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Sedentary Behaviour in Office Workers: Using Pragmatic Evaluation and the RE-AIM Framework to Improve Potential for Impact in the Real World

by

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Declaration of authenticity and author's rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

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Declaration of contribution to thesis

In all of the studies that are presented in this thesis, the majority of the work is directly attributable to the PhD student. Supervisors and co-authors have been involved in the formulation of research ideas and in editing manuscripts. All investigations, analyses and reporting have been carried out solely by the named PhD student, in keeping with the requirements of the degree of doctorate of philosophy in physical activity for health.

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Abstract

Background: To reduce the burden of disease associated with sedentary behaviour (SB), interventions targeting a reduction in SB in office workers need to have impact in the real world. The thesis aimed to use pragmatic evaluation and the RE-AIM framework to inform and improve understanding of dissemination (reporting) and implementation of interventions targeting SB in office workers in order to guide interventions towards having real world public health impact.

Methods: The thesis presents three studies. Study one is an integrative systematic review which aimed to collate and synthesise the published research which reported on at least one aspect of the reach, effectiveness, adoption, implementation and maintenance of an intervention. In the second study the RE-AIM QuEST framework was used to evaluate the potential for further implementation and scale-up of a consultation based single site workplace intervention which aimed to reduce SB. The third study used mixed methods to evaluate a digital intervention in the workplace across multiple workplace settings.

Results: In study one, 61 interventions were included in the systematic review. Reporting within included studies varied across reach (59%), effectiveness (49%), adoption (13%), implementation (44%) and maintenance (8%) and recommendations for improved reporting were given. In study two findings suggested that significant barriers to scale-up existed including lack of management support and time and cost of the intervention. Results from study three suggest that improvements could be made across the RE-AIM framework to facilitate improved effectiveness of the application while maintaining and improving reach, adoption, implementation and maintenance.

Conclusion: The studies presented in this thesis will inform and improve the dissemination and implementation of SB interventions in the workplace for

impact in the real world. Future research in this area should look to: implement testing for potential public health impact in early phases of research; further investigate the resources for health promotion in the real world and the stakeholder's perceptions of costs and benefits of interventions; investigate the manager's role as a gatekeeper to behaviour change in the workplace.

Glossary of terms

Adoption - The absolute number, proportion, and representativeness of settings and intervention agents who are willing to initiate an intervention or program.

Dissemination - the action of reporting results widely.

Effectiveness/efficacy - The impact of an intervention on important outcomes, including potential negative effects, quality of life, and economic outcomes.

Evaluation - In health promotion, it is the process of determining the value of an intervention and the extent to which it has achieved a desired outcome and the processes that lead to these outcomes.

Formative evaluation - Set of activities designed to develop and test program methods and materials.

Implementation - Concerned with setting level implementation, and is defined as the intervention agents' fidelity to the various elements of an intervention's protocol.

Light-intensity physical activity - Any bodily movement which requires an exertion that measures between 1.5 and 3.0 METs.

Logic Model - A conceptual roadmap illustration describing what an intervention intends to bring about by defining what will happen, in what order it will happen and what the anticipated effects are.

Maintenance - At the individual level, maintenance has been defined as the long-term effects of a program on outcomes six or more months after the most recent intervention contact. At the setting level it is defined as the extent to which a program or policy becomes institutionalised or part of the routine organisational practices and policies.

Metabolic Equivalent Task (MET) - A method of expressing energy cost of physical activities as a multiple of the resting metabolic rate (the amount of oxygen consumed while sitting at rest).

Moderate-intensity physical activity - Any bodily movement which requires an exertion that measures between 3.0 and 6.0 METs.

Moderate-Vigorous Physical Activity (MVPA) - Any bodily movement which requires an exertion greater than 3.0 METs.

Outcome or impact evaluation - A type of evaluation used to assess to what extent an intervention successfully achieves its goal.

Physical Activity (PA) - Any bodily movement which requires an exertion that measures above 1.5 METs.

Physical inactivity - Insufficient amounts of moderate-vigorous physical activity.

Pragmatism - A branch of philosophy in which truth (hypothesis and theory) is assessed in terms of its practicality in the real world.

Prevalence – A measure that describes how many people are affected by or have a particular problem in a defined population.

Process evaluation - A type of evaluation used to investigate and improve the implementation of an intervention or program by critically and methodically analysing the successes and/or failures of the program.

Qualitative Evaluation for Systematic Translation (QuEST) - An addition to the RE-AIM framework which facilitates the integration of qualitative inquiry across the five dimensions of the framework.

RE-AIM Framework - An evaluation framework which was developed specifically to assist researchers in the assessment of the potential for an intervention to have impact in real world settings.

Reach - The absolute number, proportion and representativeness of individuals who are willing to participate in a given initiative.

Sedentary Behaviour (SB) - Any waking behaviour characterised by an energy expenditure of ≤1.5 METs whilst in a sitting or reclining posture.

Scale-up - the process of expanding a small scale intervention or program under real world conditions to reach a greater proportion of the eligible population.

Vigorous-intensity physical activity - Any bodily movement which requires an exertion which measures greater than 6.0 METs.

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Summary of thesis publications and presentations

Chapter 2.

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Chapter 3.

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Chapter 4.

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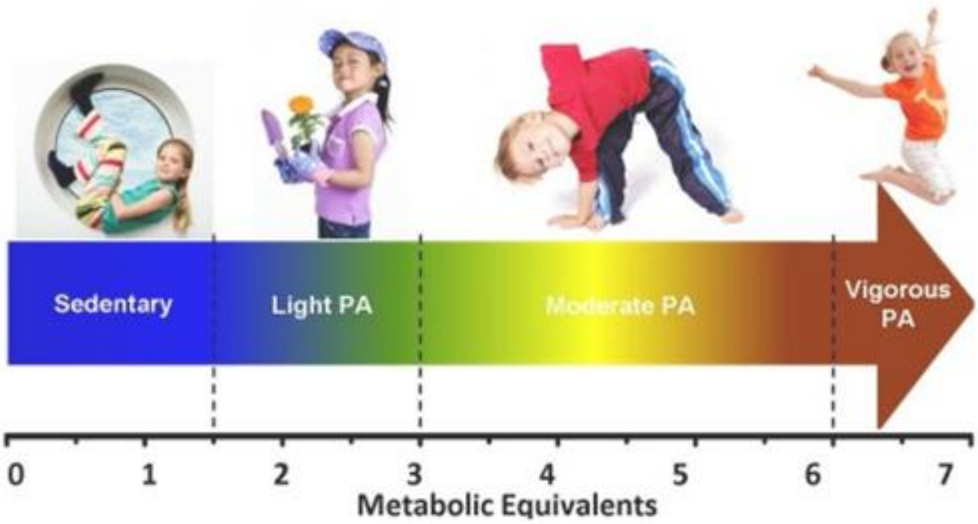
Chapter 1: Introduction and literature review

1. Sedentary Behaviour

1.1 Definition

Sedentary behaviour (SB) is defined as any waking behaviour characterised by an energy expenditure of ≤1.5 metabolic equivalents tasks (METs) whilst in a sitting or reclining posture (Tremblay et al., 2017). Any bodily movement above 1.5 METs would be considered physical activity (PA) (Ainsworth et al., 2000). Figure 1.1, from the Sedentary Behaviour Research Network (SBRN), illustrates the energy expenditure continuum of SB and PA (SBRN, 2020). SB may also be referred to, and be interchanged with, 'sitting time' (Owen, Healy, Matthews, & Dunstan, 2010). SB is widely thought of as having the potential to occur across three specific contexts or domains; occupational, transport and leisure time (Owen et al., 2010).

Figure 1. 1: Energy Expenditure Continuum



(Sedentary Behaviour Research Network, 2020)

1.2 Sedentary behaviour and health outcomes

Our understanding of the relationship between SB and health is still emerging. In this section, both physical and mental wellbeing outcomes are discussed in relation to what is currently known about their association with SB. Additionally, evidence of the association of health outcomes with occupational SB will be presented where applicable.

1.2.1 Daily sedentary behaviour and association with chronic diseases

There is significant evidence from systematic reviews and meta-analyses suggesting that high levels of daily SB are independently associated with an increased risk of cardiovascular disease, type 2 diabetes mellitus, some cancers and all-cause mortality (Biswas et al., 2015; Patterson et al., 2018; Wilmot et al., 2012). Firstly, Biswas and colleagues' systematic review and meta-analysis examined the association between sedentary time (assessed as either daily overall SB, sitting time, television viewing or screen time, or leisure time spent sitting) and all-cause mortality, cardiovascular disease, diabetes and cancer in adults, independent of PA (Biswas et al., 2015). Biswas et al. included 44 studies in a meta-analysis, in which the researchers collected hazard ratios (HR) from each paper. High levels of SB significantly increased the risk of all-cause mortality (HR, 1.220 [95% CI, 1.090 to 1.410]) (829,917 participants), cardiovascular disease mortality (HR, 1.150 [CI, 1.107 to 1.195]), cardiovascular disease incidence (HR, 1.143 [CI, 1.002 to 1.729]) (551,366 participants), cancer mortality (HR, 1.130 [CI, 1.053 to 1.213]), cancer incidence (HR, 1.130 [CI, 1.053 to 1.213]) (744,706 participants), and type 2 diabetes incidence (HR, 1.910 [CI, 1.642 to 2.222]) (26,700 participants). This was reported as being independent of PA level. Furthermore, Biswas and colleagues reported that among studies assessing cancer mortality and incidence, significant associations were specifically found with breast, colon, colorectal, endometrial, and epithelial ovarian cancer. Based on their results, Biswas and colleagues concluded that prolonged sedentary time was associated with poorer health outcomes independent of PA (Biswas et al., 2015).

Secondly, Paterson and colleagues (2018) conducted a systematic review and dose response meta-analysis of SB and risk of all-cause, cardiovascular and cancer mortality, and incidence of type 2 diabetes (Patterson et al., 2018). This review and meta-analysis strengthened the current evidence by reviewing the literature for prospective studies only, and included data in the meta-analysis from 1,331,468 participants. As with Biswas' results, Paterson and colleagues' findings also indicated that after adjusting for PA, SB (assessed as total SB or TV viewing) was associated with an increased relative risk (RR) of all-cause mortality (total SB RR = 1.02 [1.01, 1.03]; TV viewing RR= 1.05 [1.04, 1.05]), cardiovascular disease mortality (total SB RR= 1.02 [1.01, 1.03]; TV viewing 1.04 [1.01, 1.08]), type 2 diabetes (total SB RR= 1.01 [1.00–1.01]; TV viewing RR= 1.09 [1.07-1.09]) and cancer mortality (TV viewing RR= 1.03 [1.02-1.04]). Paterson and colleagues also reported that SB associations with all-cause mortality and cardiovascular mortality were non-linear, indicating that a dose response relationship exists between total sedentary time and all-cause and cardiovascular mortality. Paterson identified that mortality risk increases significantly at thresholds of 6-8 hours/day of total sedentary time, and 3-4 hours/day of TV viewing (Patterson et al., 2018).

The evidence is not without its limitations. Most notably, the heterogeneity within the measurement of SB, with different self-report measurement tools utilised. The inclusion of studies using self-reported measures of SB may have introduced bias and reduced the validity of the findings in both Biswas et al. and Patterson et al. Furthermore, it is worth noting that both studies reported that the disease associations were adjusted for PA therefore independent of PA. However, both studies acknowledge the complexity of adjusting for PA, highlighted by Biswas concluding that more studies are required to better quantify how associations between sedentary time and disease outcomes change at higher levels of PA (Biswas et al., 2015).

The evidence that has been presented suggests that high daily amounts of SB are associated with all-cause mortality, type 2 diabetes, cardiovascular disease and some cancers. This association has also been looked at within the occupational domain to understand the potential risk of increased exposure to SB at work.

Van Uffelen et al. (2010) systematically reviewed the literature for evidence on associations between occupational sitting and BMI, cancer, cardiovascular disease, diabetes and mortality (Van Uffelen et al., 2010). The results showed mixed findings across each outcome. Twelve studies examined the association between occupational sitting and BMI with half of the cross-sectional studies showing a positive association. However, Van Uffelen notes that prospective studies failed to confirm a causal relationship. There was evidence from seventeen controlled studies of a positive association between occupational SB and higher risk of breast cancer, ovarian cancer and colorectal cancer; however, Van Uffelen states that this was generally not supported by prospective studies. There was mixed evidence for the associations between occupational SB and cardiovascular disease (CVD) risk. Four studies showed increased CVD risk with occupational sitting; three showed no association, and one showed increased CVD risk with decreased SB. Three studies found that occupational SB was associated with an increased risk of diabetes; with one prospective study finding no association. Finally, Van Uffelen's review described that four prospective studies reported associations between occupational SB and increased risk of mortality. One study found no association and one found a decreased mortality risk (Van Uffelen et al., 2010).

Additionally, in a study designed to examine the associations between occupational sitting and cardiovascular disease, cancer and all-cause mortality, 5380 women and 5788 men were followed-up over 12.9 years. The results indicated that women with standing/walking occupations had a 32%

lower risk of dying from all-causes, and 40% lower risk of incidence of cancer (40%). However in men no significant differences in risk was detected (Stamatakis et al., 2013).

In summary, there is mixed evidence regarding the association between the occupational SB domain and chronic disease risk, and significant evidence that there is an association between total daily SB and chronic disease risk.

1.2.2 Sedentary behaviour and musculoskeletal outcomes

There is evidence from individual studies suggesting there is a relationship between SB and back and neck pain. This relationship is still not fully understood with some reviews concluding that there is limited evidence due to low quality of studies (Chen, Liu, Cook, Bass, & Lo, 2009). However, evidence suggests that the domain of work related sitting specifically is associated with higher prevalence of back pain; especially when sitting is required for more than half of the working hours (Evans, Jobe, & Seibert, 1989; Lis, Black, Korn, & Nordin, 2007; Tian, Lv, Liu, Xiao, & Han, 2014; Tornqvist et al., 2001). For example, in a study looking at muscular stiffness of the back, office workers reported significant increases in stiffness after 4.5 hours of sitting (Kett & Sichting, 2020). Additionally, there is evidence that breaking up sedentary bouts may help to reduce back pain. For example, in an intervention with office workers, introducing standing breaks into office workers' days significantly reduced musculoskeletal discomfort compared to office workers who remained sitting (31.8% reduction; $p=0.03$) (Thorp, Kingwell, Owen, & Dunstan, 2014).

Although emerging, this evidence suggests that there may be a significant relationship between back and neck-related outcomes and SB.

1.2.3 Sedentary behaviour and mental health outcomes

There is emerging evidence that SB may have a relationship with depression, psychological distress and anxiety (Hamer, Coombs, & Stamatakis, 2014; Sloan et al., 2013; Teychenne, Ball, & Salmon, 2010). Teychenne, Ball and Salmon conducted a systematic review of studies published between 1985 and 2010 and found evidence of a positive association between SB and risk of depression (Teychenne et al., 2010). Adding to this evidence, Zhai and colleagues (2015) reviewed the literature for observational studies to derive an estimation of the association between SB and depression (Zhai, Zhang, & Zhang, 2015). Thirteen cross-sectional studies and 11 longitudinal studies, combining data from 193,166 participants, were included in the meta-analysis. Ten included studies showed a significant association between SB and depression. They described that, for all included studies, when comparing high levels of SB to "non-occasional/occasional" SB, the pooled relative risk (RR) of depression increased to 1.25 [95% confidence interval (CI) = 1.16 to 1.35]). Additionally, in subgroup analysis, the RR for depression increased for two specific proxy measures of SB; TV viewing (RR=1.13, [95% CI=1.06 to 1.21]), and computer/internet use (RR=1.22, [95% CI =1.10 to 1.34]). Zhai and colleagues concluded that the meta-analysis indicates that SB is associated with increased risk of depression (Zhai et al., 2015).

There is also evidence of an association between SB and psychological distress. For example, Hamer, Coombs and Stamatakis (2014) investigated associations between objectively assessed SB (1947 participants) and self-reported SB (11,658 participants) with psychological distress (Hamer et al., 2014). Hamer et al. reported that objectively measured SB was directly associated with psychological distress after adjustment for all co-variables including moderate-to-vigorous physical activity (MVPA), although this was more apparent in the highest tertile of sitting (OR=1.74, [95% CI =1.07 to 2.83]). Self-report SB at the highest tertile was also associated with psychological distress (OR=1.34, [95% CI= 1.15 to 1.56) (Hamer et al., 2014). Additionally, Sloan et al. (2013) used survey data from 4337 participants to examine cross-sectional associations of daily SB and MVPA with psychological distress (Sloan et al., 2013) . The results indicated that high levels of SB (10h/day) were independently associated with increased odds (OR = 1.29, [95% CI=1.04 to 1.59]) for psychological distress (Sloan et al., 2013). Furthermore, results from a similar study by Kilpatick and colleagues indicated that men sitting more than 6 h/day had increased risk of moderate psychological distress (adjusted prevalence ratio (PR) = 1.90, [95% CI=1.22, 2.95]), and women sitting more than 6 h/day had an increased risk of both moderate psychological distress (adjusted PR = 1.25, [95% CI=1.05 to 1.49]) and high psychological distress (adjusted PR = 1.76, [95%CI=1.25 to 2.47) (Kilpatrick, Sanderson, Blizzard, Teale, & Venn, 2013). These three studies indicate that high amounts of daily SB (6-10 hours) may be associated with psychological distress (Hamer et al., 2014; Kilpatrick et al., 2013; Sloan et al., 2013).

There is some evidence that SB is associated with anxiety. In a systematic review of the literature looking at the association between SB and risk of anxiety, five studies were identified (four cross-sectional, one longitudinal) that examined the association between overall sitting time and risk of anxiety in adults. Four of the studies showed a positive association between sitting time and anxiety risk (Teychenne, Costigan, & Parker, 2015).

1.2.4 Summary

As with any new research area, the evidence is still evolving regarding the relationship between SB and many health outcomes; however, from what has been presented in this section, there is significant evidence that too much daily SB is associated with chronic disease risk, musculoskeletal pain and decreased mental wellbeing. However, it is also clear that many research questions still exist regarding how the risk strengthens and attenuates. This has been the focus of recent research, with a specific emphasis placed on how the disease risk associated with SB is altered by PA.

1.3 Prevalence of Sedentary Behaviour

1.3.1 Subjective evidence

As an emerging research area, the epidemiological evidence regarding the prevalence of SB is still progressing, however several studies have attempted to examine the prevalence. Bauman and colleagues performed analyses on data from 20 individual countries that each used the International Physical Activity Questionnaire (IPAQ) to report on the prevalence of sitting time and its correlates (Bauman et al., 2011). A sample of 49,493 adults, aged 18-65 years, reported a median sitting time of 300 min/day (5 hours), with an interquartile range (IQR) of 180-480 minutes/day (3.15-8 hours/day). Countries reporting the lowest amount of sitting included Portugal, Brazil, and Colombia, medians ≤ 180 min/day (3 hours/day). Adults in Taiwan, Norway, Hong Kong, Saudi Arabia, and Japan reported the highest amount of sitting time, median ≥ 360 min/day (5 hours/day).

In a similar study investigating prevalence of sitting time in the 28 European Union member states, data were collected as part of the standardised long-term European survey (Special Eurobarometer 412) (Loyen, van der Ploeg, Bauman, Brug, & Lakerveld, 2016). A sample of 26,617 Europeans self-reported a median sitting time of 5 hours/day (IQR: 3-7 hours). This ranged from a median of 3 hours/day (IQR: 2-6 hours) in Portugal, to a median of 6 hours/day in Denmark (IQR: 4-8 hours) and the Netherlands (IQR:4-8 hours). In the United Kingdom (UK) median sitting was reported as 5 hours/day (IQR:3-7). Additionally, it was reported that across the 28 member states, 18.5% of the sample sat for more than 7.5 hours / day (Loyen et al., 2016). The proportion of those sitting for more than 7.5 hours/day ranged from 8.9% (Spain) to 32.1% (Netherlands). In the UK, 19.3% of the population reported sitting more than 7.5 hours/day. Furthermore, the distribution of proportions of sitting generally indicated that northern European member states reported more sitting than southern member states (Loyen et al., 2016).

Both Bauman et al. and Loyen et al. reported a median daily sitting time of 5 hours/day. This would appear to add reliability to their findings however both studies reported significant variation between countries and both were potentially limited by the self-report data collection method. Therefore, it is important to understand evidence in which prevalence of SB has been estimated using objective measurement.

1.3.2 Objective evidence

Very few studies have used population representative samples and objectively assessed SB to understand sitting levels in the population. However, Hagströmer and colleagues pooled accelerometer data from two population representative samples in the United States (2,925 participants (Matthews et al., 2008) and Sweden (1,172 participants) (Hagströmer, Troiano, Sjöström, & Berrigan, 2010). Hagströmer et al. reported an average sitting time for adults from the Swedish sample of 498min/day or 8.3hrs/day (95%CI: 483min/day, 513min/day or 8.05hrs/day, 8.55hrs/day). The average for the United States sample was 476min/day or 7.9hrs/day (CI 463min/day, 489min/day or 7.7hrs/day, 8.2hrs/day) (Hagströmer et al., 2010).

When comparing the self-report evidence of daily sitting time presented in Bauman and Loyen's studies to objectively measured sitting time from Hagströmer's study, it suggests that there may be significant self-report bias in the prevalence estimates reported in Bauman et al and Loyen et al. This aligns with Chastin and colleagues' 2014 study which compared self-report sitting (IPAQ) with objectively measured sitting (activPAL). In the study, 69 adults wore the activPAL for a week, and then completed the IPAQ questionnaire. Mean sitting time for the total week when measured with the

IPAQ was 6.6 hours/day (SD=2.6) compared to a mean 9.9 hours/day (SD=1.9) when measured with the activPAL, which is currently seen as the gold standard measure for sitting time. This is a mean difference of 3.30 hours/day (95%CI=-2.15,8.93) (Chastin, Culhane, & Dall, 2014). Although minimal population representative data has been presented on objectively measured SB, based on the hierarchy of evidence, and an understanding of potential self-report bias, we must consider that the prevalence of daily sitting in the adult population is closer to 8 hours a day than 5 hours a day. Based on the evidence presented in this section there is still considerable scope for researchers to investigate the prevalence of sitting time at a population level.

1.4 Prevalence of occupational sedentary behaviour

Several studies have examined the prevalence of SB within specific domains. This section examines research that has been published to facilitate understanding of the occupational domain of SB, and its relationship with the leisure-time domain, in working adults.

1.4.1 Subjective evidence

Loyne and colleagues investigated population levels of occupational and leisure time sitting in full-time employed Australian adults. In the study, data collected across three Australian Health Surveys (2007/08, 2011/12 and 2014/15) was analysed. A national representative sample of over 21,000 participants were included, and 55% reported a combined occupational and leisure sitting time of ≥ 7hrs/workday (Loyen et al., 2018). Additionally, Clemes and colleagues analysed cross-sectional survey data collected from 4436 employees in the Northern Ireland Civil Service (Clemes et al., 2015). The study reported that the total daily SB was higher on workdays (625mins (10.4hrs) ± 168mins (2.8hrs)) versus non-workdays (469mins (7.8hrs) ± 210 min (3.5hrs)/day, P < 0.001). Similar values were reported by Bennie and colleagues who surveyed 801 office workers finding that the median of total daily SB was 540 mins or 9 hours (IQR= 531–557mins/day or 8.85-9.2hrs/day), and that the occupational domain accounted for almost 60% of total daily SB (Bennie et al., 2015). This self-report evidence presented above suggests that the occupational domain contributes to a large amount of total daily sitting time for working adults.

1.4.2 Objective evidence

In addition to the self-report evidence, there is some objective evidence that SB is prevalent in the occupational domain especially within the office context. In a study by Thorpe and colleagues, 193 desk-based employees wore Actigraph accelerometers to derive percentages of time spent being sedentary. Thorpe et al. reported that working hours were mostly spent sedentary (mean=77.0%, 95% CI: 76.3%, 77.6%). Furthermore, they reported approximately half of this time was accumulated in prolonged bouts ≥20 minutes (Thorp et al., 2012). In a similar study conducted by Parry and colleagues, 50 office workers' objectively measured (accelerometer) sedentary time accounted for 81.8% of work hours (Parry & Straker, 2013). This was significantly greater than SB during non-work hours (68.9% $p < 0.001$). Parry's results also indicated that office workers experienced significantly more sustained bouts of SB (bouts >30 minutes), and significantly fewer breaks in SB during work hours, compared to non-working hours ($p < 0.001$). Finally, in a study of 140 office-based call centre employees SB was objectively assessed using dichotomous inclinometers, and it was found that employees spent more than 80% of the shift in a seated posture (Toomingas, Forsman, Mathiassen, Heiden, & Nilsson, 2012).

The subjective and objective evidence presented indicates that office workers spend a considerable amount of their working day seated. Subjective evidence indicates that a large proportion of total daily SB is accumulated at work, and objective evidence indicates that as much as 80% of their workday is sedentary. Additionally, the evidence indicates that office workers may experience longer bouts of uninterrupted sitting time.

1.5 Relationship between sedentary behaviour and physical activity

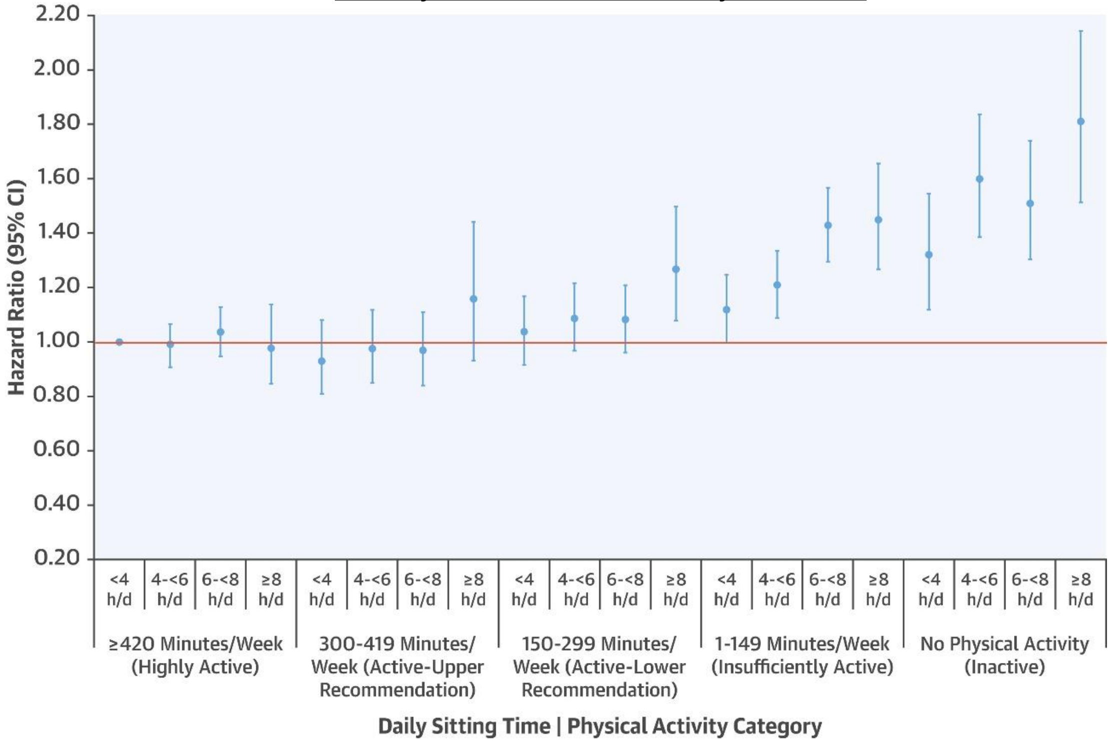
There is still a growing understanding of how frequency, intensity and duration of light, moderate and vigorous PA influences SB disease risk. In this section, published literature which focuses on how MVPA affects the disease risk associated with SB will be examined.

Currently, there is mixed evidence that SB is independently associated with health risks irrespective of PA levels. Firstly, as mentioned in the previous section, both Biswas and Patterson performed a statistical adjustment for PA and both authors concluded that SB was associated with chronic diseases independent of PA levels (Biswas et al., 2015; Patterson et al., 2018). However, both Biswas and Patterson warned of the complexity and limitations of adjusting for physical activity, highlighting that more research is needed to understand how high levels of PA affect the independent association which has been reported (Biswas et al., 2015; Patterson et al., 2018).

Recent evidence examining this relationship suggests that the intensity and duration of MVPA may weaken the association SB has with chronic disease risk (Chomistek et al., 2013; Ekelund et al., 2016; Herber-Gast, Jackson, Mishra, & Brown, 2013; Petersen et al., 2014). A recent meta-analysis published in the Lancet, which included 13 studies and data from 1,005,791 individuals, reported that, compared to the reference group (those sitting<4hours/day and in the most active quartile [>35.5 metabolic equivalents or MET hours per week]), daily sitting time was not associated with increased all-cause mortality in those in the most active quartile of physical activity. Additionally, there was no increased risk of mortality in those who sat for more than 8 hours/day, but who also reported >35·5 MET hours per week of activity (HR=1·04, 95% CI 0·99–1·10) (Ekelund et al., 2016). In their interpretation of these results, Ekelund and colleagues concluded that the evidence suggests that high levels of moderate PA (60–75 min/day) largely counteract the increased risk of death associated with high sitting time (>8 hours/day) (Ekelund et al., 2016).

In a more recent study, Stamatakis and colleagues investigated the relationship between sitting time, PA and risk of mortality in a longitudinal analysis of 149,077 adults (median follow-up = 8.9 years) (Stamatakis et al., 2019). Based on their results (Figure 1.2 - published in Stamatakis et al., 2019) Stamatakis and colleagues have suggested that there was “inconsistent” and “weak evidence” that SB increased risk of cardiovascular mortality, and all-cause mortality risks among participants meeting PA guidelines (150 to 299 MVPA min/week or ≥300 MVPA min/week) (Stamatakis et al., 2019). However, they did report that sitting time was associated with all-cause mortality and cardiovascular mortality, in a nearly dose-response manner, in the least active participants reporting <150 MVPA min/week. Stamatakis and colleagues concluded that large amounts of PA did influence the association between SB and all-cause mortality and cardiovascular mortality; with the authors stating that 150-300 min MVPA per week could largely offset the increased risk of SB in people reporting large amounts of daily SB (Stamatakis et al., 2019). Additionally, based on these results it appears that high levels of SB does influence mortality in individuals who do not meet the United Kingdom guidelines for MVPA (150 mins per week). This does suggest that, interventions targeting SB (and increasing light PA) may play a significant role in fighting non-communicable diseases within inactive adults.

Figure 1. 2: Results from Stamatakis et al., 2019. Sitting Time, Physical Activity and Risk of Mortality in Adults



(Stamatakis et al., 2019).

