12 months (3).

With respect to the theoretical makeup of these interventions, six of the thirteen studies explicitly incorporated a behavioral theory into the design of the intervention (1, 9-11, 16, 18). While other studies appeared to be theoretically driven, there was no specific mention of use of behavioral theories. Thus, we chose not to make assumptions that these interventions were based on a particular theory and were therefore not included in our quality assessment. Six of the studies reviewed utilized a technological component as the basis of their intervention (3, 4, 14, 15, 22, 23), three (1, 17, 18) utilized behavior change techniques such as goal setting/education and point-of-decision-prompt, whereas four studies (9-11, 16) utilized both of these constructs. Those utilizing technology typically used a smartphone or PC-based application (4, 14-16, 23), while three studies used wearable technology designed to provide notification in the form of haptic

feedback (alerting through vibration) (3, 9, 23) when subject had been sedentary for a prolonged, uninterupted time period (typically ≥30 minutes). Studies utilizing smartphone or PC-based technology differed by application, though all were designed to alert the participant in some fashion to prolonged time sedentary. Two studies made use of texting technology (15, 16), both in the form of daily text messages of support. Kendzor, et al. (15) tailored this message based on the amount of time sitting the previous day. One study implored the use of smartphone timers to alert participants that it was time for a break in sedentary time (16), while two others designed smartphone applications specific to their intervention (23, 4). Pellegrini et al (23) developed the *NEAT!* application which, when paired with the Shimmer accelerometer, delivered an audible or vibratory alert after 20 minutes of uninterrupted sedentary time. Bond et al (4) also developed an application (BMobile) that delivered activity prompts paired to the smartphone's onboard accelerometer. One study using a PC application (14) provided hourly alerts to break-up their sitting time. This prompt encouraged participants to stand or walk for seven minutes every hour. If this prompt was ignored or postponed, after an additional five minutes, the computer screen would "lock" for seven minutes. Finally, one study (22) used a device that would electronically "lock out" the television after a certain amount of time spent watching. With regards to sedentary time, twelve of the studies employed an objective measure of sedentary time (see Table 1 for devices used) and one study used direct observation (17).

Feasibility & Acceptability of Intervention

Five of the thirteen studies specifically reported on the feasibility or acceptability of the intervention (Table 3) (4, 11, 16, 18, 23). One additional study referred to itself as a feasibility study (10), but did not describe findings regarding feasibility. In most studies, feasibility was

typically measured objectively through enrollment, adherence, attendance, and retention, as well as through questionnaires or interviews regarding participant satisfaction, and/or acceptability. Due to the frequent use of enrollment, adherence, and retention rates as feasibility outcomes, we also included studies in the following results that provided information allowing us to calculate these rates, but did not specifically discuss them as "feasibility outcomes." Enrollment varied greatly among studies, ranging from 29% enrollment of those initially contacted (23), through 97% of those contacted (18), with one study not providing this information (10). Conversely, reported retention rates were generally high among studies (86%-100%). In those studies that collected participant satisfaction/acceptability, all reported scores that suggest that participation in the intervention was viewed as "favorable to very favorable", would use again, and that participant burden was quite low. Of those studies that specifically included and discussed feasibility data, all suggested that the interventions were feasible.

Efficacy/Effectiveness of Intervention

Data regarding the efficacy or effectiveness of the intervention to reduce time spent sedentary are presented in Table 3. Ten of the thirteen studies indicated a significant reduction in objectively measured sitting time post-intervention (4, 10, 11, 14-18, 22, 23) though in one study (23), this finding was attenuated when including outliers. With regards to significance, it should be noted that only five studies were appropriately powered (4, 11, 15, 18, 22), having included an *a priori* effect size estimate which they used to determine their sample size. In the seven studies to evaluate breaks in prolonged sitting time (≥30 min) or sit-to-stand transitions, four observed significantly favorable outcomes post-intervention (9, 11, 16, 18). The included interventions

reported reductions in total daily sedentary time of a range between 0.7% (3) and 8.1% (22) or between 22 (15) and 130 (16) min/day (pre to post or compared to control, depending on design).