There is also emerging evidence that breaking up extended periods or "bouts" of SB with PA may affect the chronic disease risk associated with exposure to SB. There have been several studies that have suggested that there is a significant relationship between health outcomes (e.g. triglycerides, glucose, waist circumference) and the total number of breaks from sitting, independent of total sedentary time (Clemes, Patel, Mahon, & Griffiths, 2014; Dempsey et al., 2016; Dunstan et al., 2012; Healy et al., 2008). For example, Dunstan et al.'s and Dempsey's short-term laboratory-based experiments have demonstrated that when sitting is interrupted every 30 min by brief activity breaks (i.e. two minutes of treadmill walking or light resistance activity), postprandial glucose and insulin levels are significantly reduced (Dempsey et al., 2016; Dunstan et al., 2012). This illustrates that breaking up sedentary time with PA may be important to reduce the harmful effects of too much sitting. These findings are an important addition to the existing knowledge base and may be highly valuable when trying to develop recommendations, and implement behaviour change interventions, for SB.

1.6 Burden of disease

Globally, inactivity, defined as insufficient amounts of MVPA, has been estimated to cost health care systems $53.8 billion (international dollars). Additionally, inactivity related deaths contribute to $13.7 billion in productivity losses and was responsible for 13.4 million DALYs worldwide (Ding et al., 2016). Although inactivity and SB are not the same thing, they are interconnected and there is evidence that SB may be a significant contributing factor to the global economic burden of inactivity. For example, in the United Kingdom, Heron and colleagues estimated the direct health care costs, and avoidable deaths attributed to prolonged SB over a one-year period. It was estimated that prolonged SB cost the UK's National Health Service £700 million pounds in 2016-2017. Additionally, the estimated avoidable deaths if prolonged SB was eliminated was 69,276 (Heron, O'Neill, McAneney, Kee, & Tully, 2019). Although minimal research relating specifically to the economic burden of SB has been done, evidence suggests a large economic burden of SB.

1.6 Sedentary behaviour recommendations

Based on the existing evidence, several countries have developed recommendations or guidelines for adults in relation to SB. The United Kingdom's 2019 update of the PA guidelines recommends that adults should "minimise the amount of time spent being sedentary, and when physically possible should break up long periods of inactivity with at least light physical activity." (Department of Health & Social Care, 2019). In relation to work-related SB, an expert statement has been published by Buckley and colleagues, which recommends that office workers should engage in standing or light-intensity activity for half of their workday. They also suggested that office workers should break-up their sitting time throughout the day at regular intervals, and avoid prolonged static postures (sitting or standing) (Buckley et al., 2015).

1.7 Interventions to reduce sedentary behaviour in office workers

It has been established above that office-based workers accumulate a large proportion of their daily sitting time at work. This has led to an increasing number of interventions aimed at reducing office workers' SB. Several reviews of the intervention work have been published recently examining the efficacy/effectiveness of different types of interventions and their ability to reduce SB in the workplace. In this section, eight of the recently published reviews of the literature will be discussed to facilitate understanding of the interventions that have been carried out, and what gaps in research may exist.

Shrestha and colleagues' 2018 Cochrane systematic review examined the effectiveness of various intervention strategies for reducing sitting time at work. The published review included 34 studies with control or comparison groups, totalling 3,397 participants, all from high income countries (Shrestha et al., 2018). The detailed findings are presented below.

Sit-stand desks

Shrestha reported the pooled analysis of ten interventions which used sit-stand desks to reduce sitting time at work, and measured time spent sitting at work. On average sitting time was reduced by 100 minutes per workday at short-term follow-up (up to three months) compared to the control group (95% CI −116 to −84) (Shrestha et al., 2018). Two sit-stand desk interventions reported effects at medium term follow up (3 to 12 months) with a pooled effect of 57 minutes per day (95% CI −99 to −15) compared to the control group. In the pooled analysis of eight sit-stand desk studies reporting time spent stepping at work, Shrestha reported no significant difference at short-term follow-up (mean difference (MD) −1 minute per eight-hour workday (95% CI −4 to 3) (Shrestha et al., 2018). Shrestha included two sit-stand desk interventions which measured total duration of sitting bouts lasting 30 minutes with the pooled effect estimate showing a reduction of 53 minutes, on average, per eight-hour work-day (95% CI −79 to −26).

Promoting breaks

Shrestha et al. (2018) included one study which compared short breaks (one to two minutes every half hour) to long breaks (two 15-minute breaks per workday); with short breaks group reducing time spent sitting at work on average by 40 minutes more per day (95% CI −66 to −15) compared to long breaks, at short-term follow-up.

Information and counselling

Shrestha reported that interventions which provided information, feedback or counselling, either on their own or in conjunction, resulted in no significant change in time spent sitting at work at short-term follow-up (MD −19 minutes per day, 95% CI −57 to 19, two studies, low-quality evidence). However, interventions which used information, feedback or counselling showed a significant decrease in time spent sitting at work at medium-term follow-up (MD −28 minutes per day, 95% CI −51 to −5, two studies, low-quality evidence) (Shrestha et al., 2018).

Computer prompts

Shrestha reported that computer prompts combined with educational information resulted in no significant change in sitting time at work at short-term follow-up (MD=−10 minutes per day, 95% CI −45 to 24, two studies, low-quality evidence), but reported that it did produce a significant reduction in sitting time at work at medium-term follow-up (MD −55 minutes per day, 95% CI −96 to −14, one study). Additionally, results showed that computer prompting resulted in a significant decrease in the average number of sitting bouts lasting 30 minutes or more (Median = -1.1 bouts per day, 95% CI −1.9 to −0.3, one study); and duration of sitting bouts lasting 30 minutes or more (MD= -74 minutes per day, 95% CI −124 to −24, one study). Furthermore, in one study, computer prompts, with instructions to stand, reduced sitting at work on average by 14 minutes per day (95% CI 10 to 19) more than computer prompts with instruction to walk at least 100 steps (95% CI 10 to 19,), at short-term follow-up (Shrestha et al., 2018).

Multi-component interventions

Multi-component interventions consisting of physical workplace changes, workplace policy changes, and informational components had significant but heterogeneous effects on sitting time at work (Shrestha et al., 2018). Two studies' results were pooled and showed a significant reduction of time spent sitting at work per eight-hour workday at short term follow-up (101 minutes, 95% CI= −117.27 to −84). A third study also showed a reduction, however the reduction in time spent sitting at work was much smaller, averaging 48 minutes per eight-hour workday (95% CI −62 to −34).

In summary, although pooled effects appear promising, upon analysis of the risk of bias, Shrestha and colleagues concluded that there was low quality evidence that sit-stand desks may reduce SB at work in the first year of their use. The author also concludes that there was insufficient evidence to draw conclusions regarding the effectiveness of all intervention types over periods longer than one year. Additionally, upon reflection on their analysis of the literature, the authors make several recommendations for future research. Firstly, the authors recommend measuring additional outcomes important to employees and employers such as productivity, job stress, absenteeism, and cardio-metabolic health. Secondly, future research should investigate cost-effectiveness analyses, to help stakeholders and decision makers determine whether the cost is justified by improvements in health and work-related outcomes. Thirdly, they recommend that there is a need to evaluate low-cost interventions, as they may be the only feasible options in workplace settings with limited financial resources. Finally, the authors state that it might be important to incorporate qualitative studies, with a specific call for a review of the qualitative literature, to better understand the perceptions workers and employers have regarding SB as a workplace health issue (Shrestha et al., 2018).

Chu and colleagues' (2016) systematic review and meta-analysis, like the Shrestha review, looked at workplace intervention strategies to reduce SB. They reviewed the literature for intervention studies with a parallel control (or treatment-comparison group used) between 2003 and 2015 (Chu et al., 2016). In total 26 studies were included in the qualitative synthesis, and 21 studies were included in the meta-analysis. The pooled intervention effect showed a significant workplace sitting reduction of −39.6 min/8-h workday (95% CI: −51.7, −27.5), favouring the intervention group. Additionally, Chu and colleagues looked at differences in effectiveness based on intervention strategies. Multi-component interventions which were categorised as a sit-stand desk intervention done in conjunction with behaviour interventions (e.g. prompts, goal setting or self-monitoring) reported the greatest workplace sitting reduction (−88.8 min/8-h workday; 95% CI: −132.7, −44.9), followed by environmental intervention (e.g. sit-stand workstations, portable elliptical/pedal machines or treadmill desks) (−72.8 min/8-h workday; 95% CI:

−104.9, −40.6) and educational/behavioural strategies (e.g. motivational interviewing, goal setting or action planning) −15.5 min/8-h workday (95% CI:−22.9,−8.2).

Chu and colleagues concluded that the results illustrate consistent evidence for intervention effectiveness in reducing workplace SB, particularly for interventions using multi-component and environmental strategies (Chu et al., 2016). However, with 18 of the 26 studies having less than five months follow-up, these effects should only be considered valid in the short term and Chu notes that more long-term effectiveness studies are needed. In addition, Chu notes that although multicomponent and environmental interventions were effective, the potential costs or resources needed to maintain these strategies needs to be understood, therefore economic evaluations are warranted (Chu et al., 2016).

Two reviews, Neuhaus et al. (2014) and MacEwen et al. (2015), looked at the effectiveness of environmental interventions designed to change the workstation. Neuhaus and colleagues performed a meta-analysis on 19 field-based and 19 laboratory studies in which participants received either a standing workstation or an active workstation (e.g,. treadmill or cycling workstations). A total of 984 participants were included in the meta-analysis, and results indicated a decrease in SB of 77 minutes per eight=-hour workday (95% CI -120, -35 minutes) when using a standing/active workstation. In addition, Neuhaus and colleagues examined both work related outcomes and “other” health outcomes. Twenty-three studies reported work related outcomes across 112 outcomes. The majority of the outcomes were work performance outcomes and 84 of the 122 measured remained unchanged. Negative impact of the workstations on work performance was observed in 21 of 99 outcomes across seven of the 23 studies. Neuhaus et al. concluded that activity-permissive workstations can be effective at reducing occupational sedentary time, without compromising work performance (Neuhaus et al., 2014) .

Very similar to Neuhaus et al., MacEwan et al.'s (2015) systematic review examined the effectiveness of using standing and treadmill desks on physiological (energy expenditure, body composition, waist circumference) and psychological (worker productivity, well-being) outcomes. The review included 23 studies, 19 of which were quasi-experimental studies, and four were randomised controlled trials (MacEwen, MacDonald, & Burr, 2015). MacEwan and colleagues reported that standing and treadmill desks showed some promise for improving health outcomes, with treadmill desks typically showing greater physiological improvements when compared to standing desk interventions. Additionally, they reported that obese individuals seemed to gain greater health benefits from standing and treadmill desks than non-obese individuals. Furthermore, MacEwan reported that, overall, standing desks were not detrimental to cognitive functions or productivity, however, a decrease in typing and mouse performance was shown with the use of treadmill desks. In relation to psychological wellbeing, MacEwen and colleagues reported that there was conflicting evidence regarding sit-stand desk use and the effect on mood state. MacEwen and colleagues concluded that the evidence suggested that standing and treadmill desks may be effective in reducing workplace SB while having a positive influence on workplace stress and overall mood. (MacEwen et al., 2015).

In summary, Neuhaus and MacEwan both looked at the effects of changing the workstation on SB. Both studies suggest that standing desks or active workstations are effective ways to reduce SB. The two reviews also suggest that using the workstations does not appear to be detrimental, and in some cases may improve, other work-related outcomes and general wellbeing (MacEwen et al., 2015; Neuhaus et al., 2014). Furthermore, both authors also highlight similar limitations, agreeing that their results are limited by minimal follow-up, and called for future studies to look at the maintenance of effects (MacEwen et al., 2015; Neuhaus et al., 2014). However, this may only be possible to measure for interventions which are institutionalised into the workplace practice. Additionally, both reviews emphasised that there is a significant need for more robust evaluation of intervention effects on additional health and work-related outcomes, such as; musculoskeletal outcomes, engagement and performance at work and wellbeing related outcomes (e.g. mood or stress) (MacEwen et al., 2015; Neuhaus et al., 2014). These may be important to understand and measure in future interventions to minimise risk, and facilitate buy-in, for both employees and employers.

In the next review, Gardner and colleagues (2016) focused on the use of behaviour change techniques used in SB interventions among adults (Gardner, Smith, Lorencatto, Hamer, & Biddle, 2016). The review included an analysis of workplace interventions that were rated as either very promising, quite promising or non-promising. This was based on the within group or between group analysis of included studies showing statistically significant reductions in SB at one or more follow-up points when compared to baseline assessments. 'Very promising' interventions showed significant reductions in at least one SB indicator within the intervention group, and the reduction was greater than what was observed in a comparator arm (e.g. control or another intervention). Interventions were assessed as 'quite promising' where there was a significant decline in at least one SB indicator, or a reduction in at least one SB indicator was greater than observed in a comparator arm. Interventions were deemed 'non-promising' where there were no SB changes and no change relative to at least one comparator arm (Gardner et al., 2016). Of the twenty interventions, seven (35%) were judged very promising, five (25%) quite promising, and eight (40%) non-promising. Very promising interventions tended to have primarily targeted SB either solely or jointly with PA (five of seven interventions; 71%), only one quite promising (one of five; 20%) and one non-promising intervention (one of eight; 13%) focused on SB, with the rest of the interventions in these categories focusing on PA. Twenty-eight behaviour change techniques were each observed in at least one intervention. Gardner reported that there was no significant association between intervention promise and the number of techniques used. However, more promising interventions tended to use more techniques (very promising mean = 8.57, SD = 6.78; quite promising mean = 5.60, SD = 2.07) than did non-promising interventions (mean = 4.13, SD = 1.81). Fourteen behaviour change techniques (BCTs) were found to be promising, including; self-monitoring of behaviour, adding objects to the environment, instruction on how to perform the behaviour, reviewing behavioural goals, providing information on health consequences, and behaviour substitution. The final eight promising BCTs reported in the review were found in promising interventions only and included; restructuring the physical environment (five interventions), problem solving (four interventions), discrepancy between current behaviour and goal (two interventions), feedback on behaviour (two interventions), providing practical social support (two interventions), social comparison (two interventions), behavioural practice or rehearsal (two interventions), and restructuring the social environment (two interventions).

Gardner and colleagues presented evidence that behavioural interventions show promise for decreasing SB, with the most promising interventions targeting the reduction of SB rather than increasing PA. The evidence also suggested that SB interventions based on environmental restructuring, persuasion, or education were most promising; and self-monitoring, problem solving, and restructuring the social or physical environment were successful behaviour change techniques. Additionally, the authors highlight that they believe the evidence base is weakened by “low-quality” study design and therefore advocate lager-controlled trials to further understand the effectiveness (Gardner et al., 2016).

Two reviews have examined digital interventions to reduce SB in office workers (Buckingham, Williams, Morrissey, Price, & Harrison, 2019; Huang, Benford, & Blake, 2019). Firstly, Buckingham and colleagues’ review investigated the effectiveness, feasibility and acceptability of mobile health interventions (wearable activity monitors and smartphone applications) to increase PA and reduce SB in office workers (Buckingham et al., 2019). Twenty five interventions were included. Ten of the interventions specifically targeted SB, and four out of ten (40%) reported a significant reduction in sedentary time. Buckingham concluded that the impact of mobile health interventions on SB is not clear and mixed methods studies are needed to explore the reasons for decline in engagement over time (Buckingham et al., 2019).

Secondly, Huang and colleagues' 2019 scoping review explored digital interventions with an aim to map the current technologies utilised in workplace SB interventions (Huang et al., 2019). The authors identified 68 articles describing 45 digital interventions designed to reduce SB in office workers. Huang reported that six common technological features had been applied to interventions in various combinations, with the two most common interventions being; using either information delivery with mediated organisational and social support, or digital logs with automated tailored feedback. Other technological features such as the integration of passive data collection, connected devices, and scheduled prompts were mostly present in development and piloting research. Huang concluded that digital interventions targeting sedentary office workers would benefit from interdisciplinary collaborations, which link expertise in health intervention content development and evaluation, with the technical knowledge and capacity of industry. Huang suggested that this type of collaboration may maximise the potential of technologies to influence behaviour (Huang et al., 2019).

Based on their findings, both Buckingham and Huang acknowledge that, while digital interventions to reduce SB in the workplace show promise, the potential for future impact is unclear. The authors specifically call for the use of evaluation frameworks and mixed methods study designs which include qualitative data, to more robustly plan, conduct, and report digital interventions (Buckingham et al., 2019; Huang et al., 2019).

Several of the reviews presented above recognised the need to qualitatively examine SB in office workers (Buckingham et al., 2019; Huang et al., 2019; Shrestha et al., 2018); therefore in the following section the qualitative literature will also be examined, as understanding this literature may facilitate wider understanding of the nature of, and factors affecting sitting behaviour in the workplace.

1.8 Sedentary behaviour in office workers qualitative literature

There has been a steady and significant increase in research studies using qualitative inquiry to understand office workers' perceptions of SB. In this section, a recently published review and two individual studies not included in the review will be examined to gain an understanding of the factors influencing SB in the workplace.

Hadgraft and colleagues' (2018) review of the qualitative literature summarised the evidence on factors perceived to influence the acceptability and feasibility of reducing SB in the workplace. In the review, 32 studies were included with 88% (28/32) of the studies done with office or desk-based workers (Hadgraft et al., 2018). The studies were divided into two categories for analysis; those with an associated intervention component and those without. This distinction is important to examine as perceptions of feasibility and acceptability will inevitably be influenced by an intervention. Hadgraft and colleagues thematically analysed each results section of the included studies and identified common themes for both non-intervention studies and intervention studies (Hadgraft et al., 2018).

As a result of this analysis, several common barriers and facilitators were identified in non-intervention studies. The major barriers included; sitting being perceived as a long-term habit and therefore hard to change; individual choice to remain sedentary; standing perceived to be tiring/uncomfortable; desk-based work means sitting is perceived as function of job; productivity; workload pressure; perceptions of going against office norms of behaviour and culture which discourage reducing sitting; costs and resource needed to invest in reducing sitting and infrastructure to reduce sitting (e.g. standing desks, access to stairs or space). The perceived facilitators included; perceived personal benefits; jobs and tasks able to be performed standing or away from their desk; organisational and management permission, encouragement and support; visible leadership within office; assessable and inviting space and infrastructure (e.g. standing desks, outdoor and indoor break out space and centrally located office printers and bins) (Hadgraft et al., 2018).

The themes identified from the studies associated with interventions centred around barriers and facilitators to behaviour change, additional outcomes of the intervention, variations in experience of an intervention and acceptability for intervention strategies. The barriers and facilitators reported in intervention studies were very similar to those reported above. The barriers to reducing sitting included; musculoskeletal discomfort when using a sit-stand or treadmill desk; time pressures and the specific job task and job roles; feeling self-conscious of co-workers' perceptions; being perceived to be less productive by the employer; minimal infrastructure and difficulty with intervention equipment. Facilitators of change included; perceived health benefits of participation; feeling personally challenged; supportive workplace cultures; colleague participation; team leader and management support; installation of standing desks and safe and accessible infrastructure (Hadgraft et al., 2018). Additionally, in these studies participants perceived a range of additional effects of the intervention. These included; improved knowledge and awareness of health risks of high volumes of sitting; feeling less fatigue; perceptions of improved alertness and concentration; reduced neck and back pain; relief of stress and improved coping capacity; improved work performance; improved social interaction; acceptance of changing workplace behaviour norms related to reducing sitting (Hadgraft et al., 2018). Furthermore, they reported that within several individual studies, there was variation in participant experience, and the factors that appeared to contribute to the variation were; the level of support received from managers/team leaders and colleagues for organisational/behavioural change; individual levels of motivation to change behaviour; and the extent to which individuals found an intervention component helpful. Finally, Hadgraft and colleagues reported that overall studies reported positive perceptions of acceptability of interventions. Within two studies' participants expressed disappointment when equipment was removed at the end of the intervention (Hadgraft et al., 2018).

Hadgraft reported that similar themes were identified across non-intervention and intervention studies, with the consistently identified barriers being; the nature of seated desk-based work, work pressures and social norms that discouraged movement. Hadgraft stated that these barriers appeared to be influenced by the perceived feasibility of reducing SB in the workplace, particularly in low-cost interventions (Hadgraft et al., 2018).The key facilitators consistently identified across studies included social support from co-workers and managers, as well as, perceptions of benefits, including enhanced emotional well-being, and associated work-related benefits. Improved physical health was also consistently perceived as beneficial, however in non-intervention studies SB was perceived as detrimental to musculoskeletal health, and there was generally limited knowledge of how SB was affecting chronic disease risk (Hadgraft et al., 2018).

Based on their findings, Hadgraft and colleagues suggested that interventions should aim to; influence behaviour through changing workplace culture and social norms; tailor strategies to organisational needs; and emphasise and target support for strategies at the organisational level. Additionally, they suggested that future research should look to prioritise investigations which assess barriers and facilitators to reducing sitting time and incorporate perceptions of stakeholders into qualitative research when assessing feasibility and acceptability of intervention approaches (Hadgraft et al., 2018).

Two additional individual studies, not included in the review, will also be examined to explore specific barriers and facilitators within an individual study context. These two studies did not have intervention components, and were designed to understand office-workers' unbiased perceptions of their ability to reduce SB.

Firstly, a qualitative study by MacDonald and colleagues (2018) used psychological theory to examine office workers' perceptions of SB in the workplace (MacDonald et al.,2018). The COM-B (capability, opportunity, motivation -behaviour) model of behaviour (Michie, Van Stralen, & West, 2011) was used to understand the unbiased perceptions of workers who had not been a part of an intervention, (MacDonald et al). MacDonald et al.'s results suggested that office workers' lack of knowledge of SB as a health risk limits their psychological capability to elicit behaviour change. For example, when one study participant was asked if they thought sitting was affecting their health, they responded: *"Never. Never. No, and I actually didn't realise I sat so long until you asked".* MacDonald and colleagues' results also indicated that the 'pressure felt to complete work' also limited psychological capability to reduce SB, however, 'benefits of mental breaks' facilitated psychological capability to reduce SB. Additional themes that were considered barriers included; the habitual nature of sitting (M), lack of intention (M) and social norm to sit (O). MacDonald and colleagues also highlighted facilitators to reducing sitting time, which included; physical capability to change behaviour (C), social acceptability of change (O) and benefits of mental breaks. MacDonald concluded office workers are influenced by capability, opportunity and motivation to change sitting behaviour suggesting that all three components may need to be addressed to facilitate behaviour change (MacDonald et al., 2018).

More recently, Stephenson and colleagues (2020) conducted nine focus groups and two interviews exploring beliefs about strategies aimed at reducing occupational sitting (Stephenson et al., 2020). Stephenson reported that the main barrier to reducing sitting time was "job related tasks taking primary priority". Stephenson's results also indicated that individual preferences, environmental factors, judgmental culture, productivity concerns, and staff knowledge were all important to consider when designing interventions. Additionally, Stephenson reported that the results suggested technology-supported strategies (e.g. smartphone applications, computer software and emails) were deemed to be useful tools to provide prompts and allow behavioural self-monitoring in an easily individualised way (Stephenson et al., 2020).

In summary, office workers' perceptions of SB appear to be similar across studies. Barriers shared across the studies included; limited resources for implementation of strategies; existing workplace social and cultural norms; productivity concerns; the habitual nature of SB at work, and workplace infrastructure. There were also similar perceptions of the benefits gained from reducing SB including; health and wellbeing benefits of reducing SB, improved social connectivity, improved productivity and improved knowledge and awareness of health. The researchers suggested that, as substantial barriers to change exist, using multiple intervention strategies, including the use of technology may be needed. Qualitative inquiry may be the best placed method to understand and address the contextual factors affecting employees' and employers' ability to reduce SB in the workplace (Hadgraft et al., 2018; MacDonald et al., 2018; Stephenson et al., 2020).

1.9 Literature summary and research gaps

The systematic reviews examining SB interventions in office workers discussed in this chapter have each evaluated the evidence base in a unique way. Based on the author's analyses of the evidence, several gaps needing future research have been identified:

1) Investigation and reporting of effects of interventions on additional health outcomes and additional indicators of work engagement and performance (MacEwen et al., 2015; Neuhaus et al., 2014).
2) Investigation and reporting of the potential costs or resources needed for effective interventions to be maintained (Chu et al., 2016).
3) Evaluations of larger interventions with longer follow-up time to understand the maintenance of intervention effects over time (Shrestha et al., 2018; Chu et al., 2016).
4) Investigation and reporting which uses qualitative methods to understand employee and employer perceptions of feasibility and acceptability of intervention strategies (Hadgraft et al., 2018; Stephenson et al., 2020).
5) Investigations and reporting of intervention processes, and the potential for wider impact of interventions through mixed method investigation (Buckingham et al., 2019).
6) Use of evaluation frameworks to plan, conduct and report digital interventions targeting sedentary office workers (Huang et al., 2019).

Based on the evidence, and subsequent research gaps presented above, there appears to be minimal understanding of outcomes outside of effectiveness, and minimal understanding of the potential for any type of intervention targeting SB in the workplace to be implemented and maintained under real world conditions, to produce impact. For example, Chu and colleagues' call for economic evaluations of interventions clearly suggests there is very little understanding of other outcomes which would inform feasibility of wider implementation (Chu et al., 2016). This is concerning as improving this is critical to reducing the chronic disease burden of SB in the adult population. Questions outside of efficacy/effectiveness such as; what resources were used in implementation; and can employees, and employers, engage with and maintain the intervention, need to be answered. The need to understand additional outcomes outside efficacy/effectiveness is echoed by Buckingham and Huang who have suggested there is a need for a new lens of evaluation of SB interventions in the workplace. This should not only focus on efficacy/effectiveness outcomes, but also address outcomes which will evaluate an intervention's potential to be practically implemented and have public health impact (Buckingham et al., 2019; Huang et al., 2019).

2. Pragmatic Evaluation in Health Promotion

Outline

In this section further details will be given regarding the underpinning epistemology, methodology and terminology used throughout the PhD to understand SB in office workers. Firstly, the rationale for the chosen philosophical paradigm of research will be presented. Secondly, Bauman and Nutbeam's conceptualisation of pragmatic health promotion evaluation, which underpins the approach and terminology used in this PhD, will be presented. Thirdly, Glasgow and colleagues' RE-AIM (reach, efficacy/effectiveness, adoption, implementation, maintenance) evaluation framework, which is the methodological backbone of this PhD, will be presented and discussed in detail.

2.1 PhD Epistemological Perspective

The gaps identified above in the SB in office worker literature clearly suggest that there is a need for a shift in scientific lens, to expand our understanding of indicators outside effectiveness. To do this effectively, it requires a shift away from traditional research paradigms, that largely ignore real world context (Long, McDermott, & Meadows, 2018), and towards an epistemological perspective that allows the researcher to place significant value on practical outcomes that need to be understood to advance this research area. In order to place value on these indicators, pragmatic philosophy has been identified as best placed to shape the inquiry presented in this PhD.

Pragmatism is a branch of philosophy, in which, "truth" or hypothesis and theory may be assessed in terms of not only effect, but also practicality. Pragmatic philosophy is concerned with balancing "verification" with the "practical" and "achievable" (Ruwhiu & Cone, 2010). Pragmatism suggests that the value of knowledge is context-dependent, and is extrinsically useful for addressing practical questions of daily life (Ruwhiu & Cone, 2010; Talisse & Aikin, 2008). Therefore, pragmatism is more concerned with establishing, firstly, what will work in the real world; and then moving towards what will work 'best' in the real world (Long et al., 2018). In health research, pragmatism is an emerging research paradigm that is proving useful in evaluating interventions that happen in complex real-world contexts (Janiaud, Dal-Ré, & Ioannidis, 2018; Long et al., 2018; Shaw, Connelly, & Zecevic, 2010). The arguments being that, until interventions are evaluated under real-world conditions, there is little understanding of their true potential (Long et al., 2018). Additionally, there is significant evidence within health research that pragmatism, as a paradigm, lends itself to combining quantitative, and qualitative methodologies in the pursuit of understanding multifaceted problems (Shaw et al., 2010).

2.2 Bauman and Nutbeam's pragmatic health promotion evaluation

Bauman and Nutbeam suggest that, in health promotion, we use evaluation to both understand the influence an intervention or program has on health outcomes, and understand the different processes that lead to these outcomes (Bauman & Nutbeam, 2013). Health interventions can be evaluated in many different ways, over a large number of indicators of success. Three distinct types of evaluation that are often utilised in health promotion are: formative evaluation, impact or outcome evaluation and process evaluation. A formative evaluation is described by Bauman and Nutbeam as a set of activities designed to develop and test program methods and materials. This type of evaluation should be undertaken in the beginning phases of the research process as part of the intervention planning. An outcome/impact evaluation or assessment is used to assess to what extent an intervention successfully achieves its goal, for example did the intervention successfully reduce SB. Finally, a process evaluation is used to investigate and improve the implementation of an intervention or program by critically and methodically analysing the successes and/or failures. The process evaluation identifies who was exposed to, and participated in, the intervention. It also seeks to understand if, and to what extent, stakeholders and partners engaged in the intervention. Although each type of evaluation described above is a part of this PhD, the process evaluation is best placed to assess additional indicators needed to understand an intervention's potential to have public health impact (Bauman & Nutbeam, 2013).

As defined above, the process evaluation seeks to understand intervention implementation in terms of what happened, how did it happen and why did it happen (Bauman & Nutbeam, 2013). The process evaluation is most often done alongside the impact evaluation and starts as the intervention is initiated, after the formative evaluation. A process evaluation may help explain which elements of an intervention facilitated effectiveness, as well as explain what barriers to effectiveness existed. Additionally, the process evaluation should encompass an assessment of health promotion outcomes (e.g. health-related knowledge, self-efficacy, motivation). Bauman and Nutbeam describe that health promotion outcomes are essential to understand as they lead to changes in intermediate health outcomes (e.g. behaviour or environment), which will directly influence the associated health outcomes. Furthermore, Bauman and Nutbeam explain that in health promotion research, collecting data regarding "the process" is important for all types of interventions, from efficacy or pilot interventions to scaled-up interventions, and should always be included. However, they suggest that due to the predominance of efficacy/effectiveness driven research, resources are directed into assessments of effects, leaving a significant gap in understanding how a program was implemented, and what led to the successes or failures in meeting the desired outcomes.

The authors suggest that a robust process evaluation would often require a mix of quantitative and qualitative methods to capture the data and information needed to answer the types of research questions it seeks to address. Additionally, they suggest that the chosen methodology used to capture this diverse data must be carefully considered and reflect the needs of individual research areas (Bauman & Nutbeam, 2013). Based on a need to investigate real world potential in the SB in office worker research area the RE-AIM evaluation framework was chosen as the methodology to underpin the PhD investigation.

2.3 RE-AIM Evaluation Framework

Although many evaluation frameworks exist, The RE-AIM (reach, efficacy/effectiveness, adoption, implementation, maintenance) evaluation framework was developed specifically to assist researchers in the assessment of the potential for an intervention to have impact in real world settings (Glasgow, Vogt, & Boles, 1999). Additionally, when evaluated with other frameworks and models for implementation and dissemination research, RE-AIM was described as; highly detailed, with step-by-step actions for completion of implementation and dissemination research processes; equally appropriate for disseminating evidence-based interventions to the target audience using planned strategies, as well as, implementing evidence-based interventions within diverse settings (Tabak, Khoong, Chambers, & Brownson, 2012).