Discussion

This review is the first to focus specifically on non-worksite interventions to limit sedentary behavior in adults. We identified thirteen studies whose primary or secondary outcome was to reduce overall sitting time and/or increase the number of breaks in prolonged sitting time. Generally, regardless of the intervention characteristics, sedentary behavior interventions appear to be efficacious, as most reported significant findings for at least one sitting time-related outcome. While these results varied with respect to the reported decrease in time spent sedentary or increase in breaks, the results are encouraging. Additionally, studies that reported feasibility data suggest that these interventions are largely acceptable, easy to use and implement, satisfactory to participants, and able to enroll and retain participants.

While the efficacy results discussed here are generally favorable, it is important to note that these non-workplace sedentary behavior interventions vary widely with respect to study design, population, intervention duration, mode of delivery, and outcome measurement. Combined with the relatively small number of currently published studies, this variability limits the ability to draw strong conclusions regarding the most appropriate or efficacious approaches to modify sedentary time. However, as these studies collectively showed promising results for reducing sedentary time, there were some intervention characteristics that were shared among studies. First, it should be noted that seven of the thirteen studies reviewed utilized a randomized design. Of those, nearly all studies were of high methodological quality as determined by the Delphi

criteria, with five of those seven reporting favorable significant findings. Further, with respect to the intervention components, interventions typically fell into one of three categories: use of technology to reduce sedentary time, use of specific behavior change techniques to limit sitting time, or a combination of the two. Interestingly, findings did not differ greatly by these intervention components among studies.

The interventions specifically based on a behavioral theory utilized various behavior models in their design, such that one particular behavioral theory could not be highlighted as more or less efficacious at limiting sedentary time than the others While the technological devices also varied among studies, they were designed to assist in alerting the user to accumulated sedentary behavior in the form of haptic feedback. This is an important finding, in that as the use of haptic feedback could be considered a form of self-monitoring, this approach to lifestyle behavior change has a strong theoretical foundation (5). Further, it is likely that the studies utilizing these approaches that did not explicitly state that their intervention was theory-based may have, in actuality, utilized these methods. Collectively, this suggests that coupling behavior change theory, specifically the use of an alert as a surrogate for self-monitoring, with a technological application, may be a successful avenue to reduce non-work related sedentary time.

While the studies reviewed here have generally been considered to be of good methodological quality, the many differences among the studies made interpretation of these data difficult. Almost half of the studies used a pre-post experimental design (4, 10, 11, 15, 18, 23), which makes evaluating these studies in conjunction with RCTs a challenge. Further, sample sizes ranged greatly among studies, with eight of the thirteen studies self-titled as, or having small

enough sample sizes (n<37) to be considered, pilot studies (Table 1). Of those, two studies reported findings on ten subjects or fewer (14, 23). To get a true idea of which intervention designs have the greatest potential, more work is warranted with appropriately powered samples. Additionally, the samples within these studies varied in age range and health status. While findings across studies are encouraging in that they suggest these interventions might be appropriate across varying populations, it adds to the challenge of highlighting the most appropriate intervention approach to limit sedentary behavior.

The duration of the intervention also widely differed among studies. One study conducted a single 1-hour session (17), four studies reported an intervention of only one week (11, 14, 15, 18), while others reported interventions as long as twelve months (3). While new literature suggests that there is considerable variation in the amount of time necessary to change behavior, successful habit formation likely occurs on the scale of weeks to months rather than days (12). Further, only one study (9) reported follow-up time points to attempt to measure if the potential change in behavior was maintained over time. While findings presented by the studies of shorter duration are comparable to those of longer duration, the varying degree of time spent in these interventions, the lack of follow-up data in the majority of studies, along with the differences in approach and mode of delivery, suggest that more work is needed to further identify the most promising duration of a sedentary behavior intervention.

There were also limitations in the analysis of the included studies. The majority of studies assembled here utilized objective measures of sedentary behavior, which are favorable to the often under-estimated self-report of sedentary time (2). However, the tools used in collecting

these data (ActiGraph, ActivPAL, Sensewear Arm bands) differed among studies. Future reviews comparing data collected from the same measure will help generate a greater consensus with respect to best practices of sedentary interventions. Also of note, few studies utilized an intent-to-treat analysis (n=4), which could lead to a potentially biased estimate of the treatment effect. Future studies should be mindful with regards to analysis strategies to shed light on true efficacy practices.

Finally, it is important to note that this review is not without limitations. As stated previously, due to the diversity of the study designs, participants, and intervention techniques, we were unable to conduct a meta-analysis, which would have furthered our understanding regarding the magnitude of the effect of these interventions, Specifically, as there were few interventions dedicated to focusing on specifically lessening sedentary time versus increasing physical activity while also not focusing on sedentary reductions in the workplace, we chose to include all studies meeting our robust criteria in which to get a full snapshot of these practices. Unfortunately, the various study designs, having included both randomized control trials and non-randomized trials, as well as pilot studies and fully powered studies, hinder our ability to quantify and describe the efficacy and effectiveness across trials. Due to these limitations, while our findings were encouraging, more work is necessary to further describe these outcomes.

Future Directions

While preliminary findings that non-worksite sedentary interventions appear to be both feasible and efficacious in the short-term are encouraging, much work remains to further our

understanding of this topic. Larger, appropriately-powered trials are needed to test these interventions and give us a better idea as to how efficacious and effective these interventions might be. Further, longer duration interventions, as well as a period of follow-up, are strongly needed in order to examine true behavior change. It is imperative that we evaluate the long-term success of these interventions to discover if individuals adopt and maintain these behaviors or if they revert back to previous sedentary patterns post-intervention.

Not only do we require further work to provide necessary information regarding the efficacy of these interventions, but also studies to provide evidence on the appropriate "dose" of sedentary reduction or number of breaks (and timing of these breaks) to optimize health benefits. While observational, prospective trials continue to support a dose-response relationship between sedentary behavior and health, using these data to inform future interventions such that recommended doses of sedentary reduction are both optimized and comparable across studies is warranted.

More work is needed to assess the appropriate intervention strategies for particular populations. The populations investigated in this review varied from young to older adults and included both healthy and populations with defined comorbidities, including those identified as overweight, obese, and/or those who had diabetes. It is possible that different interventions will be more effective in specific populations depending on how and when they incorporate techniques to lessen sedentary time. For example, younger adults may be more amenable to a sitting time prescription in which total duration of sitting is reduced whereas older adults could experience greater success with an intervention that focused on increasing the frequency of standing breaks.

Further, younger adults may be more amenable to technology-based interventions than their older counterparts. The ability to tailor intervention prescriptions to specific populations is likely to increase the effectiveness of the interventions.

As these interventions appear to be efficacious and favorable, there is a need for effectiveness studies that delineate their effects on objective markers of health. Mounting evidence suggests that there is increased cardio-metabolic risk associated with time spent sedentary. Physiological biomarkers can give us great insight into the mechanism by which limiting sedentary behavior is beneficial to health, especially in those with chronic disease, such as Type II diabetes or cancer. Greater understanding of the physiologic link between sedentary time and these health outcomes can help to shape future interventions.

Conclusions

In this first systematic review of interventions specifically designed to decrease sedentary time that are not limited to the workplace, our findings suggest that interventions to reduce sedentary time and/or increase breaks in long, interrupted periods of sedentary time show promise. As a whole, these interventions are feasible, acceptable, and generally efficacious, at least in the short term. However, due to the small body of evidence and the disparate nature of these works, our ability to make overarching statements regarding "best practices" at this time is not supported. Well-controlled trials of longer duration with larger samples, using theoretically-based interventions with consistent goals or prescriptions for limiting sedentary time and similar methods of measuring sedentary behavior are strongly warranted.

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Appendix I (Supplemental Content)

Complete search terms used for each database:

PubMed: 3684 total studies identified

(Intervention* or interference* or intercession* or mediation* or arbitration*) and (sedentary or "sedentary behavior" or "sedentary lifestyle") and (behavior* or behavior* or reaction* or "behavior* therap*" or "behaviour* therap*" or "health behavior*" or "health behavior*")

Yield: 824 studies

("Sedentary Lifestyle"[Mesh]) AND "Adult"[Mesh]

Yield: 2504 studies

("Sedentary Lifestyle"[Mesh]) AND "Adult"[Mesh] AND (Intervention* or interference* or intercession* or mediation* or arbitration*) and (sedentary or "sedentary behavior" or "sedentary lifestyle") and (behavior* or behavior* or reaction* or "behavior* therap*" or "behaviour* therap*" or "health behavior*" or "health behavior*")

Yield: 356 studies

Web of Science: 2044 total studies identified

(Intervention* or interference* or intercession* or mediation* or arbitration*) and (sedentary or "sedentary behavior" or "sedentary lifestyle") and (behavior* or behavior* or reaction* or "behavior* therap*" or "behaviour* therap*" or "health behavior*" or "health behavior*")