The RE-AIM evaluation framework was developed by Glasgow and colleagues based on their belief that the progress in translating public health interventions into real world settings had been hampered by evaluation methods which focus on “efficacy”, and ignore other dimensions or indicators considered crucial to understanding an intervention’s potential to have wider public health impact (Glasgow et al., 1999). In their original commentary, Glasgow, Vogt and Boles discuss that the emphasis on finding significant results on outcomes often produces interventions that are resource intensive, expensive and demanding on both participants and providers; all of which will affect the likelihood of successful implementation under real world conditions.

Glasgow, Vogt, and Boles suggest that deriving success of an intervention based on the narrow lens of outcome driven evaluation can lead to a waste of resources, gaps between stages of research, and failure to improve public health in an efficient manner (Glasgow et al., 1999).

Glasgow and colleagues conceptualised that the public health impact of an intervention is a function of five dimensions and these five dimensions make up the RE-AIM evaluation framework. The first dimension, reach, is defined as the absolute number, proportion and representativeness of individuals who are willing to participate in a given initiative. Effectiveness/efficacy is defined as the impact of an intervention on important outcomes, including potential negative effects, quality of life, and economic outcomes**.** Adoption is defined as the absolute number, proportion, and representativeness of settings and intervention agents who are willing to initiate an intervention or program. Implementation is concerned with setting level implementation, and is defined as the intervention agents' fidelity to the various elements of an intervention's protocol. This includes consistency of delivery as intended, and the time and cost of the intervention. Maintenance is defined as the extent to which a program or policy becomes institutionalised or part of the routine organisational practices and policies. Maintenance in the RE-AIM framework also has referents at the individual level. At the individual level, maintenance has been defined as the long-term effects of a program on outcomes after six or more months after the most recent intervention contact. Glasgow and colleagues explain that evaluating across the five dimensions should encourage scientists to improve reporting of indicators of each dimension by enabling the measurement of the external validity of an intervention alongside the measurement of internal validity (Glasgow et al., 2019).

In the 20 years since development, RE-AIM has been applied to planning and evaluation in over 450 publications. It has been widely used across a variety of populations, settings, health outcomes and study designs (Glasgow et al., 2019). For example, in a 2015 analysis of the framework's use, Shoupe and colleagues reported 144 published RE-AIM citations in the health literature, and identified the top five outcomes studied. These included PA (34 articles), diabetes (22 articles), obesity (13 articles), smoking cessation (13 articles), and heart disease (8 articles). The most frequent study designs utilised were evaluation (43), randomised control trials (31), systematic reviews (14), prospective cohort designs (14), and literature reviews (12) (Shoup, Gaglio, Varda, & Glasgow, 2014).

As the RE-AIM framework has been used over the past two decades, it has evolved from a framework that focuses on quantitative methods to a framework that encourages a mixed methods approach to evaluation. In Kessler et al.'s 2013 paper addressing what it means to "employ" the RE-AIM framework, use of qualitative methods was added as a criteria or indicator of each dimension of the RE-AIM framework (Kessler et al., 2013). The authors explained that qualitative methods help researchers understand the "how" and "why" behind both individual RE-AIM dimensions (e.g. why did drop-out occur), and understand patterns of results across dimensions (e.g. why was there high reach, but low effectiveness) (Holtrop, Rabin, & Glasgow, 2018). In a 20-year review of the framework Glasgow and colleagues further addressed the importance of using qualitative methods within RE-AIM; acknowledging that quantitative measures alone were insufficient to strongly predict outcomes or indicators of each dimension, and using mixed methods study designs can help identify causal factors related to RE-AIM outcomes in different situations. In response to the need to incorporate qualitative inquiry, a team of researchers developed an addition to RE-AIM called QuEST (Qualitative Evaluation for Systematic Translation).

2.4 RE-AIM QuEST mixed methods framework

The RE-AIM Qualitative Evaluation for Systematic Translation or RE-AIM QuEST mixed methods framework has been developed by Forman and colleagues to facilitate integration of qualitative inquiry, with the already established quantitative indicators of the RE-AIM framework (Forman, Heisler, Damschroder, Kaselitz, & Kerr, 2017). Forman and colleagues explain that RE-AIM QuEST expands each dimension to allow evaluation of contextual factors and mechanisms that link context, process and outcomes. Furthermore, Forman and colleagues suggest that using RE-AIM QuEST will help to examine and unpack how the context of implementation will influence external validity or translation of the intervention into wider settings. The framework proposes general qualitative questions that are applicable to specific dimensions. Table 1.1 illustrates the RE-AIM dimensions and the general qualitative questions Forman and colleagues suggest for each dimension.

Table 1.1: RE-AIM Dimensions with associated QuEST questions

RE-AIM Dimension	QuEST questions
Reach	What are the barriers to enrolment and how can they be addressed? What are the barriers to participation? What are the reasons for not participating?
Effectiveness	What are the conditions and mechanisms that lead to effectiveness? What explains variations in outcome measures?
Adoption	What affects provider participation?
Implementation	What were the modifications to the intervention and why did they occur? What were the barriers to fidelity? What are the contextual factors and processes underlying barriers to implementation and how do we address them?
Maintenance	In what form are the components of the intervention sustained? What are the modifications made at each site after the study? What are the barriers to maintaining the program?

These general open ended “companion questions” may be used directly or used to help create study specific questions across each dimension of the RE-AIM framework. Additionally, it is suggested by Forman and colleagues that it may be important to use multiple data sources to address questions, as it allows for triangulation and provides a holistic and robust understanding of the intervention being evaluated (Forman et al., 2017). This more robust RE-AIM framework will help facilitate understanding of the potential for SB interventions in the workplace to have public health impact

3. Thesis Aim

In this PhD, pragmatic evaluation, and the RE-AIM framework will be used to investigate SB in office workers, with an aim to inform and improve our understanding of how to disseminate (report) and implement interventions targeting SB in office workers for public health impact in the real world. The following research questions have been addressed to achieve this overall aim.

Table 1. 2: Research questions

PhD Chapter	Research questions
Chapter 2	1) What proportion of RE-AIM indicators are in the literature? 2) Do gaps in reporting indicators exist? 3) Which dimensions and indicators across reach, effectiveness, implementation and maintenance are underreported? 4) What existing methods have been used in the literature to report on underreported dimensions and indicators?
Chapter 3	1) What is the potential for future implementation and scale up of a consultation-based workplace intervention which targets reducing and breaking up sitting time? 2) What are the barriers and facilitators to reach, effectiveness, adoption, implementation and maintenance of the consultation-based intervention? 3) What are the adaptations needed to scale-up the intervention?
Chapter 4	1) What is the potential reach, effectiveness, adoption, implementation and maintenance of a digital health promotion application which targets reducing and breaking up sitting across multiple worksites? 2) What are the barriers and facilitators to reach, effectiveness adoption, implementation and maintenance of the digital application? 3) What improvements are needed to improve the digital application across reach, effectiveness, adoption, implementation and maintenance?

4. Structure of thesis

This thesis consists of three studies (chapters 2-4). Each of these chapters includes a preface section, followed by a second section in which a manuscript of the PhD study is presented. In the preface sections of each chapter the study will be introduced by providing the reader with the rationale and background information needed to contextualise the study. This also includes additional information related to the planning of the study, and further details of the methodologies used in the study. The studies themselves have been written for publication and the format and structure follows the journal's specification. Chapter 2 has been peer reviewed, and published in the International Journal of Environmental Research and Public Health (IJERPH) (Special Issue: Occupational Sedentary Behaviour). Chapter 3 has been peer reviewed and published in the topical collection "Sedentary Behaviour and Health" also in IJERPH. Chapter 4 has been published in a special issue titled Mixed Methods Evaluation in Sedentary Behaviour in IJERPH. The final chapter, Chapter 5, will be a discussion chapter; where the findings of the three studies will be discussed in relation to the wider context of the PhD thesis.

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Chapter 2: An Integrative, Systematic Review Exploring the Reach, Effectiveness, Adoption, Implementation, and Maintenance of Interventions to Reduce Sedentary Behaviour in Office Workers

1. Preface

1.1 Rationale

In order to understand the potential for public health impact of SB interventions in office workers, researchers may need to measure and report on indicators of reach, effectiveness, adoption, implementation and maintenance. Although many systematic reviews have been carried out, the majority have had a focus on evaluating the literature in relation to outcomes of effectiveness only. A review of the literature to understand what indicators of reach, effectiveness, adoption, implementation and maintenance (RE-AIM) are reported across the literature was deemed as an appropriate starting point to building understanding of how to inform and improve implementation and dissemination. This would help identify if gaps in reporting exist, and if so, which indicators are underreported, and which existing methods may be useful in collecting data on underreported indicators. To conduct a review of SB in office worker interventions that captures data across all of the RE-AIM framework dimensions, a shift in approach to reviewing the literature was needed. This was a shift towards an approach that allowed for a broad inclusion intervention methodology, and did not seek heterogeneity within included studies.

1.2 Integrative systematic review

An integrative review is a specific review method that allows for the summary of diverse literature to provide a more comprehensive understanding of a particular research area or problem (Whittemore & Knafl, 2005). The approach allowed for the inclusion of diverse methodologies including experimental and non-experimental research designs as well as qualitative investigations. There are five stages to conducting an integrative review, which include problem identification, literature search, data evaluation, data analysis and presentation. This section will focus on the methodology that is not presented in the manuscript which follows this preface, in order to give the reader a full understanding of the methodology used in the integrative systematic review.

1.2.1 Problem identification

A significant amount of reading of the literature, along with a scoping exercise in which the researcher read and analysed the systematic review evidence, became the background for identifying the research questions of the systematic review. The full table is presented in Appendix A. Additionally, a protocol was developed to further refine the objectives and aim of the systematic review.

1.2.2 Literature search

Whittemore and colleagues suggest that the literature search process of an integrative review should be clearly documented in the methods section including the search terms, the databases used, additional search strategies, and the inclusion and exclusion criteria (Whittemore, 2005). Search terms were developed using the PICOS framework (Population, Intervention, Comparison, Outcome and Study Design). This was done by identifying key words that related to the research questions of the systematic review and categorising them in relation to PICOS. For example, in the population category (P) words such as office worker, employee and staff were identified as key words. Based on the research questions and the need to look across the spectrum of research there were no comparator (C) group words needed in the search strategy. After the search terms were identified the terms that allowed for truncation symbols were added to account for alternate word endings. The search was then tested and refined to fix minor mistakes. The final search can be seen in Table 2.1. The databases that were searched and inclusion/exclusion criteria are presented along with some of the search terms in the manuscript in this chapter.

Table 2. 1: Search terms in PICOS table

PICOS	Search terms with truncation
Population	(“office staff” or worksite or work* or employ* or staff or adults or “white collar”).ti,ab.
Intervention	(“pragmatic evaluation” or “process evaluation” or “program evaluation” or feasibility or pilot or “health promotion” or “health program” or program* or trial or “program theory” or “theory of change” or “logic model“ or “health behavior change” or “intervention” or ”sitting desk” or “sitting workstation*” or “cycl* workstation*” or “treadmill desk” or “treadmill workstation*” or “activ* workstation*” or “activ* permissive workstation*” or “sitting workstation*” or “seated workstation*” or “height adjusted workstation*” or “hot desk” or “sit-stand desk”).ti,ab.
Outcome	(“validity” or “external validity” or “internal validity” or “behavior change” or “policy change” or “community change” or participation or “quality of life” or reach or influence or effectiveness or success or usefulness or efficacy or adoption or acceptance or maintenance or preservation or acceptability or rate or appraise or analyses or implement* or implementation or deliver).ti,ab.

Outcome	With mesh (Sedentary lifestyle.af. or (“Sedentary behav*” or “sedentary time” or “sedentary activ*” or sitting or “sitting time” or “sitting behav*” or “screen time” or “screen based” or “chair based” or “deskbound” or “physical inactiv*” or “inactive lifestyle” or “lack of activity”).ti,ab.
Setting	(“workplace setting” or office or business company or occupation or career or “office based” or “desk based” or “call center” or “office environment”).ti,ab.

1.2.3 Data evaluation

The data evaluation section relates to evaluating the quality of included studies. In an integrative review the evaluation of diverse interventions can become complex and the authors suggest that how quality is evaluated will vary depending on the sampling frame (Whittemore & Knafl, 2005). In this review, as the studies included were so diverse in nature it was not acceptable to rate against validated existing quality assurance tools. In an integrative review, the authors suggest that the creation of bespoke methods is often appropriate. In this review, as the PhD student was evaluating reporting across the RE-AIM dimensions, each study would get a score based on how many RE-AIM indicators were addressed. However, as the studies included were so diverse it was not appropriate to suggest that this could be considered a measure of quality outside of this review. It was therefore decided to include the studies’ ratings across RE-AIM indicators in the supplementary table of the published paper. This can be referred to in Appendix B and C.

1.2.4 Data analysis and presentation

The final two categories; data analysis and presentation are both fully addressed within the manuscript. In relation to the data analysis, integrative review methodology is predominantly concerned that material and information is ordered, coded, categorised, and summarised into a unified and integrated conclusion about the research problem. Additionally, an unbiased interpretation of primary sources, along with a clear synthesis of the evidence, are the goals of the data analysis stage (Whittemore, 2005; Whittemore & Knafl, 2005). In relation to the data presentation, it is suggested that data from individual sources is brought together around particular variables or subgroups to aid in the discussion of the results. Additionally, data displays such as graphs or charts enhance the visualisation of patterns and relationships within and across variables and serve as a starting point for interpretation (Whittemore & Knafl, 2005). This guidance significantly informed the approach taken within the analysis and discussion of the integrative systematic review.

The aim of the preface section of this chapter was to provide additional detail in relation to the rationale and methodology of the first study of the PhD, the integrative systematic review. The published manuscript will now be presented.

Paper 1: An Integrative, Systematic Review Exploring the Reach, Effectiveness, Adoption, Implementation, and Maintenance of Interventions to Reduce Sedentary Behaviour in Office Workers

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2 Abstract

Sedentary behaviour is associated with poor health outcomes, and office-based workers are at significant health risk, as they accumulate large proportions of their overall sitting time at work. The aim of this integrated systematic review was to collate and synthesise published research on sedentary behaviour interventions in the workplace that have reported on at least one an aspect of the reach, effectiveness, adoption, implementation, and maintenance (RE-AIM) framework. Studies were included if they involved adult office workers, were conducted in an office setting, and changes in sedentary behaviour had been measured as a primary outcome. Five electronic databases were searched yielding 7234 articles, with 75 articles (61 individual interventions) meeting the inclusion criteria. Reach indicators were the most frequently reported RE-AIM dimensions, which were reported on average 59% of the time. Efficacy/effectiveness was the second most reported dimension at 49% reporting across all of the indicators. Implementation indicators were reported an average of 44% of the time, with indicators of adoption and maintenance reported as the lowest of all indicators at 13% and 8%, respectively. Recommendations are provided to improve reporting across all RE-AIM dimensions, which is an important first step to enable the effective translation of interventions into real world settings.

Keywords: sitting time; sedentary; occupational; office workers; RE-AIM; translation; evaluation; review

3 Introduction

Sedentary behaviour (SB), or sitting time, is associated with an increased risk of chronic diseases, such as metabolic syndrome, cardiovascular disease, and diabetes mellitus, in addition to increased all-cause mortality in adults [1–3]. Despite the health risk, representative samples indicate that the prevalence of SB is high in Western adults (between 6.8 and 11.2 h/day) [4–6]. Research suggests that office-based workers are at significant health risk, as they accumulate large proportions of their overall sitting time at work [7–9]. The global prevalence of occupational sitting will likely continue to rise as the labour market continues to shift towards computerised employment [10]. Consequently, the United Kingdom has developed guidance for employers in order to promote the avoidance of prolonged periods of sedentary work [11].

There has been an increase in interventions targeting sedentary office workers [12–15], and a number of reviews of the intervention work have followed [16–19]. The majority of these reviews have provided an evaluation of these interventions in relation to indicators of “efficacy” [16–19]. However, there has been growing critique suggesting that, although indicators of efficacy are important to assess, there is little understanding of the additional indicators, which may help to understand the potential for successful translation and future real-world implementation [20]. Critics argue that other indicators that facilitate an understanding of generalisability and translation are equally important to evaluate, particularly if these additional indicators impact the success of future implementation, and consequently the potential public health impact of a given intervention [20,21].

The RE-AIM evaluation framework is one of several existing methods used to evaluate or report on the additional indicators that could influence the future external validity of an intervention. Glasgow et al. (1999) [22] proposed five dimensions in which these indicators sit—*reach, efficacy/effectiveness, adoption, implementation, and maintenance*. Reach is defined as the absolute number, proportion, and representativeness of individuals who are willing to participate in a given initiative. Efficacy/effectiveness refers to the impact of an intervention on the relevant outcomes, including potential adverse effects, quality of life, and economic outcomes. Adoption, within RE-AIM, is the absolute number, proportion, and representativeness of the settings and intervention agents who are willing to initiate a program. Implementation refers to the intervention agents' (e.g. research teams) fidelity to the various elements of an intervention's protocol. This includes consistency of delivery as intended, and the time and cost of the intervention. The maintenance dimension is concerned with both the setting and individual level. At the setting level, maintenance is the extent to which a program or policy becomes institutionalised or part of organisational practices and policies. At the individual level, maintenance has been defined as the long-term effects of a program on outcomes from six months onwards from the most recent contact [22,23].

Glasgow et al. (2004) [23] further explains that evaluating interventions over the five dimensions of the RE-AIM framework will help to facilitate an understanding of the potential external validity and public health impact of an intervention. This type of reporting is critically important as we move on a continuum from understanding an intervention effect produced under controlled conditions, towards implementation under real world conditions [21]. To date, no systematic reviews on SB interventions in office workers have been conducted using the RE-AIM framework. Therefore, the aim of the current study is to conduct a systematic review of SB interventions in the workplace focusing on the RE-AIM dimensions (reach, effectiveness, adoption, implementation, and maintenance). The review aims to gain an understanding of the proportion of RE-AIM indicators that are reported in the literature so as to identify whether gaps in reporting exist, which indicators are underreported, and which existing methods may be useful in collecting data on underreported indicators.

4 Methods

In order to capture published literature reporting on any dimension of the RE-AIM framework, an integrative, systematic review approach was used. The integrative methodology is specifically designed to facilitate the inclusion of a broad range of research designs, both qualitative and quantitative, so as to comprehensively understand a given phenomenon [24].

4.1 Search Strategy

Studies were included if they involved adult office workers, were conducted in an office setting, and if changes in SB had been measured (objectively or subjectively) as a primary outcome of the study. No limitations were placed on the design of the study. The inclusion/exclusion criteria and search terms were developed through scoping searches. The review team used PICOS criteria (population, intervention, comparators, outcome, and setting) to facilitate this process (Table 2.2). The search terms were used to search five electronic databases (MEDLINE (Ovid platform), PsycINFO, SPORTDiscus, Business Source Complete, and OPEN Grey), and searching was completed on 7 December 2017.

Table 2. 2: Inclusion and exclusion criteria and search terms based on PICOS (population, intervention type, and comparator, outcomes of interest, and setting)

PICOS Table	**Inclusion Criteria**	**Exclusion Criteria**	**Search Terms**
Participants /Population	Adult office workers	Children, non-working adults, workers outside of office setting, older adults	Office staff, worksite, work *, employ *, staff, adults, white collar
Intervention	All interventions targeting SB in the workplace experimental and quasi-experimental designs, natural experiment and qualitative	Systematic reviews, meta-analysis, commentaries, conference proceedings, methodology studies, validation studies, lab-based studies	Pragmatic evaluation, process evaluation, program evaluation, feasibility, pilot, health promotion, health program, program *, trial, program theory, theory of change, logic model, health behaviour change, intervention, sitting desk, sitting workstation, cycle * workstation, treadmill desk, treadmill workstation *, active * workstation *, active * permissive workstation *, sitting workstation *, seated workstation *, height adjusted workstation *, hot desk, sit-stand desk
Comparator	All comparison or self-comparison (pre-post design, natural experiment)		
Outcome	SB measured & RE-AIM checklist elements		SB (sedentary, sedentary behave *, sedentary time, active *, sitting, sitting time, sitting behave *, screen time, screen based, chair based, deskbound, physical inactive *, inactive lifestyle, lack of activity) & RE-AIM-(Validity, external validity, internal validity, behaviour change, policy change, community change, participation, quality of life, reach, influence, effect *, success, usefulness, efficacy, adoption, acceptance, maintenance, preservation, acceptability, rate, appraise, analyses, implement, deliver *)
Setting	Office setting		

SB—sedentary behaviour; *—truncation symbol; RE-AIM: reach, efficacy/effectivness, adoption, intervention, maintenance.

4.2 Screening Process

The retrieved articles (*n* = 7234) were exported into EndNote (Clarivate Analytics, Philadelphia, PA, USA) so as to remove duplicates. After the removal of the duplicates, a total of 5533 articles were left. These articles were then exported into Covidence (Covidence, Melbourne, Australia) for screening. Covidence is an online platform that is designed to enhance the reliability of systematic reviews by facilitating organisational that which enhance the rigour within the screening process. The platform also facilitates the blinding of the screening process between reviewers. Double screening of the studies was carried out at two stages, namely: title/abstract and full text. At the end of each stage, two reviewers (B.M. and M.P.) met to discuss the disagreements. Cohen's Kappa calculations were done for the title and abstract (0.96), and for the full text (0.97). The studies that could not be agreed upon were brought to a third member of the review team (X.J.) and were discussed. On all occasions, a final decision was agreed upon by all parties. Figure 2.1 highlights this process.

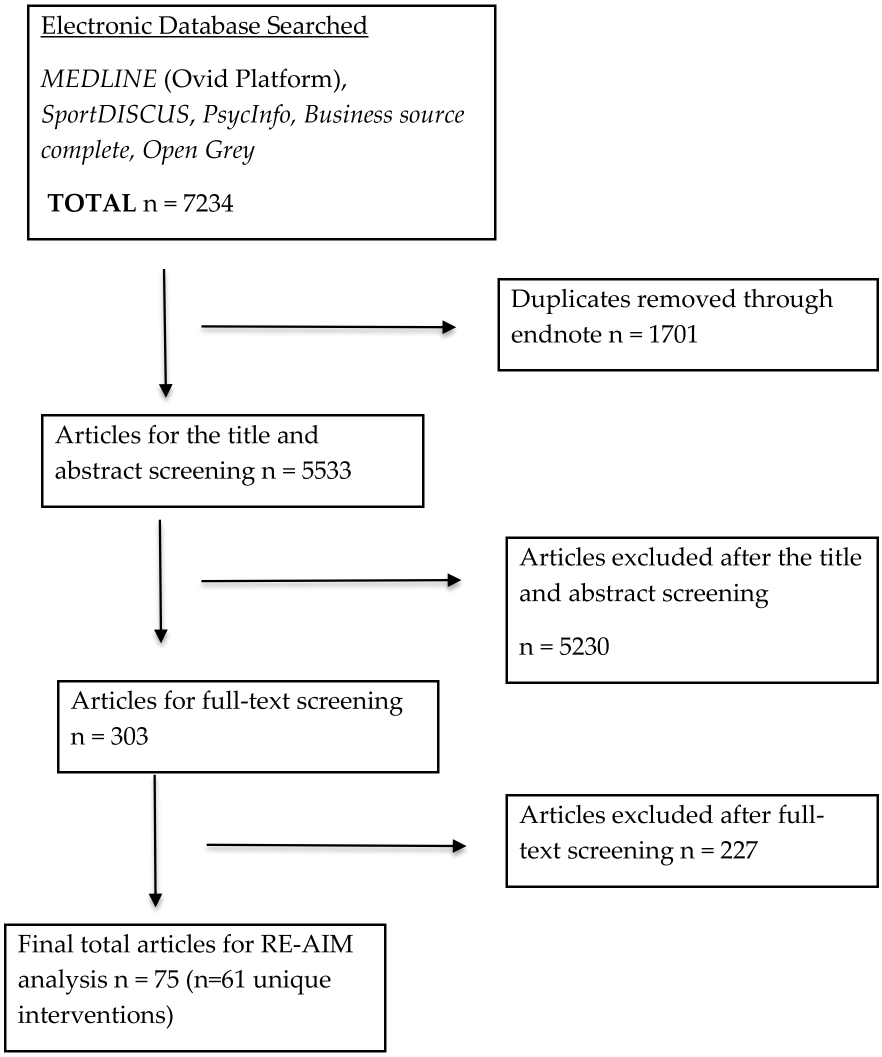

Figure 2. 1: Flow diagram of studies included in the review. RE-AIM—reach, effectiveness, adoption, implementation, and maintenance

4.3 Data Extraction

The data was extracted using a combination of two validated RE-AIM coding sheets [23,25–27]. The combination of the two sheets facilitated in the coding of information across all five dimensions of the RE-AIM framework, looking at 28 individual indicators from each intervention. The alignment of these indicators to each dimension of the RE-AIM framework is noted below.

4.3.1 Reach

The items from the extraction tool that facilitated in reporting on the potential reach of an intervention included the following: the method used to identify the target population, inclusion criteria and exclusion criteria, use of qualitative methods to understand reach or recruitment, sample size, participation rate, and sample representatives. The participation rate was calculated based on the reported number of participants, divided by the number of eligible participants exposed to recruitment. The sample representativeness information was extracted if an intervention reported the demographics of both the participants and eligible non-participants.

4.3.2 Efficacy/Effectiveness

The efficacy and effectiveness items included the following: assessment of the effect on outcomes at shortest assessment point, imputation procedures reported, the presence of quality of life measure, effects at longest follow-up, use of qualitative methods to understand outcomes, and percent attrition or dropout rate. If the attrition rate was not directly reported, it was calculated based on the participant numbers at randomization, as compared to the participant numbers at shortest assessment point.

4.3.3 Adoption

The items that were extracted for *adoption* related to both the setting and participants. Specifically, the extent to which a study reported; *the method of identifying target agent*—an agent should be identified regardless of the type of intervention (e.g. device-based or consultation approach); *level of expertise of delivery agents* (e.g. was specific training or level of understanding or influence reported for different intervention agents)—may be less relevant in device based interventions; *inclusion and exclusion criteria for target agent*—relevant for all intervention types; *the adoption rate (e.g. number of companies who took part/number of companies who were approached)*—relevant for all intervention types; *comparison of settings/participants of adoption vs. non-adoption settings* (e.g. demographic or environmental differences between adoption of program/intervention vs. non-adoption)—relevant for all intervention types; *and use of qualitative methods to understand either adoption at setting level and staff participation*—relevant for all intervention types.

4.3.1 Implementation

Information relating to the implementation that was extracted and reported on. Specifically, *the intervention type* (e.g. individual component vs. multi-component) *and intensity*. With no specific guidance on a measure of intensity, the review team judged the reporting of intensity based on the reporting of the length of the intervention, as well as components of the intervention. Further items included the following: the extent the protocol was delivered as intended (e.g. did the intervention achieve its intended implementation goal or did protocol need to be adapted); a measure of cost (e.g. monetary or time commitment); and use of qualitative methods to understand the implementation of the study.

4.3.2 Maintenance

Maintenance was assessed using the following three items: was an individual’s behaviour assessed at least six months following the completion of the intervention; is the program still in place, was the program modified, and use of qualitative methods to understand long-term effects.

All of the relevant information was extracted and coded in an excel spreadsheet by two reviewers (B.M. and M.P.), with each researcher extracting half of the papers. Upon the completion of the extraction, each of the 28 items were colour coded green if the information was presented, or red if the information was not presented. All of the data extraction was then double checked by a third member of the review team (X.J.) so as to enhance reliability.

4.4 Quality Assessment

Because of the broad range of study designs and the use of the RE-AIM reporting item for data extraction and reporting, no further assessment of the study quality was performed.

5 Results

5.1 Study Selection

The initial searches identified 7234 articles, and after title and abstract screening, 303 full text articles were screened. Of these, 75 articles representing 61 individual interventions were included in the review (Figure 2.1).

5.2 Characteristics of Identified Articles

Table 2.3 describes the characteristics of the identified articles. It is important to understand the distinction between the articles and interventions from this point forward in the review. The results of 10 interventions were reported in more than one article. This information has been brought together in order to understand the reporting of all of the indicators across the dimensions of the RE-AIM framework. This method has been used in other RE-AIM reviews for the same purpose [26,28]. In total, there were 75 included articles in the review, representing 61 individual interventions. Table 2.3 identifies which articles are from the same intervention. Of the 61 interventions, 23 interventions were completed in North America, 22 in Europe, 15 in Australia, and 1 in South America. The integrated review approach facilitated a large variety in both the study design and outcome measurement method. Of the 75 published articles, 39 reported controlled designs (both randomised and non-randomised), which was the most frequent. A total of fifteen articles reported pre- and post-test experimental designs; seven reported qualitative designs, six of which were reported as natural experiments; five reported quasi experimental designs, one of which was a cross sectional design; one reported mixed methods design; and one reported descriptive design. The duration of the interventions that were included ranged from one day to 12 months, with 20 interventions reporting less than 7 weeks, 25 interventions reporting 2–4 months, nine interventions reporting 4–9 months, and five interventions reporting 12 months. Two interventions did not report an intervention duration. In total, 17 individual data collection methods were used to measure SB. Objective measures of SB were used in 39 interventions, with the most common being ActivPAL (*n* = 20). Other objective measures included accelerometery, video analysis, and objective proxy measures. Subjective measures of SB were used in 31 interventions, with the most common type being a questionnaire (*n* = 23). Other subjective methods included interview, focus group, diary/log, and open-ended questions. It should be noted that the number of SB outcome measures does not exactly equal the number of included interventions, as a result of nine of the 61 interventions using both objective and subjective measures of SB.