Yield: 2,044 studies

PsycINFO: 579 total studies identified

(Intervention* or interference* or intercession* or mediation* or arbitration*) and (sedentary or "sedentary behavior" or "sedentary lifestyle") and (behavior* or behavior* or reaction* or "behavior* therap*" or "behaviour* therap*" or "health behavior*" or "health behavior*")

Yield: 579 studies

Sports Discus: 432 total studies identified

(Intervention* or interference* or intercession* or mediation* or arbitration*) and (sedentary or "sedentary behavior" or "sedentary lifestyle") and (behavior* or behavior* or reaction* or "behavior* therap*" or "behaviour* therap*" or "health behavior*" or "health behavior*")

Yield: 432 studies

Figure Captions

Figure 1. Flow diagram of search results and reasons for exclusion

Table 1

Table 1. Study characteristics of non-worksite based interventions to reduce sedentary behavior

Study	n	Study Population	Mean Age (SD); Percent Female	Intervention	Study Design	Duration/ Follow-up Period	Measure of Sedentary Time	Behavioral Theory Used*	Tech Component of Intervention
Otten (22)	36	Overweight or obese adults ǂ	42.6 (±13.3); 69%	Reduce TV time via electronic lockout system	RCT	3 weeks/ N/A	Sensewear armband	N/A	TV lockout system
Gardiner (11)	59	Healthy Older adults (≥60 yrs)	74.3 (±9.3); 75%	Reduce sedentary time via goal setting/education, etc.	Pre-Post	7 days/ N/A	Actigraph	Social cognitive theory, behavioral choice theory	Review of accelerometer-assessed sedentary time from previous day
Fitzsimons (10)	24	Healthy Older Adults (≥60 yrs)	68.0 (±6); 42%	Reduce sedentary time via education/Behavior Change Techniques	Pre-Post	24 days/ N/A/	ActivPAL	Ecological model + "successful Behavior Change Techniques"	Incorporated visual sedentary time feedback from ActivPAL
Aadahl (1)	166	Healthy adults (Health2010 participants)	52.0 (±14.1); 53%	Reduce sedentary time via motivational counseling	RCT	6 months (4 visits)/ N/A	ActivPAL	Behavioral Choice Theory (goal-setting, self-efficacy, Motivational Interviewing)	N/A
Bond (4)	30	Overweight or obese adults ǂ	47.5 (±13.5); 83%	Reduce sedentary time via real-time smartphone feedback, prompting, goal-setting; 3 strategies tested	Pre-Post	4 weeks/ N/A	Sensewear Mini armband	N/A	Smartphone app with onboard accelerometer
Biddle (3)	187	Overweight or obese young adults (18-40 yrs) w/ >1 additional risk factor for DM ǂ	32.8 (±5.6); 69%	Education workshop, self-monitoring tool (Gruve), motivational call	RCT	12 months/ N/A	Actigraph & ActivPAL	N/A	Self-monitoring wearable device (Gruve)

Judice (14)	10	Overweight or obese employed adults ǂ	50.4 (±11.5); 50%	Education, goal setting, pedometer, PC screen prompts	Cross-over RCT	1 week/ N/A	Actigraph & ActivPAL	N/A	Pedometer; PC-based screen prompt
Lang (17)	819	Adult PA conference attendees	N/A;N/A	Point-of-decision-prompt	RCT	One hour session/ N/A	Direct observation	N/A	N/A
Pellegrini (23)	9	Adults (21-70 yrs) w/ DM	53.1 (±10.7); 77%	Smartphone application w/ haptic feedback	Pre-Post	1 month/ N/A	Actigraph & Shimmer	N/A	Smartphone app (visual and sensory feedback) with separate wearable accelerometer
Ellingson (9)	30	Healthy young adults (18-26)	20.1 (±1.5); 50%	Reduce sedentary time w/ real-time feedback via wearable technology	RCT-pilot	5 Weeks/ 4-weeks	ActivPAL/ Sedentary Behavior Questionnaire	Habit Theory of Behavior Change	Haptic feedback from ActivPAL
Kendzor (15)	215	Healthy adults	43.9 (±12.9); 68%	Educational materials/ Smartphone app w/ daily messages	Quasi-Experimental (non-random)	7 days/ N/A	Actigraph & IPAQ	N/A	Smartphone app w/ screen prompt
Kerr (16)	30	Non-working adults (50-70 yrs)	60.4 (±5.9); 73%	Education, goal setting, "choice of other tools"	RCT-pilot	2 Weeks/ N/A	ActivPAL	Multiple Behavior Change strategies (self-monitoring, goal setting, feedback, etc.)	Multiple: Smartphone & PC app w/ prompt; timers, watches, haptic feedback, branded bracelets, standing desks, etc.
Lewis (18)	30	Non-working older adults (≥60 yrs)	71.7 (±6.5); 63%	1-hr face-to-face Education/goal setting session	Pre-post	7 days/ N/A	ActivPAL	Self-determination Theory	N/A