Table 2. 3: Characteristics of included articles

Study Author and Year	Continent (Country)	Number of Participants	Outcome Measurement	Measurement Method	Study Type	Intervention Duration
Aittasalo et al. (2012) [29]	Europe (Finland)	*n* = 295	Primary—SB and PA Secondary—work ability and employee participation	Objective—accelerometer Subjective—workforce sitting questionnaire and additional questions on work ability	Pre- and post-longitudinal	12 months
Alkhajah et al. (2012) [30]	Australia (Australia)	*n* = 32	Primary—SB Secondary—body fat, fasting total cholesterol, HDL cholesterol, triglycerides, and glucose levels	Objective—ActivPAL, bioimpedance, and cholestech LDX analyzer	Quasi-experimental design	3 months
Arrogi et al. (2017) [31]	Europe (Belgium)	*n* = 300	Primary—SB and PA Secondary—change in health-related anthropometric measures and change in psycho-social variables	Objectively—sensewear accelerometer	Randomised control trial (RCT)	3 months
Barbieri et al. (2017) [12]	South America (Brazil)	*n* = 24	Primary—SB	Objective—monitoring sit–stand table positions	Randomised 2 group design	2 months
Ben-Ner et al. (2014) [32]	North America (USA)	*n* = 43	Primary—SB and PA Secondary—effects of work performance	Objective—Actical accelerometer Subjective—Likert scale questionnaire	RCT	12 months
Bort-Roig et al. (2014) [33]; connected to [34, 35]	Europe (Spain)	*n* = 100	Primary—Update of strategies and Engagement	Subjective—semi-structured interviews and questionnaires	Mix methods	21 weeks
Brakenridge et al. (2016) [36]; connected to [37]	Australia (Australia)	*n* = 50	Primary—SB Secondary—standing and moving time, reliability and validity of the LUMOback, and predictors of change.	Objective—ActivPAL	Cluster randomised trial	3 months
Brakenridge et al. (2017) [37]; connected to [36]	Australia (Australia)	*n* = 50	Primary—participants perceptions of intervention	Subjective—interview and focus groups	Qualitative study	12 months

Carr et al. (2016) [38]	North America (USA)	*n* = 54	Primary—SB and PA Secondary—cardio metabolic health outcomes, musculoskeletal discomfort, and work productivity	Objective—GENEActiv accelerometer, sphygmomanometer, Subjective—WHO Health and Work Performance Questionnaire 3, Standardized Nordic Musculoskeletal Symptom Questionnaire	Two-group RCT	4 months
Carr et al. (2013) [39]	North America (USA)	*n* = 49	Primary—SB and PA Secondary—heart rate, blood pressure, height, weight, waist circumference, percent body fat, cardiorespiratory fitness, and fasting lipids	Objective—stepwatch, stethoscope, sphygmomanometer, and cholestech LDX analyzer	RCT	3 months
Carr et al. (2012) [40]	North America (USA)	*n* = 18	Primary—SB and PA	Subjective—questionnaire	Pre- and post-descriptive study	1-month
Chau, Daley, and Srinivasan et al. (2014) [41]; connected to [42]	Australia (Australia)	*n* = 42	Primary—evaluate the acceptability, feasibility, and perceptions of using sit–stand workstations	Subjective—focus groups	Qualitative	1 month
Chau, Daley, and Dunn et al. (2014) [42]; connected to [41]	Australia (Australia)	*n* = 49	Primary—SB and PA	Objective—ActiGraph accelerometer Subjective—occupational sitting and physical activity questionnaire (OSPAQ)	RCT	1 month
Chau et al. (2016) [43]	Australia (Australia)	*n* = 31	Primary—SB and PA Secondary—productivity outcomes	Subjective—OSPAQ	Quasi-experimental with control	2 weeks
Cifuentes et al. (2015) [44]	North America (USA)	*n* = 5	Primary—usability, safety, comfort, and productivity using treadmill work stations in a real-world setting	Subjective—Interview and focus group	Qualitative	6 months
Coenen et al. (2017) [45]; connected to [46–49]	Australia (Australia)	*n* = 231	Primary—musculoskeletal symptoms	Subjective—27-item Nordic Musculoskeletal Questionnaire	Cross-sectional	No intervention
Coffeng et al. (2014) [50]	Europe (Netherlands)	*n* = 412	Primary—recovery experience	Subjective—questionnaire	RCT	12 months

			Secondary—work-related stress, small breaks, physical activity (i.e., stair climbing, active commuting, sport activities, light/moderate/vigorous physical activity), and sedentary behaviour.			
Cooley et al. (2014) [14]; connected to [51]	Australia (Australia)	*n* = 47	Primary—perceptions of the outcomes associated with a workplace health intervention designed to reduce prolonged occupational sitting time	Subjective—Semi-structured interviews	Qualitative	13 weeks
Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup J et al. (2017) [52];connected to [53]	Europe (Denmark and Greenland)	*n* = 461	Primary—SB Secondary—musculoskeletal pain	Objective—ActiGraph Subjective—three items on pain in neck-shoulders	Cluster RCT	3 months
Danquah Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll AK, et al. (2017); [53] connected to [52]	Europe (Denmark and Greenland)	*n* = 461	Primary—SB Secondary—waist circumference and body fat percentage	Objective—ActiGraph and bioimpedance	Cluster RCT	3 months
Davis et al. (2014) [54]	North America (USA)	*n* = 37	Primary—SB, productivity discomfort	Objective—video analysis	Quasi-experimental with cross over	1 month
De Cocker et al., (2015) [55]	Europe (Belgium)	*n* = 47	Primary—SB Secondary—feasibility and acceptability	Subjective—Questionnaires	Descriptive study	2 weeks
De Cocker et al., (2016) [56]; connected to [57]	Europe (Belgium)	*n* = 213	Primary—SB Secondary—psycho-social correlates of sitting	Objective—ActivPal	RCT	3 months
De Cocker et al., (2017) [57]; connected to [56]	Europe (Belgium)	*n* = 213	Primary—SB Secondary—psycho-social correlates of sitting	Subjective—Workforce Sitting Questionnaire (WSQ)	Cluster RCT	1 month

Dewa et al. (2009) [58]	North America (Canada)	*n* = 28	Primary—SB, PA, and mental health status	Subjective—international physical activity questionnaire (IPAQ)	Quasi-experimental with control	1 month
Donath et al. (2015) [59]	Europe (Switzerland)	*n* = 38	Primary—SB Secondary—concentration, postural sway, and lower limb strength endurance	Objectively—ActiGraph	RCT	3 months
Ellegast (2012) [60]	Europe (Germany)	*n* = 25	Primary—SB and PA Secondary—health outcomes	Subjectively—Activity logs	RCT	3 months
Engelen et al. (2016) [61]	Australia (Australia)	*n* = 34	Primary—SB and PA Secondary—perceptions and productivity	Objective—accelerometer Subjective—online activity logs, mood state questionnaire, and orthopaedic medical check-up (G-46)	Natural experiment	2 months
Evans et al. (2012) [62]	Europe (U.K.)	*n* = 30	Primary—SB	Objective—ActivPAL	RCT	5 days
Fennel et al. (2016) [63]	North America (USA)	*n* = 62	Primary—SB, PA, and fitness related variables Secondary—associated psychometric factors	Subjective—IPAQ questionnaire, international personality item pool, self-efficacy and exercise habits survey, behavioural regulation in exercise questionnaire-3	RCT	4 months
Ganesan et al. (2016) [64]	Australia (Australia)	*n* = 69,219	Primary—SB and PA Secondary—weight change/BMI change and dietary change	Subjective—questionnaire	Natural experiment	100 days
Gao et al. (2016) [65]	Europe (Finland)	*n* = 45	Primary—SB Secondary—musculoskeletal discomfort and work ability	Subjective—questionnaire and Likert scale items	RCT	6 months
Gilson et al. (2009) [66]	Europe (U.K.)	*n* = 179	Primary—SB and PA	Subjective—log book	RCT	10 weeks
Gilson et al. (2016) [67]	Australia (Australia)	*n* = 57	Primary—SB	Objective—chair fitted sitting monitor	Quasi-experimental	5 months
Gorman et al. (2013) [68]	North America (Canada)	*n* = 72	Primary—SB and PA	Objective—ActivPAL	Natural experiment	4 months

			Secondary—body composition, fasting cardio-metabolic blood profile, job performance, and job satisfaction			
Graves et al. (2015) [69]	Europe (U.K.)	*n* = 47	Primary—SB Secondary—behavioural, cardiometabolic, and musculoskeletal	Subjective—momentary assessment diary	RCT	2 months
Green et al. (2016) [70]	North America (USA)	*n* = 3	Primary—SB	Objective—ActivGraph	Pre- and post-design	NR
Hadgraft and Winkler et al. (2017) [46]; connected to [45, 47-49]	Australia (Australia)	*n* = 231	Primary—perceived behavioural control, self-efficacy, perceived organisational norms, and knowledge	Subjective—questionnaire and Adapted Likert scale single items	Qualitative study	12 months
Hadgraft and Willenberg et al. (2017) [47]; connected to [45,46 48, 49]	Australia (Australia)	*n* = 136	Primary—participants' perspectives	Subjective—semi-structured interviews	Qualitative study	12 months
Healy et al. (2017) [48]; connected to [45-47, 49]	Australia (Australia)	*n* = 231	Primary—body composition, blood pressure, glucose metabolism, lipid metabolism, and a composite overall cardiometabolic risk score	Objective	Cluster RCT	12 months
Healy et al. (2013) [71]; connected to [72]	Australia (Australia)	*n* = 43	Primary—SB Secondary—standing and stepping	Objective—ActivPAL	Non-randomised controlled trial	1 month
Healy et al. (2016) [49]; connected to [45-48]	Australia (Australia)	*n* = 231	Primary—SB Secondary—standing and stepping	Objectively—ActivPAL	RCT	12 months
Hendriksen et al. (2016) [73]	Europe (Netherlands)	*n* = 396	Primary—PA, SB, and work-related outcomes	Subjective—self-report questionnaire	Pre- and post-design—longitudinal study	5 months
Jancey et al. (2016) [74]	Australia (Australia)	*n* = 67	Primary—SB and PA	Objective—ActiGraph	Natural experimental	4 months
John et al. (2011) [75]	North America (USA)	*n* = 12	Primary—SB and PA Secondary—Health outcomes	Objective—ActivPAL	Pre- and post-design—	9 months

					longitudinal study	
Jones et al. (2017) [76]	North America (USA)	*n* = 47	Primary—SB	Objective—Fitbit	Pre- and post-prospective cluster intervention	6 months
Judice et al. (2015) [77]	Europe (Portugal)	*n* = 10	Primary—SB Secondary—Standing and stepping	Objective—ActivPAL	RCT	1 week
Kerr et al. (2016) [78]	North America (USA)	*n* = 30	Primary—SB	Objective—ActivPAL	RCT	2 weeks
Kozey-Keadle et al. (2012) [79]	North America (USA)	*n* = 20	Primary—SB	Objective—ActivPAL	Pre- and post-design—longitudinal study	1 week
Kress et al. (2015) [80]	North America (USA)	*n* = 33	Primary—SB Secondary—personal factors and perceptions of sit–stand workstations	Subjective—questionnaire	Natural experiment	3 months
Li et al. (2017) [81]	Australia (Australia)	*n* = 33	Primary—SB secondary—PA	Objective—ActivPAL	RCT	4 weeks
MacEwen et al. (2017) [82]	North America (Canada)	*n* = 28	Primary—SB and cardio metabolic risk factors	Objective: SB—ActivPAL Subjective: SB—non-validated questions, Cosmed Quark, Cholestech LDX system, and glycosylated haemoglobin (HbA1c) diazyme SMART analyzer	RCT	12 weeks
Mackenzie et al. (2015) [83]	Europe (U.K.)	*n* = 24	Primary—SB, and participant views	Subjective—self report sitting log, open ended question	Pre- and post-design	5 weeks
Mailey et al. (2016) [84]; connected to [85]	North America (USA)	*n* = 49	Primary—SB and cardio metabolic health	Objective SB—ActiGraph automated blood pressure cuff and Cholestech LDX	Parallel-group randomized trial	8 weeks
Mailey et al. (2017) [85]; connected to [85]	North America (USA)	*n* = 49	Primary—arousal, mood, and fatigue	Subjective—activation–deactivation adjective checklist (ADACL), the positive and negative affect	Parallel-group randomized trial	8 weeks

				schedule (PANAS), and fatigue symptom inventory (FSI)		
Mansoubi et al. (2016) [86]	Europe (U.K.)	*n* = 40	Primary—SB and PA	Objective—ActivPAL and ActiGraph accelerometer	Pre- and post-design	3 months
Neuhaus et al. (2014) [15]	Australia (Australia)	*n* = 44	Primary—SB	Objective—ActivPAL	RCT	3 months
Parry et al. (2013) [87]	Australia (Australia)	*n* = 133	Primary—SB Secondary—PA	Objective—ActiGraph accelerometer	RCT	12 weeks
Pedersen et al. (2014) [51]; connected to [14]	Australia (Australia)	*n* = 34	Primary—SB and PA	Subjective—survey built upon the OPAQ and OSPAQ	RCT	13 weeks
Priebe et al. (2015) [88]	North America (Canada)	*n* = 142	Primary—SB and PA	Subjective—Not validated SB questionnaire	Pre- and post-design	NR
Pronk et al. (2012) [89]	North America (USA)	*n* = 34	Primary—SB, health related outcomes, and work performance	Subjective—experience sampling methodology	Pre- and post-design—two groups	7 weeks
Puig-Ribera et al. (2017) [34]; connected to [33,35]	Europe (Spain)	*n* = 264	Primary—Presenteeism, productivity loss, mental well-being, and productivity	Subjective—work limitations questionnaire; Warwick–Edinburgh mental well-being scale;	Pre- and post-design—two groups	21 weeks
Puig-Ribera et al. (2015) [35]; connected to [33,34]	Europe (Spain)	*n* = 264	Primary—SB and physical risk factors for chronic disease	Subjective—self report diary log, blood pressure, weight, and waist measurement	Pre- and post-design—two groups	21 weeks
Reece et al. (2014) [90]	North America (USA)	*n* = 34	Primary—SB and PA	Objective—Sense Wear armband	RCT	17 days
Schuna et al. (2014) [91]; connected to [92]	North America (USA)	*n* = 41	Primary—SB and PA	Objective-Acti-graph	RCT	3 months
Stephens et al. (2014) [72]; connected to [71]	Australia (Australia)	*n* = 43	Primary—SB	Objective—ActivPAL	Non-randomised controlled trial	4 weeks
Straker et al. (2013) [93]	Europe (Sweden)	*n* = 131	Primary—SB	Objective—inclinometer and portable data logger	Natural experiment—cross sectional	1 day analysis

Swartz et al. (2014) [94]	North America (USA)	*n* = 78	Primary—SB and PA	Objective—ActivPAL	Randomised trial with parallel groups	2 weeks
Taylor et al. 2016 [95]	North America (USA)	*n* = 185	Primary—SB and PA	Subjective—IPAQ sitting items and self-reported seven-day checklist from the Neighbourhood Quality of Life Study PA—pedometer and IPAQ	Cluster RCT	6 months
Tobin et al. (2016) [96]	Australia (Australia)	*n* = 52	Primary—SB Secondary—psychological distress, self-perceived physical and mental health, workability, and perceived benefits	Objective—ActivPAL Subjective—K10, SF8, and work ability index questionnaire	Pre- and post-design—two groups	5 weeks
Tudor-Lock et al. (2014) [92]; connected to [91]	North America (USA)	*n* = 41	Primary—perceptions of feasibility and acceptability	Subjective—focus groups	Qualitative	3 months
Urda et al. (2016) [97]	North America (USA)	*n* = 48	Primary—SB and perceived wellness	Objective—ActivPAL Subjective—perceived wellness survey	RCT	2 weeks
vanBerkel et al. (2014) [98]	Europe (Netherlands)	*n* = 257	Primary—SB	Subjective—non-validated SB at work questionnaire	RCT	6 months.
Venema et al. 2017 [99]	Europe (Netherlands)	*n* = 606	Primary—SB	Objective—direct observation and survey	Pre- and post-design	2 months
Verweij at al. (20d12) [100]	Europe (Netherlands)	*n* = 185	Primary—SB Secondary—PA, waist circumference, body weight, and BMI	Subjective—non-validated SB item, IPAQ Secondary outcomes—PA–(SQUASH) and BMI-calculated	RCT	6 months

NR = not reported; BMI—body mass index; HDL—high density lipoproteins; PA—physical activity.

5.3 Percentage Reporting across RE-AIM Dimensions

The total percentage of reporting across all of the indicators within the individual RE-AIM dimension is represented in Figure 2.2. Reach indicators were reported on average 59% of the time. Efficacy/effectiveness was reported at 49% across all of the indicators. Implementation indicators were reported an average of 44% of the time. The overall percentage of interventions reporting on the indicators of adoption and maintenance indicators were 13% and 8%, respectively. A full break down of reporting across all of the indicators for individual studies is available in supplementary tables S1 and S2.

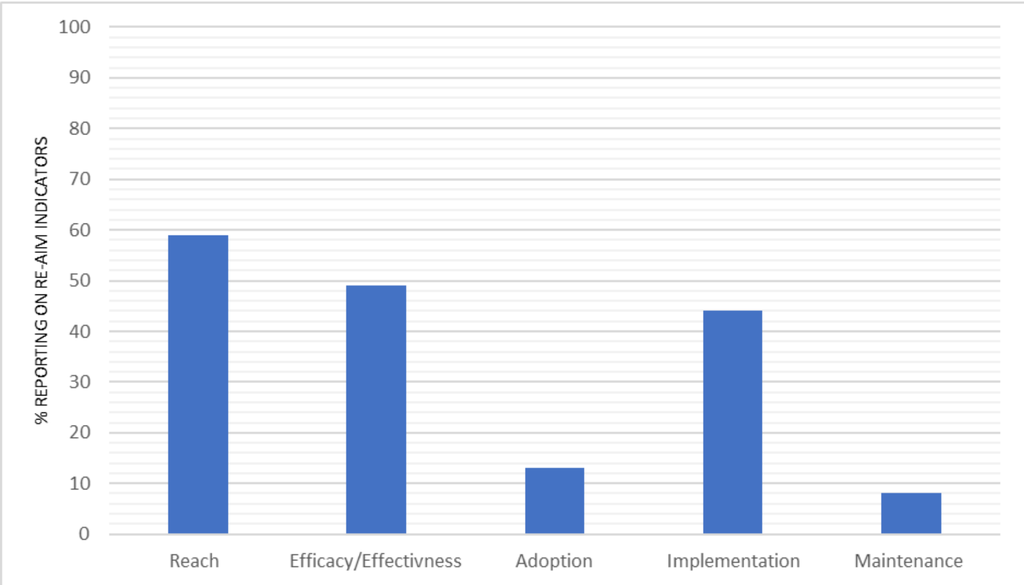

Figure 2. 2: The total proportion of reporting across all indicators within each RE-AIM dimension

5.4 Reach

There was a significant variation between the reach indicators (Figure 2.3), with a high reporting of three indicators, namely, identifying target population (*n* = 57, 93%), inclusion criteria (*n* = 50, 82%), and sample size (*n* = 61, 100%). The reporting of exclusion criteria and participation rate were lower, with both being reported at 61% (*n* = 37). There was low reporting for the characteristics of participants vs. non-participants (*n* = 6, 10%), and for the use of qualitative methods to understand reach (*n* = 4, 7%).

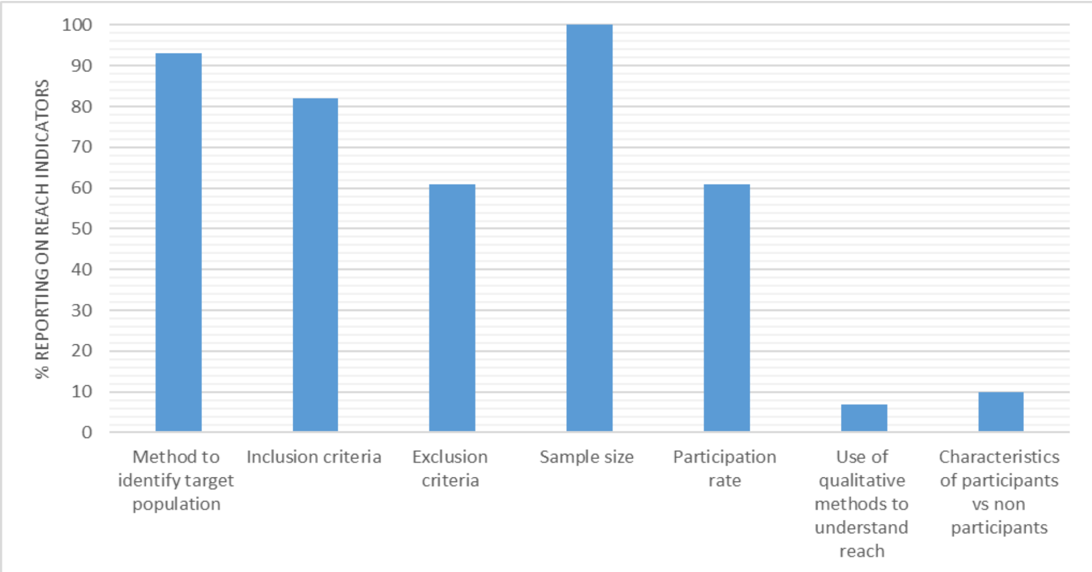

Figure 2. 3: Percentage of studies reporting reach indicators

5.5 Efficacy/Effectiveness

Figure 2.4 illustrates the percentage of reporting for individual efficacy/effectiveness indicators. High reporting was noted across several indicators, including the following: the measure of primary outcome at the shortest assessment point (*n* = 61, 100%), and the percent attrition rate (*n* = 47, 77%). The measurement of the primary outcome at extra follow up points was reported for 39 interventions (64%). The reporting dropped significantly for the remaining three indicators, with 15 interventions (25%) reporting on quality of life measurement, nine interventions (15%) reporting imputation or intention to treat analysis, and seven interventions (11%) reporting use of qualitative methods to understand outcomes.

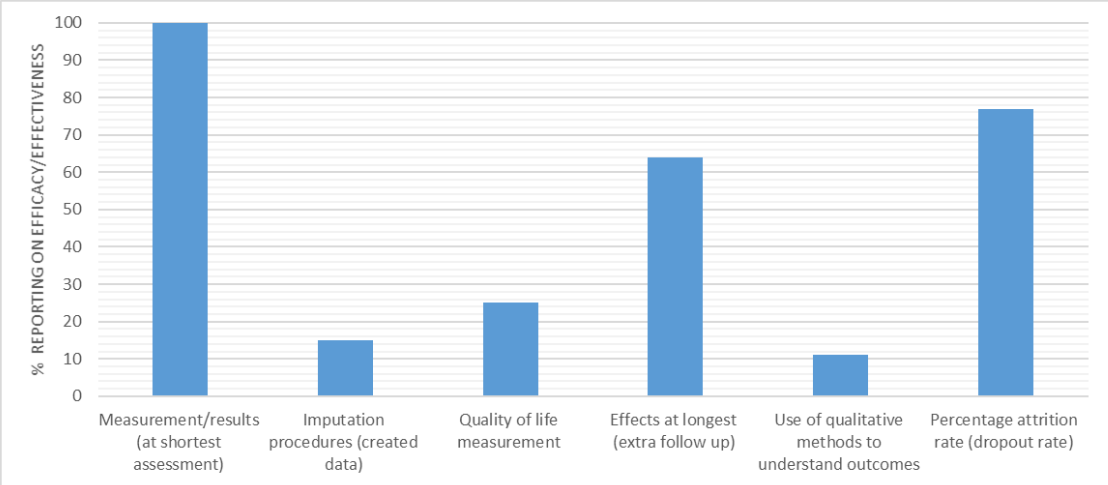

Figure 2. 4: Percentage of interventions reporting efficacy/effectiveness indicators

5.6 Adoption

Figure 2.5 illustrates the percentage reporting for individual adoption indicators. In total, 16 interventions (26%) reported methods to identify delivery target agent, 11 interventions (18%) reported the level of expertise of the delivery agents, and five interventions (8%) provided inclusion/exclusion criteria concerning adoption at the setting level. Furthermore, five interventions (8%) reported a rate of adoption at the setting level, two interventions (3%) reported the use of qualitative methods to understand adoption, and six interventions (10%) reported differences in characteristics (either participant or setting) of adoption vs. non-adoption.

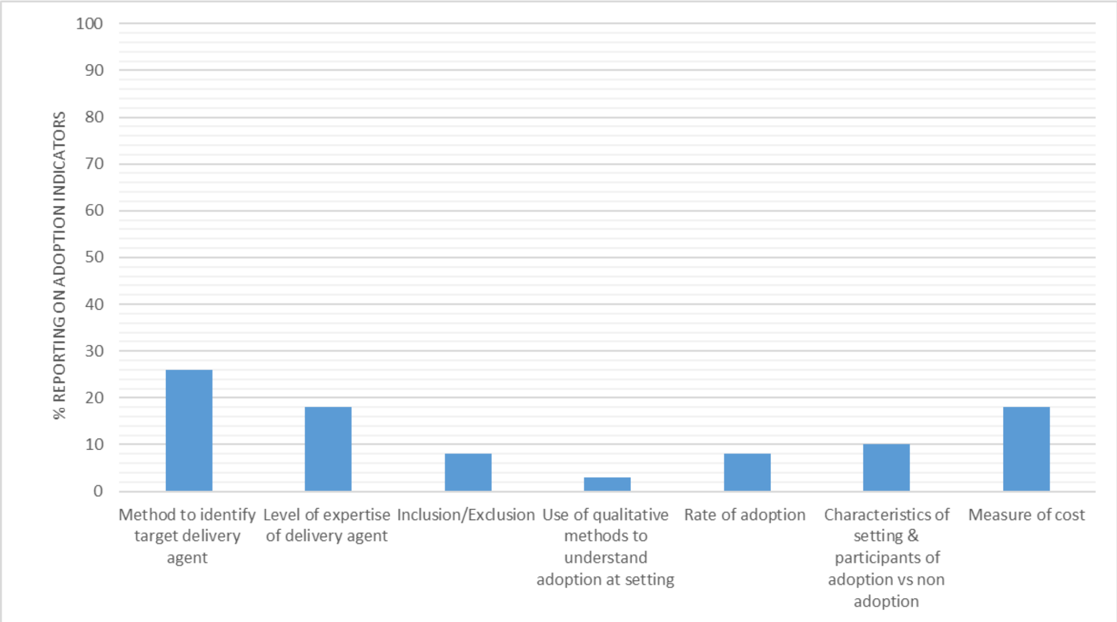

Figure 2. 5: Percentage of interventions reporting adoption indicators

5.7 Implementation

Figure 2.6 illustrates the reporting for implementation. The most commonly reported indicator was the intervention type and intensity (*n* = 60, 98%). In total, 36 (59%) interventions reported on the extent the protocol was delivered as intended, and eight interventions (13%) used qualitative methods to understand implementation. Finally, a measure of cost (protocol) was reported in three interventions (5%).

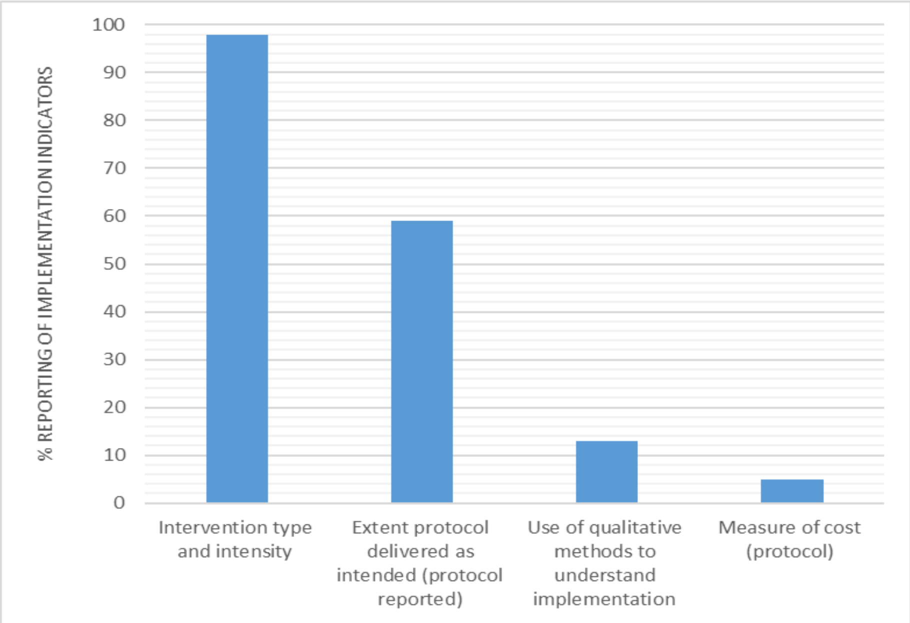

Figure 2. 6: Percentage of interventions reporting implementation indicators

5.8 Maintenance

Concerning individual indicators of maintenance (Figure 2.7), five interventions (8%) reported on an individual behaviour assessment at least six months following the completion of the intervention; five interventions (8%) reported whether the program is still in place, six interventions (10%) reported the use of qualitative methods to understand setting level institutionalization, and four interventions (7%) reported if the program was modified.

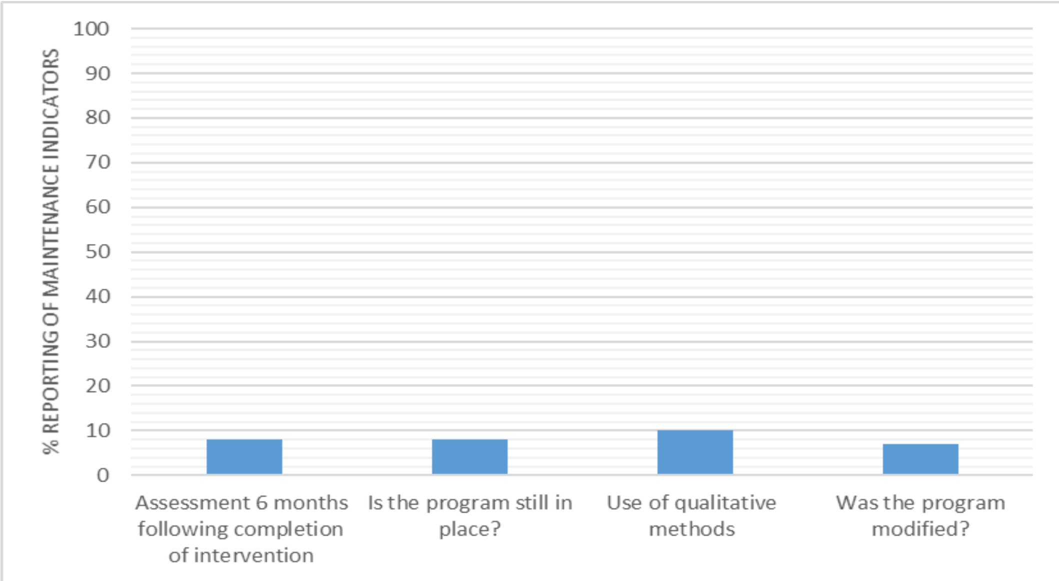

Figure 2. 7: Percentage of interventions reporting maintenance indicators

6 Discussion

The purpose of this review is to provide an understanding of the depth of reporting of indicators across the RE-AIM dimensions. Previous systematic reviews have investigated the effectiveness of workplace SB interventions [16–18]. However, to the authors' knowledge, this is the first systematic review focusing on RE-AIM reporting in office-based SB interventions. This review is the first to synthesise a breadth of the evidence in the field, with a focus on the reporting of indicators important to the future implementation and translation of interventions.