*While some of these interventions appear to be theoretically driven, there was no specific mention of behavioral theories. Thus, we did not want to make assumptions that these interventions were designed based on a particular behavioral theory. ǂ Overweight/Obese participants = body mass index ≥25kg/m^2.
Abbreviations: N/A = Not Applicable; RCT = Randomized Controlled Trial; SD = Standard Deviation; w/ = with.

Table 2. Quality ratings using criteria from the Delphi list (Verhagen et al., 1998) for randomized controlled trials of interventions to reduce sitting-time in non-workplace settings

Criteria		Otten (22)	Aadahl (1)	Biddle (3)	Judice (14)	Lang (17)	Ellingson (9)	Kerr (16)
1a	Was a method of randomization performed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1b	Was the treatment allocation concealed?	Yes	Yes	Yes	?	No	?	Yes
2	Were the groups similar at baseline?	Yes	Yes	Yes	No	?	Yes	Yes
3	Were the eligibility criteria specified?	Yes	Yes	Yes	Yes	No	Yes	Yes
4	Was the outcome assessor blinded?	?	Yes	?	?	No	No	No
5*	Was the care provider/interventionist blinded?	-	-	-	-	-	-	-
6*	Was the patient/participant blinded?	-	-	-	-	-	-	-
7	Were the point estimate and measures of validity presented for the primary outcome measures?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8	Did the analysis include an intention-to-treat analysis?	Yes	No	Yes	Yes	?	No	Yes
Total score		6	6	6	4	2	4	6

Scoring: Y=yes=1, N=no=0,? =unclear=0; maximum score=7; Inter-rater agreement: 94%

* These criteria were omitted from the final quality assessment score as they were thought to be inappropriate for application to sedentary behavior interventions. Blinding of interventionists and participants in this type of intervention is usually not possible and none of the studies included in this review fulfilled these criteria.

Table 3. Major outcomes, feasibility, efficacy and effectiveness data for reducing sedentary time from non-worksite interventions to reduce sedentary time.

Study	Primary Outcomes	Secondary Outcomes	Feasibility Data	Efficacy/ Effectiveness Data for Reducing Sedentary Time
Otten (22)	Energy intake	Energy expenditure; total sleep; time spent in sedentary activities; time spent in PA	N/A	Sig. difference in daily sedentary time b/w intervention and control group (mean change (95% CI)): -3.8% (-6.3 to -1.3) vs. 1.1% (-3.2 to 5.4); p<.04)
Gardiner (11)	Program reach (participants enrolled/participants screened & eligible) and retention (% completed); total sedentary time/breaks in sedentary time, time spent in PA; participant satisfaction	N/A	Reach: 88%; retention: 100%; participant satisfaction: 97% rated 8 or higher /10 (median=9, range=7-10)	Sig. decrease in daily sedentary time pre- to post-intervention (3.2% (-4.18, -2.14); p<.01); Sig increase in breaks in sedentary time (4.0 (1.48, 6.52); p<.01)
Fitzsimons[p] (10)	Objectively measured total sedentary time/breaks in sedentary time (pre- vs. post-intervention); subjective measures of sedentary time (incl. type)	N/A	Titled as feasibility study, but no feasibility outcomes discussed	Decrease in objectively measured sedentary time pre- to post-intervention (24 min/day; 2.2% daily reduction). No apparent diff in breaks in sedentary time pre- vs. post-intervention. Subjective data suggest participants under-reported changes in sedentary time.
Aadahl (1)	Objectively measured total sedentary time	Number of breaks in sedentary time; self-reported sitting time; weakly MVPA; anthropometrics; cardio biomarkers	*Enrollment [a]: 56%,* retention [b]: 90%	No sig. differences in objectively measured sitting time/standing breaks between groups; sig difference between groups re: self-reported leisure sitting/day (-0.81 (-1.4,-0.3) hrs/day); p<.01)