The reach indicators were the most frequently reported of all of the RE-AIM dimensions; reported on average 59% of the time. Efficacy/effectiveness was the second most reported dimension at 49% reporting across all of the indicators. The implementation indicators were reported an average of 44% of the time. The overall percentage of studies reporting on the indicators of adoption and maintenance were the lowest of all of the RE-AIM framework indicators at 13% and 8%, respectively. The results revealed that 10 of the 28 indicators were reported more than 50% of the time however, and the remaining 18 indicators were reported less than 30% of the time, revealing a distinct contrast in the indicators that are routinely reported in interventions. In light of this result, the research team has focused the discussion primarily on the indicators or indeed the whole dimensions that have been "under-reported" or have been reported for less than 30% of the interventions. The discussion firstly presents specific methods used to capture the data from underreported indicators of RE-AIM; and secondly, provides future considerations and recommendations for collecting the data of under reported RE-AIM indicators. This is done in order to facilitate improved reporting (success and failure) across the RE-AIM dimensions, so as to improve our evaluation of generalisability and potential translation of interventions, as well as the potential for the public health impact of interventions [20,21,101].

6.1 Reach

The distinct contrast in reporting is evident in reach (Figure 2). Some indicators of reach are well reported across the included interventions, such as, a method to identify the target population (*n* = 57, 93%) or inclusion criteria (*n* = 50, 82%). However, reach indicators such as representativeness of participants vs. non-participants (*n* = 6, 10%), and use of qualitative methods (*n* = 4, 7%) are underreported. Nevertheless, interventions such as those of De Cocker et al. (2016, 2017) [55–57] and Bort-Roig et al. (2014) [33] highlight the methods for reporting on these indicators specifically.

De Cocker et al. (2016) delivered computer-tailored advice to influence sitting behaviour [56,57]. To report on the representativeness of participants vs. non-participants, the authors utilised the already available health information of the office employees that did not participate, and did a comparative analysis to the demographics of the workers who participated [55–57]. In De Cocker's intervention, the office workers who were less educated were less likely to participate, therefore, an educational element may be critical in order to engage less educated office workers [56,57]. This example highlights how information on representativeness can provide further insight into how to best target intervention strategies.

Additionally, the data collected by Bort-Roig et al. (2014) used a qualitative methodology to facilitate an understanding of the participant uptake [33]. In the study, they interviewed the implementation team regarding their perceptions of factors that impacted on uptake within the study. They then triangulated the interview results with the participant surveys that rated the extent to which the uptake strategies were used [33]. This triangulation process facilitated understanding of reach, giving context to the factors that influenced the study population.

These two studies highlight methods that can be used to improve on the reporting of indicators of reach. Each method improved the understanding of the factors, which may impact on the future implementation and translation of the studies, and therefore, have a potential public health impact.

6.2 Efficacy/Effectiveness

As with reach, there are distinct differences in the indicators of efficacy/effectiveness that are routinely reported (Figure 3). The reporting of measure/results (at shortest assessment) (n = 61, 100%), effects at longest (extra follow up) (n = 39, 64%), and the percent attrition rate (dropout rate) (n = 47, 77%) were significantly higher than the quality of life measurement (n = 15, 25%) and use of qualitative methods or data to understand outcomes (n = 7, 11%), both of which were underreported.

SB is associated with the additional health related outcomes that may affect the “quality of life” of the participants, including, back, shoulder, and neck pain [102–104], and a variety of psychological issues, for example, depression [105], distress [106], and anxiety [107]. Therefore, these outcomes are also important to measure so as to improve our understanding of the association, and to monitor negative unintended outcomes. Importantly, the measurement of additional quality of life outcomes has the potential to strengthen the arguments for the importance of reducing office-based SB. For example, the methods utilised in the Pronk et al. (2012) [89] intervention “take a stand” provided an example of reporting quality of life measurement [89]. In the intervention, the research team administered validated questionnaires to collect data related to additional work-related outcomes (pre- and post-intervention), which facilitated reporting in relation to the quality of life indicator. The results showed that reductions in the sitting time were significantly associated with reductions in upper back and neck pain, fatigue, confusion, and total mood disturbance [89]. In this example, the measurement of the additional outcomes provided evidence that the intervention was not negatively affecting other related health conditions. This type of measurement may help to increase our understanding of other additional benefits of reducing office-based SB.

Hardgraft et al. (2017) [47] used interviews and focus groups to facilitate in understanding how additional factors impacted on the effectiveness of the strategies used in the study [47]. The authors found that specific at work “job tasks” were barriers to behaviour change, however “social support” was a facilitator [47]. Using qualitative methods improved how Hardgraft et al. (2017) understood how behaviour change occurred, and may be critical for improving efficacy/effectiveness in future iterations of the study [47].

It is clear that reporting on additional indicators of RE-AIM fostered a more holistic understanding of the real impact of the interventions. This information may now be used to help improve the future implementation and translation of the research into different settings.

6.3 Adoption

This review has highlighted the underreporting of all of the indicators of the adoption dimension (Figure 4). This is an interesting finding that, on face value, appears to give evidence of poor reporting on setting level indicators. However, a limited number of interventions were implemented across multiple settings (*n* = 16, 26%) in this review. Most of the included interventions were implemented in one setting only and on a relatively small scale (67%, <50 participants); this illustrates a clear gap in the literature.

This review gives further evidence that there is a barrier to translating research from small scale SB interventions to larger scale effectiveness trials [16,101]. The result of this review suggests that one barrier to translation may be the under reporting of indicators that would facilitate effective translation. However, resources, for example time and money, are also significant barriers that often result in pragmatic decision making with respect to the scale of implementation [20,21,101]. The solution to these significant barriers may lie in our engagement with additional stakeholders in workplace health. Companies continue to increase resources in order to improve employee health and wellbeing, as they increasingly understand the relationship between productivity and health status [108–110]. However, workplace health promotion programs are often not informed by evidence, and a recent review suggests that programs that are informed by research have more potential to yield positive results [111]. Therefore, a more “practice based” [21] approach, in which researchers work directly with workplace health promotion stakeholders, would bring together both the evidence-based knowledge and resources needed to effectively translate on a larger scale [21]. For this approach to be successful, understanding and addressing the potential barriers to working directly with companies would be important. For example, with new data protection regulations being implemented, one barrier to overcome may be the companies’ willingness to share/collect the health data of employees, with potential concerns that, if misused, it may bring harm to their employees [112,113]. However, if the relationship is nurtured, and concerns are mediated, the approach could help embed public–private partnerships at earlier stages of research. This will help to build stronger practice-based relationships as projects develop [114]. The approach could also circumvent funding bodies, which can be reluctant to fund scaled up trials, which are seen as less “scientifically pure” [115]. Although trade-offs in experimental design may be made, this more pragmatic “practice-based” [21] approach would produce evidence that more accurately reflects the conditions in which it is expected to be applied [20,21,116,117].

Of the 26% of the interventions implemented across multiple settings, there are none that reported all of the adoption indicators. However, there are examples of quality reporting of some individual indicators. For example, Brakenridge et al. (2016, 2017), who had the highest reporting in the review (21 of 28 indicators), reported four of the seven indicators of adoption [36,37]. In Brakenridge et al. (2017), the researchers interviewed members of the implementation team and conducted focus groups with participants in order to understand the differences in implementation across settings [37]. Qualitative findings revealed that there were differences in the role model influence and management engagement across settings, and this may have impacted on variations in the intervention effects across settings [36,37]. Collecting this information may help to improve future translations of this type of intervention. Additionally, when reporting the level of expertise of the delivery agent, Aittasalo et al. (2017) [29] explained the training process of the delivery agents, including the number of hours spent training face to face [29].

These two examples highlight that, when implementation across settings is done in office-based SB interventions, the collection and dissemination of the indicators of adoption enhances our understanding of the translational issues critical to the improvement of future implementation.

6.4 Implementation

The reporting of the indicators relating to the implementation dimension was mixed (Figure 5). Nearly all of the studies included in this review (*n* = 60, 98%) reported on the type of intervention and intensity by explaining the intervention activities in detail, and many studies (*n* = 36, 59%) reported on the extent the protocol was delivered as intended (development of a protocol). There was minimal reporting on the indicators which that are important for obtaining similar effects in future iterations of the study. These would include indicators that, for example, question whether the protocol was delivered by the implementation team as the intended? What aspects of the intervention were more or less effective than others? What was the cost (e.g. time commitment or monetary) to implement the intervention? Reporting on these indicators is critical to understanding which specific behaviour change strategies were successfully implemented and caused an effect within a study, and which were less successful. For example, Bort-Roig et al. (2014) [33] found, using both questionnaire and focus group data, that walk–talk meetings and lunch walking groups were rarely utilised within the intervention, and sitting time and step count logging were the most critical enabler of behaviour change. These results would be important to consider for the future implementation of this intervention, and may even trigger adaptations to the less successful strategies, potentially improving the potential public health impact of the study [33].

6.5 Maintenance

There was under-reporting of all of the indicators related to the maintenance dimension of RE-AIM (Figure 6), averaging just 8% overall (Figure 1). Two of the indicators assessed whether studies report on (a) if the program is still in place and (b) if the program was modified. These two indicators were only reported 8% (*n* = 5) and 7% (*n* = 4), respectively; however, Parry et al. (2013) [87] exemplified how this type of information could easily be reported, explaining, “The trial was ended due to the lack of further organisations willing to participate within the two-year data collection period” [87]. A third indicator looked for reporting on the follow up measurement six months post intervention. This indicator was also underreported (*n* = 5, 8%). This result is indicative of the fact that 41 of included studies were less than four months in length. From this analysis, it is clear there is a need for longer follow up periods. Interestingly, all of the studies that reported six-month follow-up data did so using self-report methods. Although self-report has its limitations, these results indicate that it may be best placed to pragmatically evaluate the long-term effect, which is vital to understand if long term public health impact is the objective. The six studies that reported on the final indicator of maintenance utilised qualitative methods in order to understand the setting level institutionalisation. For example, in Cifuentes et al. (2015) [44], the reporting highlighted significant barriers to maintaining change in the long term and highlighted areas, which would need to be adapted for the successful future uptake of the intervention [44].

6.6 Indicators of Cost

There were two indicators of cost within RE-AIM. Both referred to a measure of cost of implementation either at the individual level (implementation) or at setting level (adoption). Both of the indicators were under-reported, with measure of cost within implementation reported in just two interventions (3%), and measure of cost within adoption reported in 11 interventions (18%). These studies did report elements of cost, however, there was no clear example of a robust method used to fully understand the "cost" of an intervention. There is the potential to measure cost, however gaining transparency may require the development of methodology specific to office-based health promotion, which can articulate the costs incurred balanced with the benefits gained.

6.7 Recommendations for Future Reporting

In light of the significant gaps in reporting, the research team have created specific recommendations for the improved future reporting of office-based SB interventions (Table 2.4). Process evaluation is a critical part of any intervention study, however our review highlights a clear gap in the reporting of indicators that informs this practice [20]. The recommendations highlight that the RE-AIM framework may prove useful in providing a framework for collecting this breadth of process data or information. Additionally, it is clear from the recommendations that this process would require a mixed methods approach [118,119]. Using appropriate methods to capture the necessary data is the first step to both, improved translation, and population level impact.

Reporting on this breadth of indicators would often lead to the publication of a process evaluation, and this would be recommended in order to provide the capacity for reporting over so many indicators. The collection of data on under reported indicators can be done retrospectively [120]. However, it would be seen as best practice to imbed the necessary data collection methods in the initial study design, so as to inform the process evaluation [20]. Both retrospective and embedded process evaluation take careful and considered planning, however the RE-AIM recommendations would prove useful in both cases.

Table 2. 4: Recommendations for improved reporting across reach, effectiveness, adoption, implementation, and maintenance (RE-AIM), and examples of reporting methods used within included interventions

RE-AIM Dimension	Recommendations for Improved Reporting across the RE-AIM Framework for Interventions Targeting Sedentary Behaviour in Office Workers
Reach	▪ Seek or collect basic demographic or health information of all workplace setting employees, which will help to compare participants vs. non-participants. Example method found in De Cocker et al. (2016) and De Cocker et al. (2017) [56,57]. ▪ Report the number of participants exposed to recruitment activities and illustrate the calculation of participation rate of the study. ▪ Employ questionnaire or qualitative methods to understand barriers to reach of study. Example method found in Bort-Riog et al. (2014) [33].
Effectiveness	▪ If intention to treat methods are used, report specific method and rationale for appropriateness. Example method found in Arrogi et al. (2017) [31]. ▪ Seek to use biological outcome measures (e.g. body composition, cardiovascular fitness, glucose metabolism and overall cardiometabolic risk score). Example methods found in Healy et al. (2017) [48]. ▪ Use questionnaire and/or qualitative methods to understand impact on quality of life and unintended or unexpected outcomes. Example methods found in Pronk et al. (2012) [89] and Hardgraft et al. (2017) [47]. ▪ Additional questionnaires utilised for unexpected outcomes including: musculoskeletal (27-item Nordic musculoskeletal questionnaire), presenteeism (work limitations questionnaire (WLQ), percentage of work productivity loss (WLQ index score) and mental well-being (Warwick–Edinburgh mental well-being scale (WEMWBS)). Productivity—the work limitations questionnaire (WLQ) assessed profile of mood states (POMS) questionnaire.
Adoption	▪ Record and report on the specific recruitment processes, including: inclusion and exclusion criteria for businesses, the number of companies or sites approached, the number who declined available demographic information to report on representativeness of company demographics compared to local area statistics (e.g. state or province or council demographic statistics.). Example method found in Puig-Ribera et al. (2015) [35]. ▪ Collect quantitative information from implementation team regarding level of training and expertise and fidelity to implementation strategies. Example method found in Brakenridge et al. 2017 [37] Aittasalo et al. (2012) [29]. ▪ Report a measure of cost to implement per setting.

Implementation	▪ Collect qualitative or questionnaire data from the implementation team regarding the fidelity to implementation strategies and facilitators and barriers to implementation. Example method found in Bort-Riog et al. (2014) [33]. ▪ Collect qualitative or questionnaire data regarding facilitators and barriers to uptake of behaviour change strategies. Example method found in Bort-Riog et al. (2014) [33]. ▪ Report on cost (monetary or time commitment) of implementation of individual intervention strategies.
Maintenance	▪ Record and report plans for follow-up and any modifications to program. ▪ Utilise accessible questionnaire's from which to collect data at more long-term follow-up time points. Example methods such as self-report logs or sitting items from existing questionnaires found in Coffeng et al. (2014) [50], Gao et al. (2016) [65], and van Berkel et al. (2014) [98].

7. Strengths and Limitations

A key strength of the review is that it is the first review to look at a large proportion of published interventions that have been done targeting office based SB, in order to understand the state of reporting for effective future translation. This may be crucial to understand, as future population level impact relies on successful translation. Additionally, using the RE-AIM framework enabled an in-depth and critical analysis of the individual papers. This critical approach has facilitated the creation of specific and considered recommendations to enhance future intervention reporting within office-based sedentary interventions. Furthermore, the use of software tailored for reviews enabled quality assurance through the blinded double screening process. The study is not without limitations. Because of the focus on the quality of reporting across the RE-AIM dimensions, we did not include a quality assurance tool, which would be typically seen in an efficacy-based review. It could be the case that interventions that rate low across RE-AIM in this review rate high in other reviews, or vice versa. The review could also be limited by the number of databases (five) searched and the focus on workplace interventions that measure SB as a primary outcome.

8. Conclusions

The results of this review indicate that there is an imbalance in the reporting of indicators across the RE-AIM framework. The improvement of reporting across all interventions, designed to reduce sedentary behavior in office workers, will be an important first step in the effective translation of interventions into real world conditions [23]. Minimal studies have been implemented at scale with substantial follow up periods, suggesting that significant barriers exist, and this fuels arguments for a more pragmatic “practice-based” approach to intervention design, in which researchers work alongside delivery agents of workplace health [20,21,121]. Regardless of the intervention design or approach, the results and subsequent recommendations of this review would provide a useful starting point for researchers in the evaluation of important, often overlooked, indicators. Improved reporting may ultimately improve the translation of research on a large scale, and have impacts on public health as intended.

9. Chapter 2 References

9.1 Preface References – APA format

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Chapter 3: Should we scale-up? A mixed methods process evaluation of an intervention targeting sedentary office workers using the RE-AIM QuEST framework

1. Preface

1.1 Rationale

Based on the results of the systematic review, there is evidence that gaps in dissemination exist within SB in office worker interventions. In the review, 18 of the RE-AIM indicators were reported less than 30% across included interventions. In order to improve dissemination for real world impact, filling these gaps in reporting would be important aspect of the PhD thesis. Additionally, through the analysis of the results of the integrative systematic review (Chapter 2) it was evident that filling these gaps would require a type of evaluation which encompassed more than just an evaluation of impact or outcome of an intervention. It would require a critical and methodical analysis of the successes and/or failures of an intervention through a process evaluation (Bauman & Nutbeam, 2013). Additionally, through the development of the recommendations to improve reporting it was clear that incorporating a mix of quantitative and qualitative methods would be important to producing a critical and methodical analysis. With all of the above knowledge and understanding built around what gaps in dissemination existed and what type of evaluation may help to fill these gaps, the PhD student sought opportunities to evaluate an intervention.

1.2 Strathclyde-Springfield collaboration

1.2.1 Background

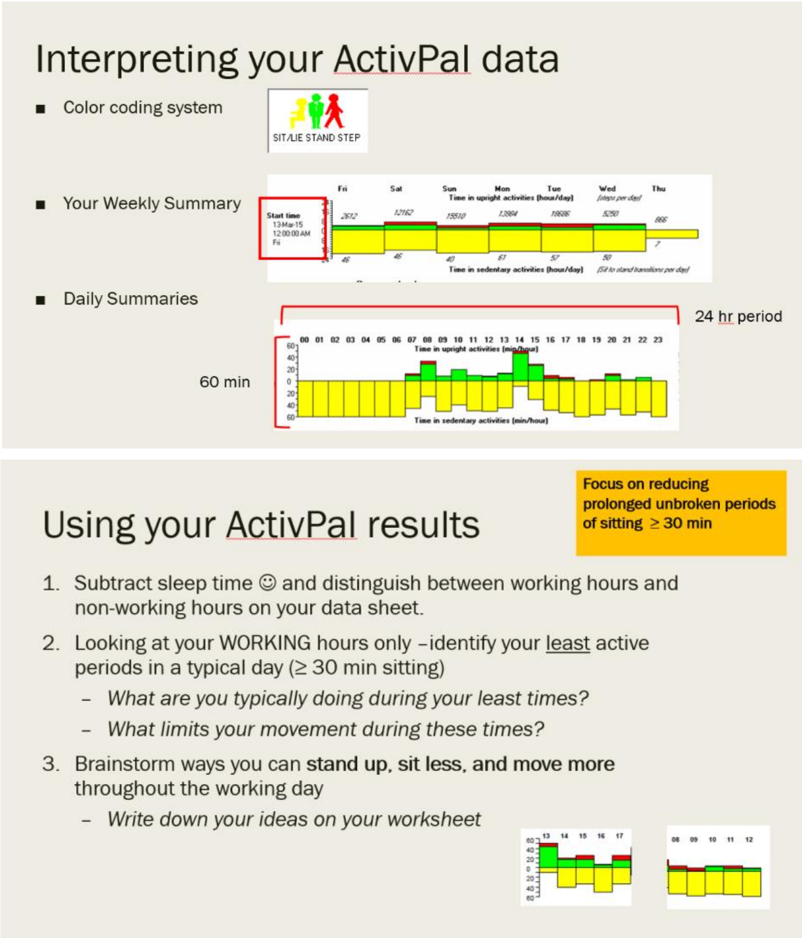
Through a developing international collaboration with researchers at Springfield College (Massachusetts, USA) it became apparent that the research team at Springfield had recently developed and implemented an intervention targeting sedentary office workers. The Springfield research group evaluated the intervention for its effectiveness, however wanted to understand the potential for scale-up or translation of the intervention into real world office settings. The research team had minimal background knowledge and understanding of the methodology and evaluation processes needed to inform an evaluation of the intervention's potential to be scaled up.

1.2.2 The Intervention

The single group pretest-posttest intervention aimed to test the feasibility, and pilot the effectiveness of a personalised consultation aimed at reducing and breaking up sitting time in the workplace. The Springfield research team recruited office workers from the university campus to participate in the intervention. During participants' first intervention visit, they were fitted with an activPAL 3 monitor. Participants were asked to wear the activPAL continuously for seven consecutive days. A second visit was scheduled one week after returning the activPAL to allow for data processing time. It was at this point the participants received their personalised SB consultation (Hutchinson et al., 2018).

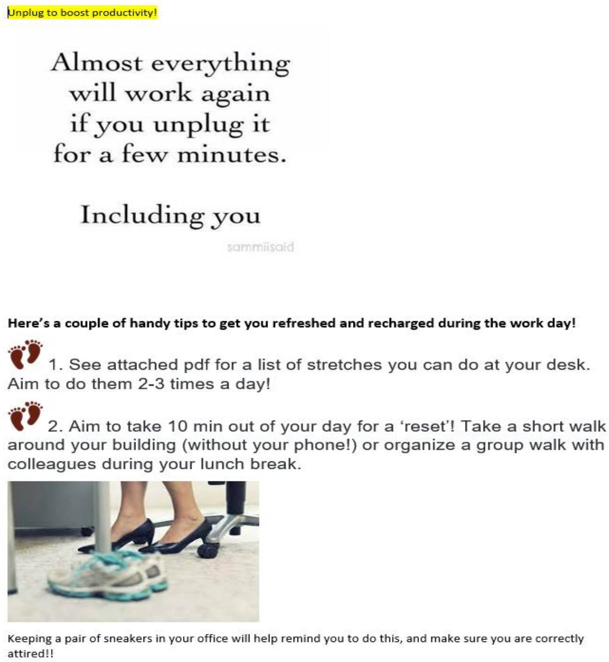
The consultation was informed by Lewin's force field theory (Lewin, 2016). Lewin's theory suggested that behaviour status quo represents an equilibrium between driving forces which favour change, and restraining forces or barriers to change (Lewin, 2016). For positive behaviour change to occur, Lewis suggested that the magnitude of the driving force needs to match the magnitude of the restraining force. The goal therefore of the consultation-based intervention was to increase the driving forces for reducing sitting time, while reducing the restraining forces. This was done in five stages, with the first stage focusing on increasing knowledge of the health effects of high volumes of sitting. In stage two, participants reviewed their personalised activPAL data and reflected upon their sitting patterns, after which they identified specific driving forces for reducing sedentary time. Through brainstorming and group discussion in stage three, participants identified feasible ways to reduce their sitting time at work. In stage four, potential restraining forces were identified and through further group discussion, potential solutions to barriers were explored. In stage five, additional behaviour strategies were offered and participants created feasible goals to reduce sitting time, with the specific goal to break up bouts greater than 30 minutes. Figure 3.1 shows two example slides from stage two of the consultation in which participants were being taught how to read their personalised activPAL data.

Figure 3. 1: Example slides from stage two of consultation intervention



Following the consultation, participants were sent weekly prompts as reminders to break up their sitting time. The emails were informed by psychological theory targeting attitudes towards SB. (Conner, Rhodes, Morris, McEachan, & Lawton, 2011; O'Keefe & Jensen, 2007). The email content varied between short simple messages, graphic illustrations, information sharing and specific tactics of how to break up sitting bouts. An example email is presented in figure 3.2.

Figure 3. 2: Example email sent to participants

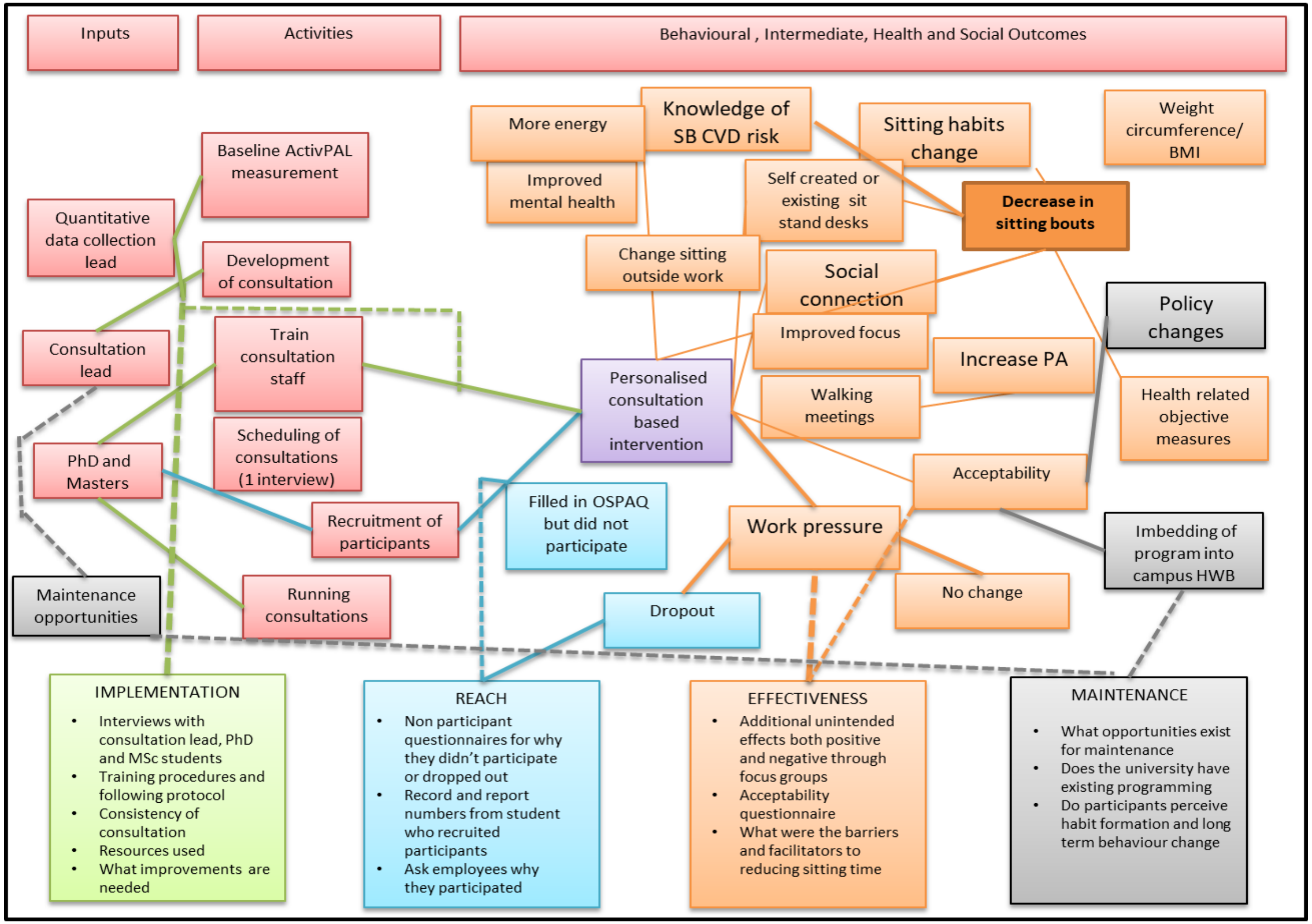


After 16 weeks of the intervention, participants had the activPAL fitted for a further seven consecutive days. Thirty-six participants provided at least five days valid activPAL data for both baseline and follow-up. Participants significantly reduced their bouts of sitting more than 30 minutes from baseline to follow-up (Hutchinson et al., 2018). This suggested that the theory informed, personalised consultation intervention, which targeted reducing bouts of sitting more than 30 minutes was effective. However, it was unknown whether there was potential to scale-up the intervention in the real world.

1.3 Evaluation Planning

The mixed methods evaluation of the intervention was planned by, firstly, creating a logic model of intervention activities. A logic model is a visual tool which helps to plan an evaluation by illustrating how an intervention or program should work, and how it affects behaviour and health outcomes (Bauman & Nutbeam, 2013). The model should depict what resources have been used (*inputs)*, for example staff used, and what activities will be done with those resources (*activities*). Additionally, it should illustrate what has resulted from the activities (*outputs*); and how they affect health outcomes in the short and medium term (*short and mid-term outcomes*), and the long term (*long-term outcomes*). As described, a logic model would inform and predict interventions' effects on behavioural and health outcomes only (Bauman & Nutbeam, 2013), however for this study it was important to expand on this to evaluate RE-AIM outcomes, and indicators which would inform these outcomes. Therefore, RE-AIM outcomes and indicators were placed within the model to facilitate understanding of a) what indicators of RE-AIM have been affected by the intervention and b) what pragmatic opportunities could be utilised to measure the RE-AIM indicators. Additionally, the development of the logic model added to the understanding of what inputs and activities were done in the process of implementation, what health promotion outcomes could be predicted (e.g. increased knowledge) and what data had already been collected which could be further explored to help to inform the evaluation. Figure 3.3 depicts the logic model developed to facilitate planning of the evaluation of the Springfield consultation intervention. Although the logic model is complex, the PhD student felt it was important to present it as part of the preface to fully illustrate the planning of the evaluation.

Figure 3. 3: Logic model for the RE-AIM evaluation of the Springfield consultation intervention



In the model, boxes represent individual inputs, activities and predicted outcomes. Lines which connect two boxes illustrate that there is a predicted connection of influence between individual inputs, activities and outcomes. If a line is drawn between two boxes in a logic model it suggests that there may be an opportunity to measure (quantitatively or qualitatively) this connection of influence to understand the relationship more clearly. For example, in relation to the inputs and activities section of the model, there is a line drawn between the 'PhD and Masters students' inputs box and the 'recruitment of participants' activities box. This signalled that there may be an opportunity to collect data from the PhD and Masters students which would help to understand the processes of recruitment that were undertaken. In this example, collecting this information would help to inform the RE-AIM dimension of 'reach' therefore the line is colour coded blue and links directly to the blue reach box located below the model. This process generated potential indicators of assessment within each RE-AIM dimension, and these are illustrated in the figure under the logic model in four boxes labelled; implementation, reach, effectiveness and maintenance. The RE-AIM recommendations for reporting, developed in study one, were used throughout the process to facilitate understanding of what methods could be feasibly used in data collection given the resources available. At the end of the process a clearer idea of the process evaluation took shape and a more detailed and structured evaluation plan was created which included the research questions in relation to RE-AIM, detailed data collection methods, and a timetable for data collection. The final outcomes and indicators that were assessed in the process evaluation are detailed in the manuscript.

1.3.1 Planning data collection

As this was an international collaboration, planning the data collection was done remotely. Ethical approval for the study was sought, and granted, by both Strathclyde University and Springfield College. Additionally, prior to the visit a risk assessment was carried out. After ethical approval was awarded, the PhD student worked with a member of the Springfield research team (J.H.) to email intervention participants and staff about taking part in the evaluation. This initial email included a participant information sheet (Appendix D). Participants and employees volunteered by email to be involved. This was then followed up with signed consent in person. The majority of the data collection took place on a research visit to Springfield College in July of 2018.