Bond (4)	Objectively measured total sedentary time	Time spent in PA; acceptability and preference of intervention	*Enrollment [a]:49% ; *retention [b] :86% ; acceptability: 90% of subjects "agreed" or "strongly agreed" that intervention 1) significantly increased motivation to take PA breaks and 2) significantly decreased time sedentary due to intervention	Percent of waking hours spent sedentary was sig. decreased in all 3 conditions (3-6% decrease; p<.01); pairwise comparisons showed sig greater reductions in percent sedentary for the 3 min break in sedentary time after 30 continuous min sedentary vs. 12 min break after 120 min sedentary
Biddle (3)	Objectively measured total sedentary time	Self-report sedentary time; objectively and subjectively measured PA; biochemical, anthropometric, psycho-social & variables	*Enrollment [a]: 96%,* retention [b]: 71%	No sig differences in sedentary time (0.73% decrease in daily sed time; p>.05)
Judice[p] (14)	Objectively measured total sedentary time	Changes in stepping, standing, breaks in sedentary time (sit/stand transitions) and participant satisfaction	*Enrollment [a]: 33%;* retention [b]: 100%; intervention satisfaction: 60% of participants rated intervention extremely satisfying (score of 10 on a 1-10 scale; median: 9.5, min-max: 8-10). Seven of ten participants reported leisure-time to be the greatest domain to perform sedentary time changes	Participants in the intervention group had less daily sitting time (1.85 hrs (0.6-2.75)), more standing (0.77 hrs (0.06-1.48)), and more stepping (1.09 hrs (0.79-1.38)). No apparent changes in sit-to-stand transitions
Lang (17)	Number of conference attendees standing during presentations at an academic conference	N/A	N/A	Larger proportion of individuals in the intervention group (point-of decision prompting) stood during presentations than those in the control group (17% ±2% vs. 11% ±2%)
Pellegrini[p] (23)	Smartphone app usage & acceptability; anthropometric data; objectively measured total sedentary time	N/A	*Enrollment [a]: 29%;* retention [b]: 89%; acceptability: all participants agreed or strongly agreed that the app made them more aware of their sedentary time. 88% would use again. 88% helped to remember to break sedentary time. 50% stated the app was easy to use	Sedentary time decreased 8.1% (±4.5%) between baseline and one month [addition of outlier (n=1) attenuated the effect]

Ellingson[p] (9)	Objectively measured total sedentary time	Changes in objectively measured PA and mood; participant perception of sedentary behavior	N/A	No differences in total minutes of time spent sedentary; participants receiving intervention decreased sitting time in prolonged bouts (≥30 min) and increased time spent in shorter bouts (<30 min). Perception: 27/28 participants were more aware of, and agreed with the importance of limiting, sedentary behavior post-intervention. 26/28 planned to limit sedentary time after completion of the study
Kendzor (15)	Objectively measured total sedentary time & PA	N/A	N/A	Significantly fewer minutes of sedentary time/day (B=-22.1; p<.05)
Kerr[p] (16)	Objectively measured total sedentary time, daily stepping time, number of sit-to-stand transitions	Feasibility and acceptability of intervention	Qualitative interviews suggested that the intervention was "acceptable and feasible," as participants found wearing the device to be comfortable, the information presented to them to be helpful and understandable, as well as satisfied with the modes of intervention delivery and content. *Enrollment [a] (number eligible/number enrolled): 59%;* retention [b] : 100%	Participants randomized to sitting time reduction group had a decrease (130 min/day) in daily sitting time, but no differences in sit-to-stand transitions; those randomized to increase in sit-to-stand transitions increased the number of transitions (13/day), but no change in total sitting time
Lewis (18)	Objectively measured total sedentary time and bouts of prolonged sitting (≥30 min); time spent watching TV; time spent in PA; participant satisfaction & burden; program uptake [a] & retention [b]	N/A	Program uptake: 97%; program retention: 90%; participant satisfaction: overall program satisfaction was high (8.2±1.8 out of 10) and 8.2 ±2.2 would likely recommend the program; participant burden was rated as low (8.8±1.2 out of 10, with 10 representing 'not time consuming at all). 96% of participants reported easy to wear	Participants significantly reduced their total daily sitting time (-51.5 min; p=.01), sitting time accrued in prolonged bouts (-53.9; p<.01), number of bouts of prolonged sitting (-0.8; p<.01), and % waking hours spent sitting (-5.3%; p=.01)

[p]=designated as pilot study. *=Feasibility data not officially presented, but can be calculated from information presented in the study. [a]=percent of participants eligible who were enrolled in study. [b]=Percent of participants enrolled in study who completed post-intervention assessment.