1.3.2 Materials

Two questionnaires were developed by the PhD student in conjunction with a member of the Springfield research team (J.H.) who delivered the intervention at Springfield College. One 2-item questionnaire was developed to assess reasons employees did not participate in the intervention. A second 9-item questionnaire was developed to collect data in relation to participants' experience of participating. These questionnaires are available in Appendix E. All other information relating to the questionnaire data collection methods is presented in the manuscript.

Topic guides were developed for both the semi-structured focus groups with participants and interviews with key informants of the intervention. These were both piloted and refined prior to the commencement of the process evaluation. Example questions are provided in the manuscript. Additionally, a coding framework was developed to facilitate deductive coding of the qualitative data in relation to the RE-AIM framework.

1.4 Qualitative Methodology

To understand "change" within the real world context, pragmatic research requires built-in flexibility within methodology (Goldkuhl, 2012). Braun and Clarke's reflexive approach to Thematic Analysis (TA) is described as theoretically flexible methodology, and can be adapted and applied to a variety of epistemological perspectives, research questions and types of data (Braun & Clarke, 2013). For example, the authors describe that TA can be used for inductive data coding and analysis, in which the researcher looks for meaning in the data, free from a theoretical lens, to explore the meaning that participants place on phenomena. It can also be deductive, used to work within a theoretical framework to answer research questions driven by a specific theoretical lens (Braun & Clarke, 2006, 2013, 2014). For this reason, TA was the chosen methodology used to analyse the qualitative data within the process evaluation. The background to the approach and detailed methods which were used in the data collection of the process evaluation are described in this section.

1.5 Braun and Clarke's Thematic Analysis

Braun and Clarke describe that TA is often used as an umbrella term for a wide range of approaches to doing qualitative research in which researchers seek to find and understand themes that exist within data (Braun & Clarke, 2019). The authors suggest that there are three main schools of TA which share underlying philosophy and characteristics, such as broad approaches to procedure. These include; coding reliability thematic analysis, code book thematic analysis and reflexive thematic analysis. Coding reliability thematic analysis, and code book thematic analysis have been critiqued by qualitative research experts for their inability to fully realise and analyse the data with any depth or meaning (Braun & Clarke, 2014; Kidder & Fine, 1987). They argue that in order to create actionable outcomes, applied researchers must seek to employ a reflexive approach in which the researcher critically interrogates the data with more in-depth and interpretative analytical skills to uncover the underlying pattern, concepts and ideas within the data (Braun & Clarke, 2013, 2014, 2019). Understanding reflexivity as a concept is central to Braun and

Clarke's approach. Reflexivity refers to the researcher's understanding that they are central to the analysis and interpretation of the data therefore they cannot be fully separated from the results as the results are a product of their own perceptions of reality or truth (Haynes, 2012).

The authors describe six key steps to TA methodology. The first step is familiarisation with the data. This is described as getting to know their data by immersing themself within it by collecting their own data; listening back to recordings; transcribing their own data sets; creating reflexivity notes in relation to audio recordings or transcripts; and actively reading their data, so that they have an existing understanding of the content before the analysis process begins. In relation to the reflexivity notes the authors suggest that the researcher should reflect on what assumptions they may be making based on their experiences, background and understanding of the topic. In this present study the PhD student listened back to the audio recordings after the interviews, transcribed the data and actively read back each transcript and created a reflexivity journal. An example of the reflexivity journal entry for one of the participant focus groups is presented in table 3.1. Through engaging in the process of familiarisation, the researcher starts to see the richness and complexity within the data (Braun & Clarke, 2006, 2013, 2019).

Table 3. 1: Reflexivity journal entry for Springfield evaluation

Data source	Journal Entry
Focus group 1	I took some time to tell them a story to put the participants at ease and then everyone introduced himself or herself. It is important to get the group on your side so I feel it is important to do this. The group was open and honest with their responses. The topic guide is complicated and each person should feel comfortable sharing his or her opinion. I tried reminding people of the questions. This helped to stimulate the conversation and, on this occasion did not prompt people to repeat opinion and create over representation of thoughts on topics. It may be important as I move forward to watch that people are not just repeating opinion which may get coded several times and over represent the data. I feel a sort of between person analysis may be important to highlight who's opinion was strong and who's was weak between themes. There is tendency to lead people slightly in the later sections of the topic guide because the concepts are not things they went through. I feel it is important to give examples within this section so they understand what may be happening in the future with the intervention. The group got along very well. They were all female and I will need to check the numbers of participants in the whole study to see if we have representation of full sample. They respected each other's opinion. I feel I stayed neutral partly because I have no vested interest in what happened in the intervention. This is an interesting aspect of doing the evaluation as an independent party. There are challenges in probing extra questions as I do not have the in-depth knowledge of the intervention compared to if I had been involved but this could improve my ability to think of the data in a neutral way, letting the inductive themes develop more naturally than if I had lived the experience of the intervention as a researcher and brought that bias into the project.

The second step to TA is generating codes. TA conceptualises codes as labels that capture something interesting or insightful in the data. Braun and Clarke suggest that coding labels should not be one word, as they would not provide enough detail to accurately represent the data. This should be done systematically line by line and the researcher should remain conscious of their place in the research and how their understanding of the data is evolving as they critically examine the data and create codes. This process was followed using the Nvivo program. Each transcript was read line-by-line looking to capture meaningful data related to the research questions. When a section of meaningful text was found, it was highlighted and selected to create a code. The code names reflected the researcher's opinion, at the point of coding, of what this piece of data meant in relation to the research questions. Critical to Braun and Clarke's reflexive approach to TA is that codes are not fixed, and they can evolve as the researcher continues to analyse and reflect on the analysis. To facilitate these processes Braun and Clarke suggest two coding sweeps are done in this phase (Braun & Clarke, 2006, 2013, 2019). Upon the completion of the first coding sweep by the PhD student, an experienced qualitative researcher was used to employ a 'critical friend' approach to interrogate the analytical decisions made during the first sweep of coding and therefore enhance trustworthiness of the data (Smith & McGannon, 2018). This method of enhancement of trustworthiness is preferred by Braun and Clarke and other world experts in qualitative methods over member checking and triangulation (double coding), as the latter fails to recognise the researcher as a fundamental part of creating the research results (Braun & Clarke, 2013; Levitt, Motulsky, Wertz, Morrow, & Ponterotto, 2017; Smith & McGannon, 2018). In this critical friend process, the experienced qualitative researcher was sent the file of the coded transcripts to examine and make notes. The two researchers then met in person to discuss each of their interpretations. The PhD student led the coding discussion to help minimise student-mentor bias (Smith & McGannon, 2018). Both researchers gave their rationale for how and why they interpreted individual coding labels. This process generated notes for the PhD student to reflect on before starting the second coding sweep.

Generating themes and reviewing themes involves bringing together codes which have shared meaning, ideas or concepts which the researcher sees as analytically important to answering their research questions. Reviewing themes involves collating extracts within a theme to decide if they form a coherent pattern. If some do not, in a second level of review, the researcher considers whether some data extracted do not fit or whether there is a problem with the theme itself. This often involves referring to the central organising concept, reworking and renaming themes and discarding some codes from the analysis (Braun & Clarke, 2006, 2013). The detail of how these steps were followed is provided in sufficient detail in the manuscript.

In step five, the researcher defines and names each theme. In this step the researcher should think about the nuance and specificity of what each theme is about and what the overall analysis is telling them. Braun and Clarke suggest that the name of the theme should clearly relate to the central organising concept which the codes developed around (Braun & Clarke, 2006, 2013). Stage six is producing a report. Braun and Clarke suggest that in reporting qualitative research results, the researcher should recognise that qualitative research isn't about giving the absolute total and complete picture of their final data, but rather about telling a relevant and rich story in relation to the research questions. (Braun & Clarke, 2006, 2013, 2014, 2019). The evidence that these steps have been followed is exemplified in the results section of the manuscript. In summary, Braun and Clarke's reflexive TA formed the predominant research methodology for analysing the qualitative data. This approach was theoretically flexible and allowed for rigorous yet epidemiologically aligned trustworthiness procedures to be utilised (Braun & Clarke, 2013; Smith & McGannon, 2018).

The manuscript for the process evaluation of the Springfield intervention will now be presented.

Paper 2: Should we scale-up? A mixed methods process evaluation of an intervention targeting sedentary office workers using the RE-AIM QuEST framework

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2. Abstract

Background: Interventions targeting a reduction in sedentary behaviour in office workers need to be scaled-up to have impact. In this study, the RE-AIM QuEST framework was used to evaluate the potential for further implementation and scale-up of a consultation based workplace intervention which targeted both the reduction, and breaking up of sitting time. Methods: To evaluate the Springfield College sedentary behaviour intervention across multiple RE-AIM QuEST indicators; intervention participant, non-participant (employees who did not participate) and key informant (consultation delivery team; members of the research team and stakeholders in workplace health promotion) data were collected using interviews, focus groups and questionnaires. Questionnaires were summarized using descriptive statistics and interviews and focus groups were transcribed verbatim, and thematically analysed. Results: Barriers to scale-up were: participant burden of activity monitoring; lack of management support; influence of policy; flexibility (scheduling/locations); time and cost. Facilitators to scale up were: visible leadership; social and cultural changes in the workplace; high acceptability; existing health and wellbeing programmes; culture and philosophy of the participating college. Conclusion: There is potential for scale-up, however adaptations will need to be made to address the barriers to scale-up. Future interventions in office workers should evaluate for scalability during the pilot phases of research.

Keywords: sedentary; sitting; office workers; workplace health; process evaluation; RE-AIM; scale-up

3. Introduction

Adult office workers spend as much as 80% of their working day engaging in sedentary behaviour (SB) or sitting [1]. Sitting at work has emerged as a global health issue due to the increasing evidence that sitting time is associated with type 2 diabetes, cardiovascular disease and mortality [2-4]. Additionally, there is evidence to suggest that the disease risk is greater if an individual accumulates sitting time in uninterrupted bouts [4, 5]. The disease risk associated with sitting carries a considerable societal and economic burden. For example, in the United Kingdom alone, sitting time is conservatively estimated to be associated with over 16,000 preventable deaths a year; costing the country's health care system an estimated 700 million pounds a year [6].

Reducing the burden of disease is contingent on effective workplace interventions being implemented at scale; and, although interventions have been effective [7, 8], a significant proportion have been conducted on a relatively small scale [9]. Furthermore, in these interventions, there is a clear emphasis on reporting indicators of efficacy, and a failure to measure and/or report on indicators that would inform the potential for scale-up and sustainability (E.g. participation rate and/or cost) [9-11]. Failure to measure and report on additional indicators relating to the reach, implementation and maintenance of the intervention may mean that barriers to scaling up go unnoticed, making the goal of population-level risk reduction unattainable [9, 12]. Collecting data and comprehensively evaluating interventions across additional indicators will help inform the researchers' understanding of the potential for translation and implementation at scale [9-12].

The RE-AIM QuEST (Qualitative Evaluation for Systematic Translation) mixed methods evaluation framework can facilitate a comprehensive evaluation of an intervention across five dimensions (R-reach, E-effectiveness/efficacy, A-adoption, I-implementation and M-maintenance) [13]. Reach is defined as the absolute number, proportion, and representativeness of eligible individuals who participate in a given initiative. Effectiveness/efficacy refers to the impact of an intervention on the relevant outcomes, including potential adverse effects, quality of life, and economic outcomes. Adoption looks at the reach and effectiveness/efficacy of an intervention at the setting level. It is defined as the absolute number, proportion, and representativeness of the settings and intervention agents (a group of people who implement the intervention) who are willing to initiate a program. Implementation refers to the intervention agents' fidelity to the various elements of an intervention's protocol. This includes consistency of delivery as intended; and the time and cost of the intervention. The maintenance dimension is concerned with both the setting, and the individual level; at the setting level, maintenance is the extent to which a program or policy becomes institutionalised or part of organisational practices and policies; at the individual level, maintenance is considered the monitoring of effectiveness of an intervention or program six months or more after the most recent contact [10, 14].

RE-AIM QuEST facilitates a broadened approach by enabling qualitative inquiry to further explore and report on additional indicators which would inform the potential for scale-up across the RE-AIM dimensions [13]. For example, questions such as; What are the barriers and facilitators to each dimension?; What are the conditions and mechanisms that lead to effectiveness?; What are the contextual factors and processes underlying barriers and facilitators to further implementation [13] ? In this study, the RE-AIM QuEST framework was used to evaluate the potential for further implementation and scale-up of a consultation based workplace intervention which targeted both the reduction, and breaking up of sitting time.

4. Materials and Methods

4.1 Springfield College sedentary behaviour intervention

The intervention aimed to explore the effect of a consultation based personalised intervention on both reducing total sitting time and increasing breaks in sitting time among desk based US college employees. Participants were first asked to wear an activPAL accelerometer to objectively measure sitting time over one week. This individual data was analysed and given as feedback as part of a behavioural consultation. The consultation was underpinned by Lewin's force field theory and sought to increase driving forces for change and reduce restraining forces [15]. The consultation consisted of one 45-min face-to-face session conducted by a member of the consultation team. This was followed by a series of weekly follow-up emails delivered over 16 weeks. 87 employees participated in the consultation intervention and a sub subsample of 36 participants wore an activPAL at follow-up. Changes in objectively measured sitting outcomes have been previously reported in Hutchinson et al., 2018 [8]. In brief, 36 participants (7 men, 29 women; mean age, 51.1 ± 11.1 years; mean BMI, 29.2 ± 7.6 kg/m^2) completed data collection and as result of the intervention, the number of prolonged sitting bouts >30 min decreased significantly by 0.52 bouts/day ($p = 0.010$) [8].

4.2 Evaluation participants

Participants included a) intervention participants, b) Non-participants (employees who completed the Occupational Sitting and Physical Activity Questionnaire (OSPAQ) prior to the intervention, but decided not to participate in the intervention); and c) key informants. Key informants included; members of the consultation delivery team; study coordinator; members of the research team and additional stakeholders of the health programs on campus. All evaluation participants provided informed consent.

4.3 Process evaluation study design

This evaluation utilises both qualitative and quantitative methods to collect data across four of the RE-AIM dimensions. Information on the “adoption” dimension was not collected as the intervention was implemented in only one setting. Data collection was informed and guided by the RE-AIM QuEST mixed methods framework for program evaluation [13]. This framework has been developed to enhance a RE-AIM evaluation by facilitating both quantitative and qualitative exploration of each of the five RE-AIM dimensions; looking to understand the how and why behind intervention implementation [13].

4.4 Data collection

Data were collected for the RE-AIM evaluation retrospective to the completion of the intervention by a researcher independent of, and based at a different university from, the original research team. Ethical approval for the evaluation of the intervention was granted from both Universities’ ethics committees.

4.4.1 Qualitative data collection

4.4.1.1 Interviews and focus groups with intervention participants

Fifteen participants (14 female and 1 male) who took part in the intervention were invited, via e-mail, to participate in the evaluation. Each consenting participant took part in one of two focus groups Two participants who could not find a convenient focus group time were offered individual interviews, and both were interviewed individually using the same semi-structured topic guide. The focus groups and Interviews were all conducted at the participants place of work in a meeting room. All were recorded using a Dictaphone (OLYMPUS). The topic guide for participants was developed in line with the RE-AIM QuEST mixed methods framework. The topic guide was developed, piloted and refined prior to the focus groups and interviews taking place. Semi-structured interviews were approximately 40 minutes in length (n=2) and focus groups were approximately 1 hour in length (n=2). Participants of the focus groups and interviews also completed a demographics questionnaire prior to starting the focus group or interview. Some example questions from the interview guide are highlighted below (table 3.2).

Table 3. 2: Example questions from focus group and interview topic guide
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RE-AIM Dimension	Questions
Reach	What convinced you to participate in the intervention? Why do you think this worked for you and not others?
Effectiveness	How did the intervention effect your sitting behaviour? Why do you think you adopted this behaviour? Were there any strategies you tried that didn't work? Were there any barriers to you adopting new behaviours?
Implementation	Were there any challenges to being involved in the intervention? What improvements, if any, would you make to the intervention?
Maintenance	What will stop you continuing to reduce your sitting time at work? What do you think could help the intervention be maintained by the college?

4.4.1.2 Interviews with key informants

Seven key informant interviews were conducted either in person or over the phone. Key informants were identified through the research team and were emailed to be a part of the evaluation. Those who responded were then sent an information sheet, consent form and a convenient time and place were scheduled for the interview. A key informant interview guide was developed in line with the RE-AIM QuEST framework. The key informant interview guide was developed separately to the participant topic guide due to their different experience with the intervention. There was very minimal overlap in questions however the core themes of questions remained the same (see table 3.3). The interview guide required some minimal adaptations in order to reflect the specific key informants' involvement with the intervention. The interviews varied in length (23min-67mins).

Table 3. 3: Example questions from key informant interview topic guide

RE-AIM Dimension	Key informant questions
Reach	Were there any groups of employees you felt were not represented or missed due to the recruitment strategies undertaken? What do you think influenced the reach of the intervention?
Effectiveness	Were there any unintended or unexpected issues reported from participants?
Implementation	How did you ensure consistent implementation of the consultation? How much time was needed to train staff? Did you change or adapt the implementation as the intervention progressed?
Maintenance	What do you believe are the barriers to continuing the program? Could it become part of existing programming? If so, how?

4.4.2 Questionnaire data collection

The quantitative data was collected through three individual questionnaires (supplementary file 1). These three questionnaires were developed specifically for obtaining feedback for this intervention and were given to three unique evaluation participant groups. These groups included; non- participants, participants who dropped out and participants who completed the intervention. Both the non-participants and participants who dropped out were sent links to a brief two-item online (Qualtrics) questionnaire to explore reasons for non-participation and dropout. In the two similar questionnaires, employees were first asked why they did not participate. They were given a list of potential options which slightly differed depending on if they were a non-participant or a dropout participant. The second item in both questionnaires was a free text box in which participants could further explain their answer or give an alternative answer. The third questionnaire was developed for participants who completed the consultation intervention. Each were sent a link to a nine-item post intervention questionnaire in which they answered questions on regarding their participation. For example, participants were asked “Did your awareness of time spent sitting change following the intervention: a) A lot b) A fair amount c) Moderately d) A little e) Not at all.

In addition, participation rate was calculated based on information obtained from the college’s department of human resources and the study coordinator regarding employment numbers and the study response numbers. Cost of implementation (in hours) was calculated based on information obtained from the study coordinator regarding the total study hours used for training the consultation team, and the total hours worked by the consultation team delivering consultations to participants.

4.5 Measures

Table 3.4 illustrates each of the indicators assessed in this process evaluation to inform on specific dimensions; and the data source used to measure and/or understand each indicator.

Table 3. 4: RE-AIM dimensions, indicators assessed and the data source used to measure or inform indicators.

RE-AIM Dimension	Indicator	Measure
Reach	Quantitative How many and what proportion of the target employee population were participating in the intervention?	Quantitative measures Participation rate= # participating/ # eligible. Drop-out rate = # signed up/ # completed assessment. Questionnaires with participants who did not take part or dropped out.
	Qualitative What were the barriers to enrolment? What explains the variation in reach, number of participants enrolled and the decline in rate of participation? What were the barriers to participation for employees? What were employees' reasons for not participating?	Qualitative measures Interviews and focus groups with participants and key informants. Questionnaires with free text responses from both participants who dropped out and non-participants.
Effectiveness	Quantitative What were the effects of the intervention on objectively measured indicators of SB?	Quantitative measures Reported in Hutchison et al 2018. [8]
	Qualitative Were there any unintended effects of the intervention (positive or negative)? What were the conditions and mechanisms that lead to effectiveness?	Qualitative measures Interviews and focus groups with participants and key informants. Questionnaires with intervention participants.

	What adaptations are needed to improve effectiveness?	
Adoption	Not assessed	
Implementation	Quantitative What was the estimated cost of the intervention?	Quantitative measures # of working hours to implement intervention/ # of participants.
	Qualitative What were the contextual factors and processes underlying fidelity across implementation and how do we address them? What were the contextual factors and processes underlying barriers to implementation and how do we address them?	Qualitative measures Interviews and focus groups with participants and key informants. Questionnaire responses from participants who dropped out and non-participants.
Maintenance	Qualitative What were the barriers to maintaining the program? In what form are the components of the intervention sustainable?	Qualitative measures Interviews and focus groups with participants and key informants.

4.6 Data analysis

4.6.1 Qualitative

Braun and Clarke's [16] approach to thematic analysis was used to separately analyse both the study participant data and the key informant data. This approach was selected for its adaptability to both participant and key informant interview data. Furthermore, Braun and Clarke also advocate for the approach's theoretical flexibility, which facilitated the use of both inductive open coding across the data, as well as deductive coding, based on the RE-AIM framework [16, 17].

Familiarisation – All of the data collection and analysis was done by the PhD student. With a wider understanding of the researcher's central place in the interpretation of the data [18] the PhD student listened back to the recordings after completion of the focus groups and interviews and created reflexivity notes [18]. The interviews were then listened to again and transcribed verbatim.

Generation of initial codes - The transcripts were uploaded onto an analysis software tool Nvivo (12) to facilitate organisation of the coding process. The PhD student performed all of the initial coding by creating initial codes, which pulled together text that the PhD student considered analytically important in relation to the research question. Deductive coding was carried out in relation to the RE-AIMQuEST framework, aligning data to one of the five indicators of the framework. Inductive open coding of the data was also carried out to ensure information that did not specifically relate to the indicators of RE-AIM was not lost. To enhance trustworthiness of the data, a second sweep of coding was conducted [17] in which both the PhD student, and another experienced qualitative researcher or “critical friend” (A-M.G.), interrogated the initial interpretation [19, 20]. This coding process was used firstly for all of the intervention participant data. It was then separately repeated for the key informant data, with the analysis being more deductive in nature. Finally, it was repeated for the free text responses from the questionnaires, with the analysis being purely inductive in nature.

Generation of themes- Similar coding constructs were brought together into initial themes by the PhD student. At this point, to further enhance trustworthiness of the data, a process of critical examination was employed. The PhD student and critical friend met on four occasions. In these meetings each initial theme was interrogated by both the critical friend and the PhD student. Through this process, written feedback was generated for each theme. After reviewing and reflecting on the feedback, the PhD student revisited the theme constructs, making changes to the initial themes, and subsequently, renamed and defined each theme. Quotes were then selected which best represented the central organising concept within each theme.

4.6.2 Questionnaire data analysis

Questionnaire data was analysed in SPSS using descriptive statistics to understand the frequency of responses for each question. The free text responses for all of the questionnaires were uploaded into Nvivo and coded for themes.

5. Results

A total of 148 individuals participated in the evaluation. One male and 14 female (aged between 47-64) office based workers who took part in the intervention, and self-reported sitting daily sitting time per working day as >8 hours, participated in one of two focus groups (n=5, n=8) or an individual interview (n=2). Additionally, seven interviews were carried out with members of the consultation team (n=3), study coordinator (n=1) and additional stakeholders of workplace health (n=3). Sixty-nine office-based employees completed the non-participant questionnaire; seven employees completed the drop-out questionnaire, and sixty-one employees completed the 9-item post intervention questionnaire. The results are presented within the dimensions of the RE-AIM framework to clearly illustrate where data relates to individual dimensions.

5.1 Reach

5.1.1 Participation rate

Of the 680 university employees, 376 completed the baseline OSPAQ questionnaire (55%). All of the 376 employees were then asked to participate in the study, and 87 participants enrolled; equalling approximately 15% of the original eligible employee population. The questionnaire data and four qualitative themes outlined below highlight the facilitators and barriers to high participation, reported by evaluation participants.

5.1.2 Facilitators of enrolment to the intervention

Theme 1- Inclusive participation and feeling welcome

Participants expressed that the recruitment strategies helped to foster welcoming feelings and widened participation in the study. For example, one participant stated; "Y*eah, and it included the entire campus regardless of your job and I think that that is a great opportunity for us all."* Key informants also shared this view, with one stating:

"The campus was pretty energised too, and we got a good response rate because at the start of the year when they announced ...(the study)...he said this is what I want to do and I hope everyone will jump in, and, I think we got to a lot of people and more than if you did the "hey did you want to be in that research study? "

Theme 2- Buy-in facilitated by visible leader

This theme developed as participants discussed their perception as to what motivated them to get involved in the study. It was apparent that participants' buy-in increased with a respected and well-liked colleague visibly leading the intervention, as suggested below: *"I think the participation and the width of the participation is much because Jonny is a well-known and well liked, well connected researcher, faculty member, member of our community(staff).* Additionally, another participant said; *"having Jonny next door… if I have been* *sitting about for a bit and I hear him, I'm like, you've been sitting for a long time?! You better stand up!"*

Theme 3 – Participants curiosity and concern about their health facilitated enrolment

In this theme, participants shared that their reasons for taking part in the research was associated with interest and worry regarding their health. The theme was characterised by statements such as:

"We're not 30 year olds anymore, most of us anyway and I think the logistics are starting to catch up you know. I've got friends my age who've had heart attacks or who are on blood pressure medicine and maybe have developed diabetes you know it's all around me and I think that health is really really important to me."

5.1.3 Barriers to enrolment

Sixty-nine office-based employees who, after showing interest in the study decided not to participate, completed a separate non-participation questionnaire. Of the respondents; 18 said they were too busy, 10 felt uncomfortable with data collection, five said it was not a convenient time for them; three said they did not understand what it would entail; three said they forgot to respond; two said they were not interested in the information and one person said they already stand/move a lot in their occupation. Twenty-seven of the 69 respondents selected the "other" category. When these responses were coded, four key reasons for not participating were identified. These included; did not meet the inclusion criteria for the study (n=4); medical issue, pregnancy or disability hindered participation (n=11); organisational and logistical issues with recruitment (n=7); perceived workload pressure (n=5). One person felt they did not need the intervention.

Seven employees who participated in the baseline data collection but did not participate in the consultation completed the drop out questionnaire. Three respondents reported being “too busy” to participate. Four respondents reported scheduling/logistical issues with intervention data collection. Adding to this, one barrier to recruitment was also identified through the key informant interviews.

Theme 4 - Email recruitment not suitable for all employees

It was discussed in key informant interviews that the recruitment strategy of using emails only may have been a barrier to enrolment of some types of employees. For example, one key informant stated:

“We did not successfully reach all campus employees I’d say we had under representation in the people that work in like the services like the dining services, maintenance crew, cleaners so a lot of those people…. also it tends to be a position where, so we recruited via email, so it assumes that people are sat at a computer so that’s not really a population that are really email users.”

5.2 Effectiveness

Nine qualitative themes, and quantitative data facilitated reporting on multiple indicators of effectiveness. These indicators included; effectiveness of intervention components; additional outcomes of the intervention; and facilitators and barriers to effectiveness.

5.2.1 Effectiveness of intervention components

<u>Theme 1- Email intervention component was less effective</u>

This theme developed through responses such as; *“Sorry, but I don't really remember the weekly e-mails.”*, and *“Although I am incredibly aware of the dangers of sitting, I still do it. The emails haven't helped me change my habits at all.”* Adding to this, data the post intervention questionnaire reflected how useful participants thought the weekly emails were; with 29.5% responding that they felt they were “very useful”; and 31.2% saying they were “fairly useful”. In addition, 19.7% felt the emails were “somewhat useful” and 18% felt the emails were “minimally useful”. One participant (1.6%) felt they were “not at all useful.”

<u>Theme 2- Consultation with ActivPAL feedback was a positive experience</u>

In this theme, participants expressed their positive opinions about the consultation, and how they perceived the consultation affected them. For example, one participant said:

“Personally, I am a visual learner so that I was shocked to see the results of how much…. To see it on a graph in colour, and to see how much time I am actually sitting and because it’s 24 hours. I sleep too you know!... and it really captured it visually for me.”

Additionally, questionnaire data regarding the consultation was collected through the post intervention questionnaire. In the questionnaire participants were asked how informative they felt the consultation was; with most of the participants (77.4%) feeling the consultation was either very informative (45.6%)

or fairly informative (32.8%). Some participants felt the consultation was somewhat informative (19.7%), and only one participant felt the consultation was minimally informative (1.9%).

5.2.2 Additional outcomes of the intervention

Theme 3- Intervention caused social and cultural changes which facilitated reducing sitting time

This theme developed as participants shared their perceptions of how the intervention affected the social acceptability in the office culture to stand or move, instead of sitting. For example, one participant said:

" We've actually, we almost are continuing the perpetuation of the (standing) *culture campus wide,……….of course doing it* (standing) *in the larger meetings has been, you know, everyone laughed at first, but now everyone is stood up! So it's ok. So, I do think it's starting a cultural shift almost like a paradigm shift to stand".*

Theme 4- Increased education of sitting as health concern

In this theme, participants sharied their belief that the intervention fundamentally changed their understanding that too much sitting is a health concern. For example, one participant said: *"I think what influenced me the most probably was the first time I sat down and received all the educational material which explained you know the benefits of standing up and the costs of staying sedentary."* Adding to this theme, data from the post-intervention questionnaire indicated that 32.8% of participants said their awareness of sitting increased a lot, 31.1% said it increased a fair amount, 18% said it increased moderately, and 18% said it increased a little.

Theme 5- Breaks energise the brain

Participants shared how breaking up and reducing sitting time affected their energy and productivity. This is highlighted through three participants conversing about breaking up sitting time, saying: Participant A: "*Your brain is more active too I think."* Participant B responds: *"I think you're thinking level too.*" Participant C responds: *"Yeah and your energy."*

Theme 6- Made changes at home to reduce sitting time.

In this theme, participants shared examples as to how the intervention affected their sitting and activity behaviours outside of the office environment. For example, one participant stated:

"*I started parking my car on the other side of the parking lot when I go home, and I work from home… I have a, I guess its bar height, in my kitchen, and so instead of going into my office and working at my desk I started putting my computer and working there in the mornings*."

5.2.3 Barriers to effectiveness

Theme 7- Concentration and focus on work tasks was a barrier to sitting

Participants expressed the difficulty they experienced trying to reduce and break up sitting time when they were concentrating and focussing on work tasks. For example, one participant stated: *"With the kind of work that we do, we are super focused when we're working it's almost impossible to even track the time that goes by".* Additionally, another participant stated*; "And then I'll get into a project and the next thing you know an hour and a half's gone by, and I've not stood up at all."*

Theme 8- Lack of management support

Participants shared their experiences of coming up against institutionalised middle management barriers to reducing and breaking up sitting time:

"It has to do with the middle manager, if you will…. Who is in charge of that unit; and in some cases, you work in human resources, and you darn better be logging in and out of the computer every time you go away from your desk."

Theme 9- New working policy limited employees' ability to reduce sitting time

Key informants learned through the intervention that the implementation of a new policy regarding employees working hours limited behaviour change for some employees. For example, one key informant explained:

"Those that work hourly there was a big shift this year and they had to sign in and sign out electronically so if they took a break at all like if they had to walk to their car because they forgot something, they would have to swipe out and swipe back in, and everything became very monitored ….they felt someone was almost breathing down their necks and that was a very common frustration.