Figure 1

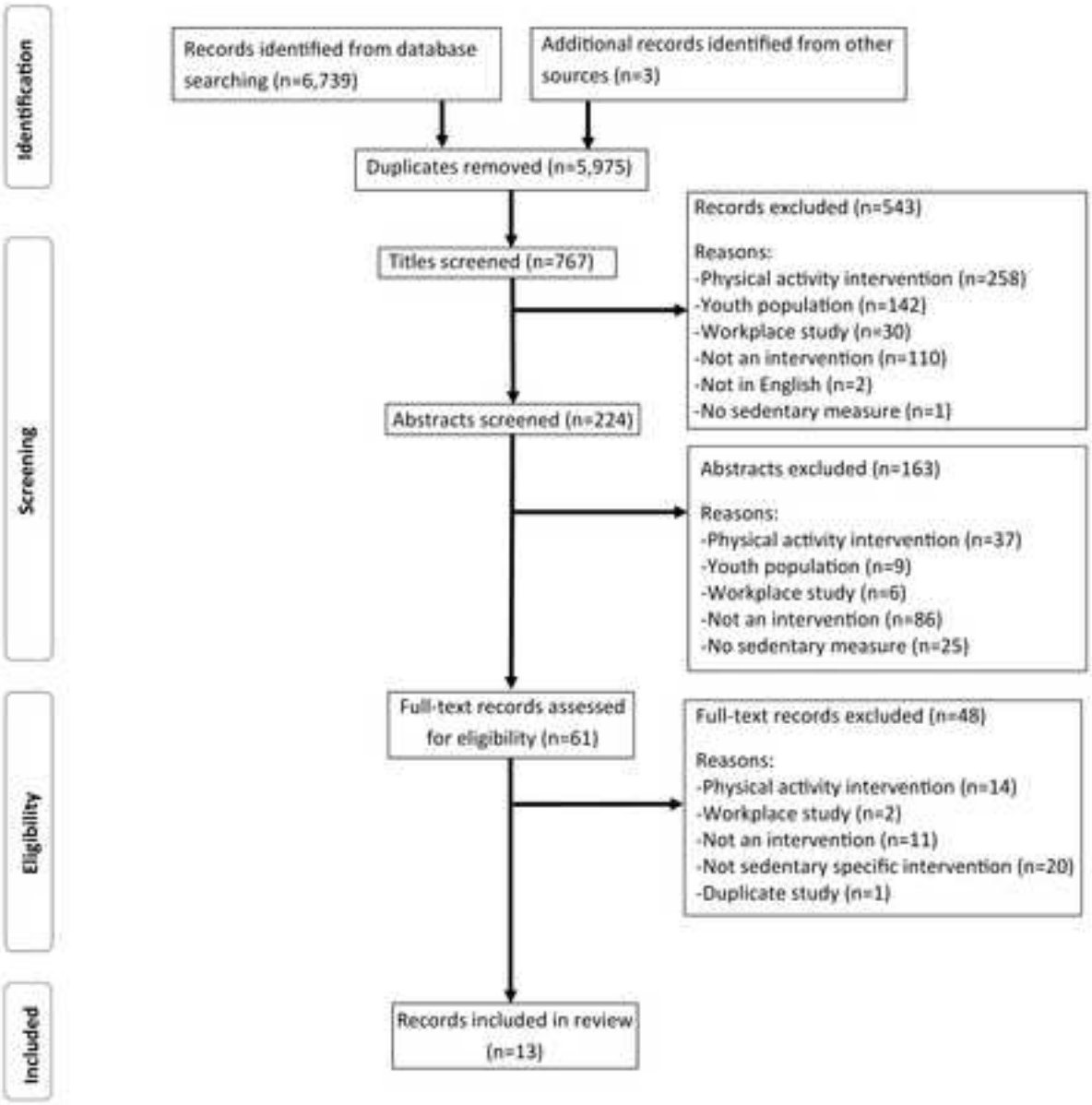

Figure 1. Flow diagram of search results and reasons for exclusion