I think it rolled out right at the beginning of the study...so it was interesting to kind of see that shift of flexibility, to really not having much flexibility at all."

5.3 Implementation

Two qualitative themes, and quantitative data facilitated reporting on the cost of the intervention, and facilitators and barriers to implementation.

5.3.1 Cost of implementation

One member of the Springfield research team (J.H.) spent approximately seven hours training staff, and the consultation team spent approximately 24 hours delivering the consultation to participants totalling 31 hours of time spent implementing the intervention. This estimate excluded the time spent by researchers collecting data.

5.3.2 Facilitators and Barriers

Results of the post intervention questionnaire indicated that 79.3% of study participants would not change anything about the intervention, while 20.7% said they would change something. Analysis of the qualitative data gave further insight into how the study was implemented, revealing two themes (one facilitator and one barrier).

Theme 1 -Training procedure in place to keep consultation delivery consistent (facilitator)

Key informants explained details of how training, and the implementation of the consultation was managed. For example, one key informant explained:

"She (study researcher) *actually had us come in one evening and basically kind of presented the presentation to us and had us ask questions along the way and then we had a couple days to look it over and we signed up to lead our first intervention and she sat in on it and then so she was there to chime in if we forgot something or skipped over something and afterwards she gave us some constructive feedback."*

Theme 2 - Minimal flexibility (scheduling/locations) caused fidelity issues (barrier)

This theme developed as both non-participants and intervention participants shared that the study management team were not flexible when scheduling the intervention related activities. For example, one participant stated; *"If you are going to ask for a second set of data, schedule it before the end of classes."* Additionally, a second participant stated; *"I had emailed and said- "well could I do it another week cause it's breaking through thanksgiving* (a holiday long weekend) *and I got- "No this is it! If you're gonna do it, this is the week. There aren't any other ones (dates), they're all signed up for.""*

5.4 Maintenance

Three qualitative themes facilitated reporting on facilitators and barriers to the maintenance of the intervention.

5.4.1 Facilitators and Barriers

<u>Theme 1- Existing health and wellness programmes could facilitate maintenance (facilitator)</u>

Both participants and key informants discussed the potential for the program to be sustained and institutionalised into the college as a part of existing workplace health and wellbeing programs. For example, one participant stated: *"I also wonder, our campus rec and our employee wellness program they do monthly wellness seminars, maybe one of them could be about sedentary behaviour and kind of just bring it to more people."* Additionally, one key informant said;

"We already do some of those sorts of things (consultations) *and I think now it might just be repurposing or reframing some of the stuff that we do…. the fact that some of the faculty members have done the hard work with some of the research. It's there now. There is no reason on my end, which is the implementation and delivery of the* (Health) *programs, to not be able to figure that out."*

Theme 2- Culture and philosophy of college may help facilitate long term behaviour change. (facilitator)

Participants shared how they felt the study aligned with the ethos of the college. For example, one participant said:

"I think the philosophy of spirit, mind and body that sort of puts you know, this is a healthy school we need to do this, and it just makes you think more about your body and what you're doing and what's good for you."

Theme 3 - Consultation unsustainable due to the resources needed for delivery (barrier)

This theme developed as key informants described their perception that the consultation would be challenging to sustain given the resources used. For example, one key informant said; *"So a lot of what we did is not sustainable so I did it for free... I obviously wanted to do that, but it was not something I could sustain and I couldn't do it all year long."* Additionally, another key informant said:

"Who is doing the consultation I guess is more of the question? Just because, this has been put to me in a very informal way, and it wasn't going to be consuming in any way, and I was just going to have my grad assistant send out an email once a month sort of thing."

6. Discussion

The RE-AIM QuEST framework was used to facilitate a mixed methods process evaluation to understand the potential for further implementation and scale-up of a consultation based intervention aimed at reducing and breaking up sitting time in the workplace. Upon interpretation of the results, there is potential for the intervention to be scaled up; however, the process evaluation reveals that there are some barriers across the RE-AIM QuEST framework which need to be addressed to improve the potential for successful scale-up. This discussion will firstly focus on the four RE-AIM dimensions assessed in this evaluation (*reach, effectiveness, implementation and maintenance)*, and secondly give specific recommendations for scaling up the consultation based intervention; with considerations for researchers seeking to evaluate interventions for potential scalability.

6.1 Reach

6.1.1 Facilitators

The reach of the intervention was positively affected by perceptions that “sitting” as a behaviour is easier to change than other health behaviours. Focusing an aspect of workplace health programming on reducing and breaking up SB may foster wider engagement in employees who are otherwise inactive. Additionally, visible leadership was important to the buy-in of participation. In this study, the intervention lead worked in the same office environment as the participants. Participants reported that this person’s presence and personal qualities were a crucial part of their motivation to be a part of the study. This aligns to other office based sitting interventions; for example, in Neuhaus et al, visible “team champions” were reported as “crucial” to the identification of behaviour change strategies suitable to the workplace, and in the promotion of the intervention to participants within the study [21].

6.1.2 Barriers

Whilst over half of the employees complete the OSPASC questionnaire, the participation rate of the intervention was relatively low. Analysis of the questionnaires identified that the three most frequently reported reasons for not participating or dropping out of the intervention relate to a perceived lack of time; scheduling/logistical issues with data collection; and feeling uncomfortable with data collection. These results suggest that the perceived burden of data collection had a significant effect on participation. As an efficacy study, it is important to objectively measure both behaviour and health outcomes in early trials, therefore data collection activities may need to be adjusted to increase the participation rate and decrease the dropout rate at scale-up. There is evidence in the literature suggesting that pragmatic approaches to measurement, such as questionnaires, may need to be considered to achieve large participation rates while still measuring behavioural outcomes [22, 23]. A second barrier reported identified that the email recruitment method may have missed out staff who spend a large proportion of their day sitting, but do not work on a computer (e.g. canteen staff). In a scaled-up intervention, an alternative recruitment strategy could be added, for example promotional posters to facilitate full inclusion of staff who may be highly sedentary, but are not computer-based.

6.2 Effectiveness

6.2.1 Intervention components

There were two intervention components; the weekly educational emails, and the consultation with Activpal feedback. Participants felt that the emails were a less effective element of the intervention. Qualitative responses suggest that the emails were predominantly used as prompts, rather than for educational content. There is evidence in the literature suggesting that prompts can be an effective intervention component to reduce and break up sitting time [24-26]. In Swartz et al., prompts were delivered to break-up sitting bouts once an hour via a wrist-worn device or a desktop computer application [26], and these effective methods may be better placed than emails to deliver prompts to reduce/break up sitting time.

It was clear that participants felt strongly that the consultations were informative. The qualitative responses gave specific context to this, highlighting that participants felt that the analysis of their personal Activpal data was crucial to unlocking motivation to change sitting behaviour. It is therefore clearly important that the visual feedback is taken forward in the consultation at scale-up. However, it has been suggested that the reach of the intervention was negatively affected by the participant burden created by the intensive data collection process. Additionally, resources needed to collect the data may not be pragmatic in a scaled up, more real-world intervention [27]. Therefore, if scaling up, it would be important to consider potential alternatives to giving participants behavioural feedback. Recent research suggests that mobile and wearable monitors are effective [28] and could provide feedback on sitting behaviour with minimal researcher involvement [28-30].

6.2.2 Additional effects on behaviour

The results revealed several additional positive effects of the intervention, with no additional negative effects reported. In this intervention, the participants reported positive social and cultural changes towards an acceptance of reducing sitting time, and reported positive changes to sitting practices at home. Interestingly, these results contrast another study's findings in which the office culture was identified as a barrier to reducing sitting time [31]. Additionally, a separate study demonstrated that sitting at home increased, compensating for reductions in sitting time found at work [32]. Through measuring additional behavioural outcomes, we have improved our holistic understanding of behaviour change, and the mechanisms of change. This can only help to improve future scaled up versions of the intervention by helping researchers identify where best to target efforts for improvement [10, 33].

6.2.3 Barriers to effectiveness

Concentration and focus on work tasks were a barrier to change in the intervention. This aligns with the results from several other studies [34, 35], and suggests that office workers associate specific levels of concentration and focus needed to complete tasks, with sitting. It is unclear how this barrier could be addressed in a scaled-up intervention, and more research may be needed to understand the nature of this association. This may help identify appropriate ways to challenge normalised, habitual behaviour in the future.

The two remaining barriers (*Lack of management support* and *New working policy limited employees' ability to reduce sitting time)* that developed may relate to a common issue of "support" or "buy- in" of managers for the intervention. Minimal support was reflected in the implementation of a new workplace policy which required workers to clock in and out of working tasks on their personal computers. This affected some participants' ability to reduce and break up their sitting time. These two barriers have the potential to significantly influence the success of a scaled-up intervention. It is therefore important that all of the gate keepers of power which could affect behaviour change are engaged in the intervention process. In a study published by Danquah et al., the research team of the scaled-up intervention introduced a buy-in scheme in which managers attended study meetings, and agreed to act as role models throughout the study [36]. This is a good example of how to ensure managers are educated and committed to employees' engagement in health opportunities. Our evaluation highlights that if it is not carefully considered and planned for, organisational level barriers, such as mid-level policy initiatives, can significantly inhibit all other intervention components.

In office-based research we propose it may be beneficial to conceptualise the relationship of the organisational level influence on the individual and environmental levels as pictured in Figure 3.4. This illustrates that the organisational level (e.g. management buy-in or policy) most likely mediates/influences the response to intervention activities at both the individual, and environmental level. Furthermore, this conceptualisation more accurately illustrates that having a multi-component intervention may not elicit behaviour change if the organisational level is not carefully negotiated, to understand facilitators, and uncover barriers, to change.

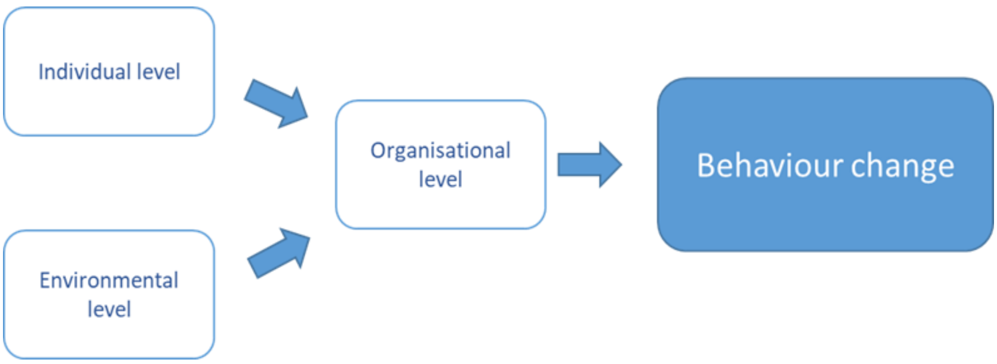

Figure 3. 4: Conceptualisation of mediators of behaviour change in workplace-based research

6.3 Implementation

6.3.1 Cost

Within RE-AIM, dissemination of the time and cost of the intervention [10] is considered important however the “cost/benefit” of interventions targeting office workers is seldom reported [9, 37]. With limited access to information which could inform cost, the research team estimated the time needed to implement the intervention activities which equaled 31 hours to deliver the consultation based intervention to 87 employees. This estimate was designed to best reflect the resources needed to scale up the already developed program, therefore it did not include the resource development time or the data collection time. This ratio of 31/87 (hours implementation/participant) has the potential to improve if the recommendations of this evaluation are implemented effectively. For most companies, time directly equates to cost; therefore, reducing the time spent implementing the intervention will be important to establishing buy-in, and ensuring uptake of workplace interventions. Reporting on time and cost could be very important to businesses which are looking to implement workplace health programs.

6.3.2 Facilitators

Key informants perceived that the training procedures for the consultation were robust; explaining that each team member attended a training afternoon approximately three hours in length. They then attended a consultation delivered by a member of the Springfield research team (J.H.). This researcher then watched an initial consultation and gave feedback at an arranged feedback meeting. Although initial resources are needed, this type of training procedure helps to ensure that deliverers are knowledgeable and that the consultations are being delivered consistently across the study. If resources become limited in a scaled-up intervention, alternative modes of delivering the training may need to be considered. For example, in Salmond and colleagues recent scaled up intervention, researchers successfully moved from in person training to online training to reduce the resources needed [38, 39]. Although an investment of time would be needed initially, this method could make scaling-up training considerably more efficient.

6.3.3 Barriers

Most of the participants had a positive experience with the intervention with the majority of them saying they would not change anything about the intervention. However, some employees felt that the research team could have been more flexible in the scheduling and location of intervention related visits. This may have caused some fidelity issues to the intervention protocol and should be considered prior to the scaling-up the intervention.

6.4 Maintenance

6.4.1 Facilitators

The qualitative data revealed that both participants and key informants felt that their existing employee wellness program could facilitate maintenance of the intervention by adapting existing content and incorporating aspects of the intervention. Collaboration could reduce the resources needed to intervene, help to raise awareness as well as create motivation and buy-in that sitting is a workplace health issue of concern. When moving to scale, and implementing in a real-world office setting, there is a need to move away from singularly focused wellness interventions and towards a holistic integrated workplace wellness approach. In a resource limited environment, this will more likely elicit the motivation of both participants and employers alike, and facilitate long term maintenance of sitting interventions [40-42].

A second facilitator of maintenance of the program was the overarching philosophy of the college; spirit, mind and body. The philosophy directly links to health and, if used tactfully, it has the potential to make the implementation or integration of health-related interventions, programs or policy easier to justify.

6.4.2 Barriers

Maintenance in RE-AIM QuEST looks at sustainability of both the intervention as a whole, and behaviour change long-term. Barriers to the sustainability of the intervention have been addressed through each of the other three sections (reach, effectiveness, implementation) in this evaluation. Measurement of behaviour change long-term is a limitation which relates to limited resources to collect objective data [8]. In the evaluation, participants shared that they have maintained behaviours to reduce and break-up sitting time, but this is not quantifiable or comparable to the baseline measurement of sitting. In a recent intervention, DeCocker and colleagues used questionnaires alongside objective measurement to easily administer and compare follow-up data to baseline [43]. DeCocker’s approach could be used to facilitate the pragmatic collection of long-term follow-up data in a scaled-up version of this intervention [43].

Key informant interviews revealed that they believed the resources allocated for data collection and delivering the consultation could not be sustained long term. This has a direct effect on the potential to scale-up the intervention in its current form. As discussed previously, there is potential to reduce the burden of data collection by moving from objective data to subjective data. Additionally, there are recent examples of scaled up interventions successfully moving from face to face delivery to virtual delivery [38, 39, 44, 45]. For example, due to significant costs, unaffordable in the real world, Goode and colleagues transformed an effective multi-component intervention targeting sedentary office workers (BeUpStanding™ program) into a web based scalable program that could be implemented directly by the workplaces [45]. Adopting this strategy may be effective in reducing the resources needed to deliver the sedentary consultation in a scaled-up intervention.

6.5 Considerations for scale-up

Recommendations for scale-up of the consultation intervention are presented in Table 3.5. Although specific to this intervention, these recommendations can be used to understand the modifications which may be needed to scale-up SB interventions in real world office settings. Engaging in this process evaluation highlights the importance of assessing additional indicators outside the effectiveness of primary outcomes before scale-up is attempted and how this might shape the modifications made to improve the likelihood of successful scaled up implementation. These results exemplify a need for a shift in approach suggested by Zamboni et al., and Reis et al.; in which researchers assess for scalability in pilot phases of research [12, 46]. Put simply, if a public health problem requires wide scale implementation to have impact, then scale-up should be planned for (and evaluated) in the beginning [12, 46-48]. This approach would mean that, rather than over resourcing pilot studies to enhance effectiveness [12] interventions are implemented with similar resources as available in the real-world settings [47]. This approach would also require an evaluation which measures additional indicators. As this evaluation has shown, measuring additional indicators will give researchers an understanding of the potential for, and modifications needed for scaled-up implementation [12, 49]. This approach would not be without its challenges and may require researchers to work directly with stakeholders to co-produce, and test for, sustainable interventions under real-world conditions [40].

Table 3. 5: Recommendation for scaling up the sedentary behaviour intervention

RE-AIM dimension	Recommendation
Reach	▪ Consider adding a non-computer-based recruitment strategy to promoting inclusion of all types of employees. ▪ Consider the addition of peer champions as visible leadership buy-in was important to initial recruitment. ▪ Reduce participant burden of outcome measurement by adjusting to be minimally intensive.
Effectiveness	▪ Consider using the email distribution more frequently as prompts could facilitate improved effectiveness. ▪ Consider alternative ways to capture baseline sitting data for the consultation (e.g. Use data from participants existing mobile or wearable device). ▪ Adopt a system or process for buy-in of managers. ▪ Carefully consider and address organisational level barriers which could affect behaviour change at the individual and environmental level.
Implementation	▪ Continue training procedures; however, consider alternative modes of delivering training (e.g. online training). ▪ Explore options of mobility of delivery of the intervention in convenient locations for employees (e.g. Explore if the consultation and data collection could be done in the participants' own working environment.)
Maintenance	▪ Work with existing workplace health program providers to explore opportunities for collaboration and integration into existing content. ▪ Utilise ethos of workplace health to increase buy-in from individual departments. ▪ Consider adding a subjective measure of behaviour change to facilitate long term follow-up data collection. ▪ Consider alternatives to the delivery of the consultation (e.g. digital delivery) to reduce resources and cost of implementation.

7. Strengths and Limitations

Many of the strengths of this paper are rooted in the pragmatic research approach and methodologies used. This study is one of the first to use the RE-AIMQuEST mixed methods framework to facilitate reporting on indicators that are often overlooked in research to provide detailed insight into the genuine potential for scale-up. The qualitative data was collected and analysed using up to date trustworthiness procedures and utilised epistemologically appropriate methods (e.g. TA) that aligned to the research questions. Also, through the non-participant questionnaire, the research team collected data on this challenging population to gather insight into why employees do not participate. This study is not without its limitations. Firstly, there was minimal demographic information collected about evaluation participants (e.g. ethnicity). Also, the proportion of intervention participants recruited for qualitative data collection was relatively low (15/87). Furthermore, the questionnaires used to collect data on participant/non-participant experiences were not validated. Additionally, the retrospective nature of this type of data collection could be improved upon. Future work could collect some of the implementation data prior to or during the intervention. Finally, although up to date trustworthiness procedures were used, the researchers acknowledge that inherent bias exists in qualitative data analysis, and the results should be interpreted with an understanding of this.

8. Conclusions

RE-AIM QuEST framework facilitated a comprehensive evaluation of the potential for further implementation and scale-up of a consultation-based workplace intervention which targeted both the reduction, and breaking up of sitting time. There is potential for the intervention to be scaled up; however, the process evaluation reveals that there are barriers across reach, effectiveness, implementation and maintenance. These barriers will need to be addressed before scale-up of the effective intervention is attempted. Recommendations for scaling up (table 4) have been presented. Specifically, the research team should seek to use the recommendations to; reduce the participant burden of data collection and reduce the resource and cost of implementation. A shift in the approach to the research process in research fields that ultimately require scaled-up interventions to address the problem may be warranted. Interventions should assess for scalability in pilot phases of research.

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Chapter 4: A Mixed Methods Evaluation of a Digital Intervention to Improve Sedentary Behaviour across Multiple Workplace Settings

1. Preface

1.1 Rationale

The knowledge gained through evaluating the Springfield consultation intervention significantly influenced the direction of the present study. In study 2, it was clear that the Springfield consultation required too many resources in its current form to be implemented at scale and significant adaptations were suggested in the form of recommendations. In addition, although the process evaluation met the aim of the PhD and addressed several gaps in the research, it also highlighted the pitfalls of implementing intervention in which scale-up or public health impact is an afterthought. This suggested that plans for scale-up should be a part of an intervention from the beginning, and evaluating for potential impact in the real world in pilot studies may be as important as testing for effectiveness. This type of evaluation would need to be done across multiple office settings to gain understanding of indicators of the adoption dimension of RE-AIM. Based on this, opportunities were explored to evaluate an intervention for potential real-world impact across multiple settings.

1.2 Welbot Collaboration

Through a Scottish Government-funded developing innovation scheme, a collaboration between Strathclyde University and a start-up company called Welbot^{TM} was established. Welbot was in the beginning stages of developing a digital application aimed at reducing workplace SB. The collaboration was made up of three stages: stage one - hypothesis validation; stage two - content validation, creation and analysis; and stage three - pilot testing. The developmental flow chart in Figure 4.1 highlights the key elements of each stage of the project. The research team was made up of seven Strathclyde members of staff, and the PhD student played a critical role within the team working across all three stages of the collaboration.

Figure 4. 1: Project flowchart

Stage 1 – Hypothesis Validation

- Conducted literature review in order to evidence-base Welbot's three key hypotheses:

i) Sedentary computer bound work styles produce unhealthy outcomes

ii) There are strategies and interventions that can produce healthier behaviours in the workplace

iii) Real-time computer prompts can deliver effective interventions that change behaviours

- Comprehensive report of evidence, which helped to guide refinements and future developments with the digital intervention

Stage 2 – Content Validation, Creation, and Analysis

- 3 sub-phases

i) Content Validation – Research team validated previously developed content, which involved providing a quality score, correlating specific nudges with the evidence-base, and suggesting recommendations for improvement

ii) Content Creation – Involved creating new content for the digital intervention, resulting in 532 new nudges.

iii) Content Analysis – Involved collating all content into 4-week progressive journeys that were either more physically orientated (e.g. 'Stand Up, Sit Less, and Move More' or 'Less Time on Screens')

Stage 3 – Pilot Testing

- Comprehensive evaluation of the digital intervention, which involved examining the impact of Welbot on sedentary behaviour, physical and mental wellbeing in a sample of employees

1.3 Stage 1 – Hypothesis Validation

In stage one, the Welbot company provided details, in the form of a brief (Figure 4.2), of how they felt the research team could aid in developing the company's understanding of the research by searching for evidence which tested Welbot's assumptions or hypotheses about the research. Figure 4.2 illustrates that the requirements fell across three overarching hypothesis: a) Sedentary computer-bound work styles produce unhealthy outcomes; b) There are strategies and interventions that can produce healthier behaviour in the workplace; and c) Real time computer prompts can deliver effective interventions and change behaviours. As illustrated in Figure 4.2 these hypotheses were further divided into subcategories. In total 14 hypotheses were tested against the available evidence.

Figure 4. 2: Hypothesis validation brief for stage 1 of the Welbot Strathclyde collaboration

welbot®

HYPOTHESIS VALIDATION BRIEF

Requirement:

Welbot has identified a need for access to up-to-date research, expertise and evidence to validate their hypothesis that - (a) sedentary computer-bound workstyles produce unhealthy outcomes; (b) there are strategies and interventions that can produce healthier behaviours in the workplace, identifying what works and the most beneficial activities; (c) real time computer prompts can deliver effective interventions and change behaviours.

More specifically, Welbot would want the following validated.

(A) Sedentary computer-bound workstyles produce unhealthy outcomes

1. Sedentary computer bound workstyles produces varied musculoskeletal problems.
2. The amount of time we spend seated at work is a contributor to obesity in the work population.
3. Prolonged computer use causes a decline in our eyesight.
4. Prolonged computer use in a work environment will negatively impact your mental health.
5. There are other workplace specific factors that cause a decline in mental health.
6. There is a maximum amount of time you should spend looking at your computer screen, before needing to take a screen break.
7. Sitting for more than 20 mins at a time produces unfavourable health outcomes over a prolonged period

(B) There are strategies and interventions that can produce healthier behaviours in the workplace

1. Short bursts of physical activity of 1 to 5 mins, such as stretching and desk-based exercises, will produce favourable health outcomes.
2. There are desk based interventions that can be performed to help improve your mental health.
3. Screen breaks can help improve both physical and mental wellbeing.
4. There is an optimum number of differentiated short-break exercises that a person should engage with in a typical working day

(C) Real time computer prompts can deliver effective interventions and change behaviours

1. Interventions at work, of the type and duration proposed by Welbot, will aid rather than reduce productively.
2. The ideal interval between nudges is 40 mins, to produce the desired response and healthy outcome.
3. The ability for users to control the type of nudges they receive, in the form of goal setting, will increase engagement and use of the product.

At the end of stage one, a comprehensive report was developed which validated to the company that high volumes of sitting are detrimental to the health and wellbeing of employees and that using digital prompts to reduce and break up SB may help to improve health. Table 4.1 exemplifies the process by illustrating how the PhD student pulled together evidence to test hypotheses A7, B1, B4 C1 and C2.

Table 4. 1: Evidence used to test hypotheses

Hypothesis	Evidence	References
A7) Sitting for more than 20 minutes at a time produces unfavourable health outcomes over a prolonged period.	Evidence suggests that interrupting sitting time with frequent brief bouts of light-intensity (aerobic and resistance) activity produces acute positive effects on cardiometabolic health outcomes. In the majority of studies sitting has been interrupted every 20-30 minutes with significant effect on cardiometabolic health outcomes.	(Bailey & Locke, 2015; Dunstan et al., 2012; Peddie et al., 2013)
B1) Short bursts of physical activity of 1 to 5 mins, such as stretching and desk-based exercises, will produce favourable health outcomes. **&** **B4) There is an optimum number of differentiated short-break exercises that a person should engage within a typical working day.**	There is evidence that suggests that short breaks (specifically a combination of 9 x 20 second exercises such as; squats, arm circles, calf raises, knees to elbows and forward lunges) every 20-30 minutes may be an effective intervention to break up sedentary time and decrease the potentially damaging effects of prolonged sitting on cardiovascular health. There is evidence that breaking sitting with standing and light-intensity walking effectively improved 24 hour glucose levels and improved insulin sensitivity. Interrupting prolonged sitting with brief bouts of light walking or simple resistance activity (SRA) every 30 minutes decreases the presence of harmful waste products in the blood stream which increase a person's risk of heart disease and type 2 diabetes.	(Carter & Gladwell, 2017; Dempsey et al., 2016; Dunstan et al., 2012; Duvivier et al., 2017; Healy et al., 2017).
C1) Interventions at work, of the type and duration proposed by Welbot, will aid rather than reduce productivity.	Currently no evidence exists on the effects of prompt-based intervention and productivity. However, several studies have reported positive effects of workplace interventions on productivity and/or absenteeism.	(Mills, Kessler, Cooper, & Sullivan, 2007; Serxner, Gold, Anderson, & Williams, 2001)
C2) The ideal interval between nudges is 40 mins, to produce the desired response and healthy outcome.	There is no evidence available on the effect of breaks every 40 minutes. However, there is evidence that nudges every 20-30 minutes produce significant improvement in health outcomes (see A1, A2, A3, A7, B1, B4). Nevertheless, a recent study reported office workers most often self-selected nudges to occur every 60 minutes and reported that this frequency of breaks felt the most "manageable"	(Carter & Gladwell, 2017).

1.4 Stage 2 - Content Validation, Creation, and Analysis

In stage two, the PhD student worked on three sub-phases of the Welbot development; content validation, creation, and analysis. Firstly, the PhD student validated previously developed content including stretches, exercises and mindfulness nudges. This involved providing a quality score, correlating specific nudges with the evidence-base, and suggesting recommendations for improvement. Secondly, the PhD student along with the research team created new evidence-based content to the specifications needed for the Welbot company to create new nudges. This resulted in the creation of content for 523 new nudges. An example of content creation for one nudge is illustrated in Table 4.2.

Table 4. 2: Example of content development for stage 2 of the Welbot collaboration

DOING CARD - **Short Description (114 characters including spaces)**	**DONE CARD- (heading in bold) (content in unbold - 156 characters including spaces)**	**DESCRIPTION CARD -** **Long Description (369 characters including spaces)**	**Full Description (720 characters including spaces)**	**Idea for Animation**
Try to interrupt sitting time with short & frequent (every 20-30 mins) breaks! Stand up, sit less & move more!	**Nice!** Short & frequent breaks are the key to standing up, sitting less & moving more!	Exercise cannot compensate for too much sitting - instead it is all about interrupting sitting time with SHORT & FREQUENT breaks! Research suggests that interrupting sitting time every 20-30mins is best for your health. BUT, don't worry if this doesn't work out – any break from sitting is a move in the right direction! So stand up, sit less & move more!	We often find ourselves sitting at work for hours on end. These long periods of sitting can slow metabolism, which over time increases your risk of conditions like type 2 diabetes & cardiovascular disease. BUT, by standing up, sitting less & moving more, we can make BIG steps to reducing our risk, & ultimately boosting our physical & mental wellbeing! So it's really important that we try to stand up, sit less & move more! This exercise emphasises that exercise cannot compensate for sitting too much, instead it is all about taking short & frequent breaks!	Stand UP, sit LESS, move MORE

Finally, in sub-phase three, the new content was pulled together into four-week progressive goals, that were either more physically orientated (e.g. 'Stand Up, Sit Less, and Move More' or 'Less Time on Screens') or mentally orientated (e.g. 'Reduce Stress', or 'Reduce Procrastination'). Figure 4.3 illustrates the goal for 'Stand Up, Sit Less and Move More' which was created by the Strathclyde research team for the Welbot collaboration.

Figure 4. 3: Example of a 'Goal' created for the Welbot collaboration

Goal = Stand Up, Sit Less & Move More

- This goal targets STANDING UP, SITTING LESS & MOVING MORE (Sedentary Behaviour Awareness; Planning for Breaking Sedentary Behaviour; Breaking Sedentary Behaviour at your desk; Goal-Setting; Booster Breaks; Workplace Challenges to get Active; Desk-Based Stretches; Desk-Bases Exercises; Yoga), but also includes tech breaks, hydration, smoking, and morning/afternoon/evening greetings (as advised by Welbot)

Steps:

- Week 1 (Awareness/Planning/Exercises) = Sedentary Behaviour Awareness; Planning for Breaking Sedentary Behaviour; Desk-Based Exercises (week 1)
- Week 2 (Goal-Setting/Breaks/Exercises) = Goal-Setting; Booster Breaks; Desk-Based Exercises (week 2)
- Week 3 (Stand up, Sit Less, & Move more; Yoga; Exercises) = Breaking Sedentary Behaviour at your Desk; Yoga; Desk-Based Exercises (week 3)
- Week 4 (Stretches; Challenges; Exercises) = Desk-Based Stretches; Workplace Challenges to get Active; Desk-Based Exercises (week 4)

Nudge Groups and Nudges (red = new content; green = content taken from newly created goals; black = existing content):

STANDING UP, SITTING LESS & MOVING MORE:

- SEDENTARY BEHAVIOUR AWARENESS = How much SB do I engage in?, Exercise doesn't compensate, Short & Frequent SB breaks, Positives of breaking SB 1-11
- PLANNING FOR BREAKING SEDENTARY BEHAVIOUR = Obstacles to breaking SB, Timers to stand up & move more, Sit for 20 Stand for 8 Move for 2, Reward yourself
- BREAKING SEDENTARY BEHAVIOUR AT YOUR DESK = Breaking Sitting Tracker, Simply stand up, Stand up & walk 100 steps, Stand up & do exercise of choice, Move more & hydrate, Stand up with feet shoulder width apart, Stand up with feet wide, Stand up on one leg, March on the spot, Stand up like a superhero, Walking meetings, Standing meetings, Take the stairs, Consider Standing, Choose the longest route, Use the centralised office equipment, Email less & move more, Link your workplace with physical activity, Link your clock with physical activity, Move more while commuting
- GOAL SETTING = Specific Goals, Measurable Goals, Achievable Goals, Realistic Goals, Time-Managed Goals
- BOOSTER BREAKS = Yoga Booster Break 1-3, Physical Activity Booster Break 1-4
- WORKPLACE CHALLENGES TO GET ACTIVE = Workplace challenges to get active 1-3
- DESK-BASED STRETCHES (that break sitting) = Chest opener, Chest stretch, Forward fold, Lateral stretch, Shoulder shrugs, Standing active trunk lateral, Standing quad stretch, Standing shoulder stretch, Wall calf stretch, Wall shoulder stretch, Wrist stretch, Wrist supination
- DESK-BASED EXERCISES (that break sitting) (week 1-4)= Tricep dips, Tricep dips, Arm circles, The hover, The sumo hover, Mini chair squat, Desk chair plank, Seated reverse plank
- YOGA = Yoga 1-8

Other: Tech break group; hydration group, smoking group; morning/afternoon/evening greetings

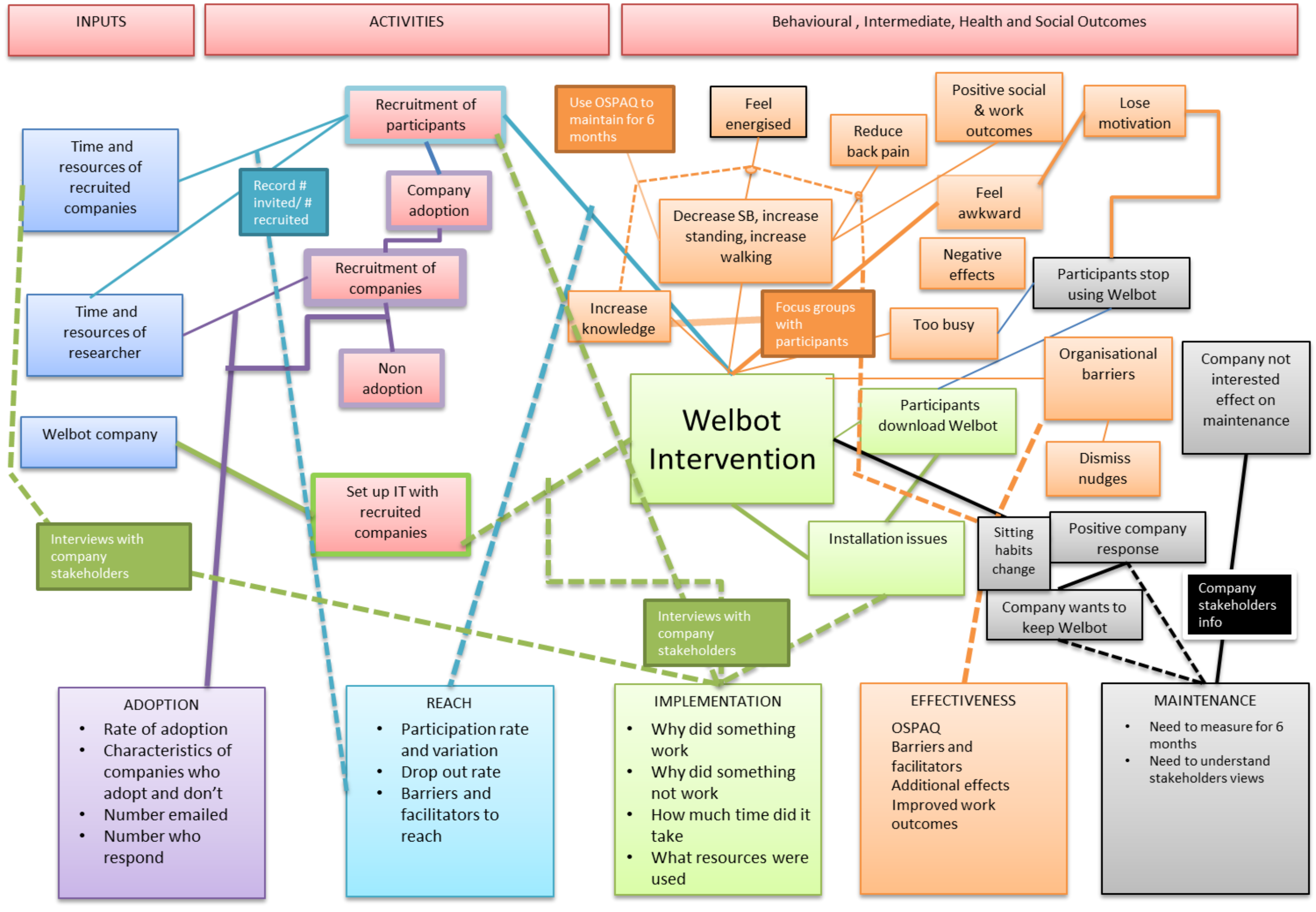
1.5 Stage 3 – Pilot Testing

The final phase of the project is the subject of the mixed methods evaluation that will be presented in this chapter. The evaluation was planned to assess the Welbot application across all five dimensions of the RE-AIM framework in multiple workplace settings to understand its potential to have real world impact.

1.6 Evaluation Planning

To try to understand the potential for the digital intervention to have real world impact across settings, the PhD student planned to limit their influence on the implementation. For example, limiting efforts to maintain participants and fixing problems. This meant planning to embed evaluation methods which would allow for minimal interference with the individual companies. Building a logic model, and using the recommendations for reporting from study 1 helped to guide decision making in relation to the methods used for data collection. The logic model for planning the evaluation of Welbot across multiple settings is presented in Figure 4.4. As in study 2, the logic model is presented to fully illustrate the steps taken to plan the evaluation. Specifically, the logic model helped to unpack the inputs, activities and outcomes of the intervention, and how they each related to individual dimensions of the RE-AIM framework.

Figure 4. 4: A logic model for planning the evaluation of the Welbot digital application.



At the end of the logic model process a more concrete picture of how study 3 would be implemented and evaluated took shape and a more formal evaluation plan was developed. Importantly, the model illustrated that to fully understand the potential for the digital application to have real world impact it would need a mixed methods evaluation, implemented in multiple office settings. This would allow for reporting of indicators of adoption. Also, it could help to detect setting variations in the other RE-AIM dimensions. Additionally, to facilitate data collection within maintenance the intervention would need to be implemented over six months. With these objectives in mind a single group repeated measures study design was deemed the most appropriate to optimise data collection across multiple workplace settings. The final outcomes and indicators which were assessed in the process evaluation are detailed in the manuscript that follows this section.

1.7 Materials

A Qualtrics questionnaire (Appendix F), participant information sheets (Appendix G), consent forms (Appendix H), draft emails (Appendix I) and topic guide (Appendix J) were all developed and approved in the ethics process.

1.8 Quantitative measures

Additional detail and rationale for selection of quantitative measures is provided in this section. Brief summaries of these measures are also provided in the study manuscript in this chapter.

1.8.1 Measuring sedentary behaviour

SB was measured primarily with The Occupational Sitting and Physical Activity Questionnaire (OSPAQ). It was developed as a simple and effective self-report assessment tool for measuring the percentage sitting, standing, walking and heavy labour at work (Ketels, Maes, Dyck, & Clays, 2020). In relation to test-retest reliability, a study conducted by Jancey and colleagues reported good to excellent intra class correlations for sitting (ICC=0.66), standing (ICC=0.83) and walking (ICC=0.77) (Jancey, Tye, McGann, Blackford, & Lee, 2014). This result is comparable to other results (Chau, Van Der Ploeg, Dunn, Kurko, & Bauman, 2012). In relation to validity, several studies show moderate validity when compared to criterion accelerometer measures (Chau et al., 2012; Ketels et al., 2020). For example, Ketels et al. reported assessed criterion validity of the OSPAQ across 401 participants reporting ICC's and Spearman rho correlations (r). The results indicated that criterion validity was good for assessing percentage of sitting (ICC=0.84; r=0.53), and moderate for assessing standing (ICC=0.64; r=0.53). The criterion validity for walking was weak to moderate (ICC=0.50; r=0.49), and weak for performing heavy labour (ICC=0.28; r=0.35) (Ketels et al., 2020). Additionally, stronger validity scores were found in sedentary professions for occupational sitting (ICC= 0.81; r=0.70), and standing (ICC=0.66; r=0.75). All of these authors agree that the OSPAQ instrument has acceptable measurement properties for application in the office workplace setting (Chau et al., 2012; Jancey et al., 2014; Marshall, Miller, Burton, & Brown, 2010).

The OSPAQ was chosen for several additional reasons outside its validity and reliability to use in the office workplace setting. Firstly, the approach would limit the burden on participants compared to objective measurement of SB. This could facilitate understanding of the reach of the intervention in the real world if participants decided not to sign up or dropped out because of the data collection burden. Additionally, the OSPAQ is easily implemented and requires minimal labour meaning the study did not limit recruitment based on availability of devices or research staff. Also the questionnaire has been used in other SB interventions making the intervention results easily comparable to other interventions if necessary.

Additionally, as Welbot promotes breaking up bouts of sitting, they were measured by asking how many times participants stood up from their desk at work per hour and per day at the present time.

1.8.2 Measuring additional outcomes

In relation to the effectiveness of the intervention, RE-AIM explains that it is also important to assess if an intervention has additional positive or negative effects on a participant's health or quality of life. Furthermore, the systematic review produced evidence that additional outcomes are underreported in SB interventions with office workers (MacDonald, Janssen, Kirk, Patience, & Gibson, 2018). Therefore, study 3 included several additional outcomes. The rationale for choosing these additional outcomes and measure is outlined below.

1.8.2.1 Musculoskeletal Symptoms

In relation to additional effects on health, as described in the literature review, there is evidence that work-related sitting is associated with higher prevalence of back pain (Chen et al., 2009). Therefore, a recommendation from the review was that interventions in office workers should measure this outcome to understand if the intervention had positive or negative effects on musculoskeletal symptoms. Some other researchers investigating SB in office workers have also measured musculoskeletal symptoms (Brakenridge et al., 2018; Danquah, Kloster, Holtermann, Aadahl, & Tolstrup, 2017; Pronk, Katz, Lowry, & Payfer, 2012). Upon examination, Brackenridge et al.'s choice of measurement, the standardised and validated Nordic Musculoskeletal Questionnaire (NMQ) (Kuorinka et al., 1987), was chosen for the Welbot evaluation (Brakenridge et al., 2018). The questionnaire aligned well with the

Welbot application as it measured musculoskeletal symptoms across the whole body, including extremities (arms and legs), which are targeted by Welbot's stretches and exercise nudges.

1.8.2.2 Engagement in work

In relation to quality of life measures, it was also seen as important to understand how the behavioural intervention affected the participants' working lives. This can be measured in a variety of ways which include measures of mental health-related outcomes in the workplace (Tennant et al., 2007). However, in this investigation, Welbot as a stakeholder in the intervention made it clear that measures which may highlight improved work performance or productivity were a priority for them. As a compromise, the validated Utrecht Work Engagement Scale Questionnaire (UWES-17) was used (Seppälä et al., 2009). Specifically, UWES-17 enabled some insight into constructs of work-related psychological state (e.g. mental resilience while working), but also allowed for more overall understanding of how engagement in working tasks was affected by the intervention, and how this may have any additional effects on interrupted or improved productivity (White, Wells, & Butterworth, 2014). Mental wellbeing was not ignored, and in the qualitative data collection participants had the opportunity to share perceptions of the effect of the intervention on their mental wellbeing.

1.8.2.3 Health related absenteeism

Additionally, there was an interest from both the researchers and the stakeholders to understand if there were any longer term positive or negative effects on indicators of health such as health-related absenteeism. Upon investigation, the Health and Work Performance Questionnaire (HPQ)- Short Form (absenteeism questions) was chosen as it allowed for the isolation of health-related absenteeism from other forms of absenteeism (Kessler et al., 2004).

1.9 Qualitative Methods

TA was chosen as the methodology for data collection for its flexibility to analyse diverse research questions and its alignment to the pragmatic research objectives. The detailed background to this methodology was given in chapter 3 and a detailed explanation of the implementation of the approach to analyse the qualitative data, including trustworthiness procedures is given in the manuscript

1.10 Quantitative data analysis

The quantitative data was exported from Qualtrics into excel files where it was cleaned for analysis. The cleaning of the data involved creating a coding sheet. In the coding sheet question responses were given a numeric code. This code was then applied to all responses in the file changing all of the data over to numeric data. This was done for baseline, 1 month, 3 month and 6 month data files. All cleaned data sets were then imported into SPSS and participant data was matched by participant ID across the data time points ready to be analysed. Full details of the analysis process are provided in the manuscript.

The manuscript for the mixed methods evaluation of a digital intervention to improve SB across multiple workplace settings will now be presented.

Paper 3: A Mixed Methods Evaluation of a Digital Intervention to Improve Sedentary Behaviour Across Multiple Workplace Settings.

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Tables: 12

Figures: 7

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2. Abstract

Background: Prolonged sedentary behaviour (SB) is associated with risk of chronic diseases. Digital interventions in SB require mixed method evaluations to understand potential for impact in real-world settings. In this study, the RE-AIM QuEST evaluation framework will be used to understand the potential of a digital health promotion application which targets reducing and breaking up SB across multiple workplace settings. Methods: Four companies and 80 employees were recruited to use a digital application. Questionnaires were used to measure SB, and additional health and work-related outcomes at baseline, one month, three month and six month follow-up. Qualitative data was collected through focus groups with employees and interviews with stakeholders. Questionnaire data was analysed using Wilcoxon Sign Rank tests and qualitative data was thematically analysed. Results: The digital application significantly increased standing time at one month for the total group and transitions per hour in one of the companies. Facilitators and barriers were identified across RE-AIM. Conclusions: Addressing the barriers which have been identified, while maintaining the positive attributes will be critical to producing an effective digital application which also has the potential for impact in the real world.

Keywords**:** RE-AIM; sitting time; office workers; process evaluation; workplace health

3. Introduction

Sedentary behaviour or sitting time is any waking behaviour which is under 1.5 metabolic equivalents done whilst seated or in a recline position [1]. Accumulating high daily amounts of sitting time is associated with increased risk of cardiovascular disease, type 2 diabetes, all-cause mortality, some cancers, and reduced mental wellbeing [2–5]. Office workers accumulate large amounts of sitting time [6,7], and are therefore at particular risk.

Digital interventions to reduce sitting time in office workers may have the potential to reach large populations of employees for minimal resources; however, little is known of this potential as most interventions report only on the effect on behaviour; and very few evaluate for wider potential for impact across settings, under real-world conditions [8–10]. Researchers have suggested that building collaborations within the health industry is the best way forward, as collaborations would enable the sharing of expertise and resources. This should maximise the capacity to adequately test a technology's potential to influence behaviour in the workplace [11,12]. Additionally, experts have suggested that these evaluations should be performed in early phases of research [13–15], and evaluate multiple indicators of real-world potential, to enable early understanding of the adaptations which may be needed to have large scale, real-world impact [8,13,15–17]. This approach, however, would require appropriate evaluation methods, and in two recent reviews of digital workplace SB interventions, both authors advocated for the use of evaluation frameworks that support mixed methods study designs to more robustly plan, conduct and report digital interventions in office workers [8,9].

The RE-AIM framework, aided by Qualitative Evaluation for Systematic Translation (QuEST), provides a mixed methods evaluation framework which can support a robust evaluation of the potential for wider impact by examining indicators across five distinct intervention dimensions (R—reach, E—effectiveness/efficacy, A—adoption, I—implementation and M—maintenance) [11,18]. Reach is defined as the absolute number, proportion, and representativeness of eligible individuals who participate in a given initiative. Effectiveness/efficacy assesses the impact of an intervention on the relevant outcomes, including potential adverse effects, quality of life, and economic outcomes. Adoption assesses the reach and effectiveness/efficacy of an intervention at the setting level. It is defined as the absolute number, proportion, and representativeness of the settings and intervention agents (a group of people who implement the intervention) who are willing to initiate a program. Implementation refers to the intervention agents' fidelity to the various elements of an intervention's protocol. This includes consistency of delivery as intended; and the time and cost of the intervention. The maintenance dimension is concerned with both setting level indicators, and the individual level indicators. At the setting level, maintenance is the extent to which a program or policy becomes institutionalised or part of organisational practices and policies. At the individual level, maintenance is assessed by monitoring of effectiveness of an intervention or program six months or more after the most recent contact [11,19]. Forman and colleagues added QuEST to RE-AIM to guide qualitative inquiry to further explore the dimensions of RE-AIM [18].

In this study, the RE-AIM QuEST evaluation framework will be used to examine and understand the potential reach, effectiveness, adoption, implementation and maintenance of a digital health promotion application which targets reducing and breaking up SB across multiple workplace settings.

4. Materials and Methods

4.1 Collaboration

A collaboration with the digital health company, Welbot, was established in the early phases of the development of the Welbot digital application aimed at improving wellbeing in the workplace. The ultimate aim of this collaboration was to create a digital intervention that was evidence-based and uniquely tailored to each individual user. Through this collaboration, the research team provided expertise across two project phases. In the first phase, the PhD student analysed existing content, and created and analysed new intervention content. Firstly, the PhD student validated previously developed content including stretches, exercises and mindfulness nudges. A nudge is a notification that asks users to engage in a simple 1–5 min activity aimed at reducing and breaking up their sitting time (e.g. perform an exercise, make a mindful cup of tea). Validation involved providing a quality score, correlating specific nudges with the evidence-base, and suggesting recommendations for improvement. Secondly, the PhD student along with the research team created new content for the digital intervention, which resulted in approximately 532 new nudges. The final part of phase one was content analysis. This involved collating all content into 4-week progressive journeys that were either more physically orientated (e.g. 'Stand Up, Sit Less, and Move More' or 'Less Time on Screens') or mentally orientated (e.g. 'Reduce Stress' or 'Reduce Procrastination'). The second phase of the collaboration focused on testing the digital application, part of which, was to evaluate Welbot in the real-world across multiple settings. This is the focus of this paper.

4.2 Intervention

The digital application is downloaded by individual users onto their work computer, and incorporates activities such as stretching, exercises, screen breaks and mindfulness; which are delivered to users in the form of 'nudges'.

Each ‘nudge’ has three phases; a ‘preparation card’ which explains what the nudge will require; a ‘doing card’ which explains and visually demonstrates how to perform the nudge; and a ‘done card’ which explains why the nudge is good for physical and/or mental wellbeing. Figure 4.5 illustrates an example nudge from the Welbot digital application.

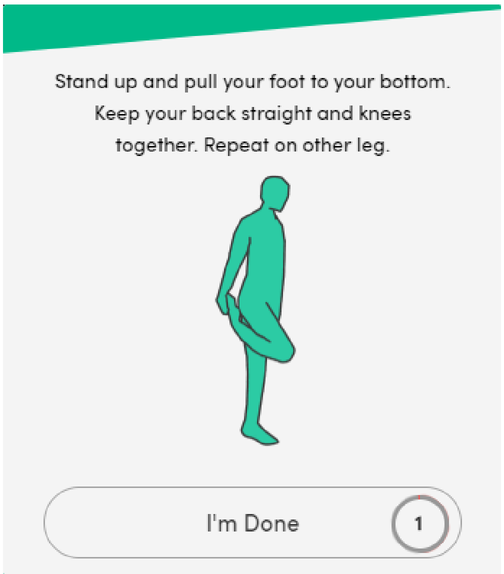


Figure 4. 5: Example of nudge ‘doing card’ delivered during the intervention.

4.3 Study Design

This study utilises both qualitative (interviews and focus groups) and quantitative (questionnaire) methods to collect data across the five RE-AIM dimensions. Data collection was informed and guided by the RE-AIM QuEST mixed methods framework for program evaluation.

4.4 Recruitment

Ethical approval was obtained from the university ethics committee and, after this, a contact list of companies was developed by the research team and Welbot. A convenient sample of 18 companies with primarily office-based employees were approached via email to participate in the study. Within each company, a gatekeeper was approached to send a participant email to all eligible employees. Each employee received an email with a participant information sheet, and was asked to attend a brief presentation explaining how to download and use the desktop-based application. After the presentation, employees were given the option to sign informed consent in person or respond via email at a later point. Employees were eligible if they were adults; employed full time or part time at the company and spent the majority of their working day seated using a computer. Employees were excluded if they were not 18 or had a physical health issue (e.g. severe back pain) that would affect their ability to alter their SB.

4.5 Data Collection

Information relevant to indicators of adoption and reach was collected during the recruitment process. For example, in relation to adoption, the PhD student recorded: the number of companies approached to participate, company size, the recruitment methods used and any reasons given for not participating. The quantitative data were collected at baseline, one month, three months and six months. The qualitative data (participant focus groups and stakeholder interviews) were collected after three months of using Welbot. The primary effectiveness outcomes measured were breaks in SB at work, and total SB at work. Secondary efficacy/effectiveness outcomes included musculoskeletal pain, health related absenteeism and engagement in work.

4.5.1 Questionnaire Data Collection

After providing informed consent, participants were sent an email with a participant identification number and a baseline questionnaire via Qualtrics. The questionnaire data was collected in the same manner at one month, three month and six month follow-up time points.

Questionnaires

The Occupational Sitting and Physical Activity Questionnaire (OSPAQ)—The OSPAQ was used to measure effectiveness on occupational sitting time. It is a brief instrument which measures the percentage of work time spent sitting, standing, walking, and doing heavy labour, as well as the total length of time (in hours) worked in the past seven days. This questionnaire has been reported to have acceptable reliability and validity for application in office-based studies [20,21]. Additionally, as a measure of breaking up SB participants were asked, via the Qualtrics questionnaire, how many times they stand up from their desk per hour and per day.

Nordic Musculoskeletal Questionnaire (NMQ)—The NMQ (Cronbach's alpha = 0.854) was used to measure pain across nine items (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/upper leg, knees and ankles). Participants were asked if they experienced pain in the past seven days across the nine items indicating pain = 1 or no symptoms = 0. A pain score was calculated by totalling the participant's responses across the nine items, with a maximum pain score of nine and a minimum pain score of zero. NMQ has been used to assess pain in a variety of workplace settings, including desk-based employees, and is considered valid and reliable for use as a screening and surveillance tool for musculoskeletal pain [22,23].

The Utrecht Work Engagement Scale Questionnaire (UWES-17)—The validated UWES-17 was used to measure changes in engagement in work [24]. It measures three dimensions of engagement: vigour, dedication and absorption [25]. Each of the 17 items (Cronbach's alpha = 0.905) is scored on a seven-point rating scale from zero (never) to six (always). A mean engagement score is calculated for each participant, with a range from zero (no engagement) to six (always engaged).

Health and Work Performance Questionnaire (HPQ)-Short Form (absenteeism questions)—The short form of the validated HPQ was used to measure health related absenteeism and presenteeism [26,27]. The short form consists of six questions and enables a calculation of net change in absenteeism.

4.5.2 Qualitative Data Collection

Focus Groups with Intervention Participants

All intervention participants were e-mailed to further participate in a focus group. A convenient sample (n = 16) agreed to take part and signed a second consent form. A semi-structured topic guide was developed to explore the participants' perceptions of using the Welbot application in line with the RE-AIM QuEST mixed methods framework. The topic guide was developed, piloted and refined prior to the focus groups and interviews taking place. Focus groups were approximately 45 min in length.

Interviews with Stakeholders

Stakeholders were identified through the recruitment process and were emailed to be a part of the evaluation. Four interviews were conducted in person with at least one stakeholder from each participating company. A stakeholder interview guide was developed in line with the RE-AIM QuEST framework, and adapted for each interview based on the stakeholder's position in the company, and involvement with aspects of the intervention. The interviews varied in length (15–60 mins).

4.6 Measures

Table 4.3 illustrates each of the dimensions and indicators assessed in this process evaluation, along with the measures used for assessment. Each indicator corresponds to a dimension of RE-AIM and helps to explain that dimension. The measure column indicates the data source used to inform the corresponding indicator of RE-AIM.

Table 4. 3: RE-AIM dimensions, indicators assessed and the data source used to measure or inform indicators.

Dimension	Indicator	Data Source/Measure
Reach	Participation rate (total and variation across sites)	Record and report # participating/# eligible
	Drop-out rate	Record and report # signed up/# completed assessment
	Reasons for non-participation	Interviews and focus groups
	Decline rate across office sites	Record and report
	Barriers/facilitators	Focus groups with participants Interviews with stakeholders
Effectiveness	Sedentary behaviour	Occupational Sitting and Physical Activity Questionnaire (OSPAQ) Two item breaks in sitting questionnaire
	Musculoskeletal pain	Nordic Musculoskeletal Questionnaire (NMQ)
	Productivity-engagement in work	Utrecht Work Engagement Scale (UWES)
	Absenteeism	Absenteeism and presenteeism questions of the World Health Organisation's Health and Work Performance Questionnaire (HPQ)
	Additional unintended consequences; physical and/or psychological effects (positive or negative)	Focus groups with participants
	Barriers/facilitators of effectiveness. What are the conditions that lead to effectiveness or no effect? What adaptations are needed to improve effectiveness? (RE-AIM QuEST)	Focus group with participants Interviews with stakeholders
Implementation	Barriers/facilitators, contextual factors and processes underlying barriers/facilitators How do we address barriers?	Focus groups with participants Interviews with stakeholders
	Measure of cost (financial and time)	Individual company self-report and stakeholder interviews
Adoption	Rate of adoption	Record and report # approached, # declined and # enrolled
	What affects company participation/engagement	Interviews with stakeholders
	Method used to identify target deliver agent	Record and report
	Inclusion vs. exclusion criteria of delivery agents	Record and report
	Characteristics of setting and participants of adoption/non-adoption (drop-out participants/setting characteristics)	Record and report company characteristics
Maintenance	Outcome measurement six or more months from baseline (RE-AIM QuEST)	All questionnaires
	Is the program still in place and to what extent?	Record and report
	What are the barriers to maintaining the program?	Contact companies post-intervention reporting most up to date maintenance information possible Focus group participants Interviews with stakeholders

4.7 Data Analysis

4.7.1 Questionnaire Data Analysis

The data collected from all questionnaires was downloaded from Qualtrics survey program into excel where incomplete or missing data was removed. The cleaned data was then extracted into SPSS statistical analysis tool, and analysed. Visual inspection of the Q-Q plots and box plots revealed outliers in the OSPAQ data set. This was due to participant error when self-reporting the percentage of their working day spent sitting, standing, walking and performing heavy labour. The total percentage of all four categories should equate to 100%. However, certain participants reported totals below or above 100% therefore, totals that were ≥ 90% or ≤ 110% were used as cut of points and values outside these were not included in the analysis of the OSPAQ. Data were checked for normality using skewness and kurtosis measures and Shapiro–Wilk tests [28–30]. The skewness and kurtosis z values were checked by dividing the value by its standard error to see if it fell between −1.96 and +1.96. Histograms were also generated and visually inspected for skewness and kurtosis. These analyses showed the majority of the data was not normally distributed, and therefore non-parametric Wilcoxon Sign Rank tests were conducted [28–32]. A Bonferroni correction was made for the three data collection time points, and alpha value was set at 0.0167. A value under 0.05 but over 0.0167 was categorised as trending toward significant.

4.7.2 Qualitative Data Analysis

Braun and Clarke's thematic analysis (TA) approach [33] was used to separately analyse both the study participant data and the stakeholder data. This approach was selected for its adaptability to different types of interview data. It also enabled the use of deductive coding, based on the RE-AIM framework [33] [34]. Firstly, the PhD student familiarised themselves with the data. As the PhD student understood their central place in the interpretation of the data [35], this process started by listening back to the recordings after completion of the focus groups and interviews and creating reflexivity notes [35]. The interviews were then listened to again and transcribed verbatim. The transcripts were uploaded onto an analysis software tool Nvivo (12) to facilitate organisation of the coding process. The PhD student read each of the transcripts and pulled together text that the PhD student considered analytically important and created initial codes. Deductive coding was carried out in relation to the RE-AIM QuEST framework, aligning data to one of the five indicators of the framework. A second sweep of coding was conducted to enhance trustworthiness [34]. Additionally, to enhance rigour, the PhD student, along with another experienced qualitative researcher and critical friend (A.M.G.), interrogated the PhD student's initial interpretation of the data [36,37]. This coding process was used first for the intervention participant data, and then repeated in a second analysis of the stakeholder data. After the completion of the second coding sweep, similar coding constructs were brought together into initial themes and renamed. The themes were reviewed and after reflecting on the feedback, the PhD student revisited the theme constructs and subsequently renamed and defined each theme. Quotes were then selected which best illustrated the central organising concept within each theme.

5. Results

Eighty employees (24 males, 55 females and one non binary person) between the ages of 20 and 65 completed the baseline questionnaire. The mean age of participants was 34 years (SD = 11.2 years, (male = 35.3 years, SD = 11.7, female = 33.4 years SD = 11.2)), with mean working hours of 38.3 h per week (SD = 7 h/ week), and mean working days of 4.8 days per week (SD = 0.8 days/week). The sample was predominantly white European (*n* = 76). On average, participants report to be sitting for 77.3% of their working day at baseline. All baseline descriptive statistics are presented in Table 4.4.

Table 4. 4: Baseline descriptive characteristics of participants.

Characteristic	**Valid Data**	**Mean (Standard Deviation)**	**Median (Interquartile Range)**
Age (years)	80	33.8 (11.3)	29.5 (25.0, 40.3)
Height (cm)	79	169.8 (10.1)	169 (161,175)
Weight (kg)	76	71.6 (13.9)	70 (60.2,82.0)
BMI	76	24.8(4.2)	24.5 (22.4, 26.8)
Sitting (% workplace)	75	77.3 (14.9)	80 (70.0, 90.0)
Standing (% workplace)	75	10.8 (12.4)	5 (5.0, 10.0)
Walking (% workplace)	75	11.8 (7.5)	10.0 (5.0, 10.0)
Sit to stand transitions per hour	80	1.8 (1.1)	1.8 (1.0, 2.0)
Sit to stand transitions per day	80	11.5 (6.7)	10.0 (7.0, 15.0)
Hours missed for health (previous 4 weeks)	80	1.5(5.2)	0 (0, 1.0)
Total engagement	80	3.97 (0.68)	3.97 (3.53, 4.46)
Musculoskeletal pain	80	2.16 (2.00)	2.00 (0, 3.00)

Additionally, 16 of the above-mentioned participants took part in one of three focus groups. Five stakeholders across the four participating companies also took part in interviews. The five stakeholders had various roles within each company, including: human resource manager, company director, managing director, human resources and business officer and director of operations.

In the results section, quantitative and qualitative indicators are presented within the dimension of the RE-AIM framework to clearly illustrate where data or information relates to individual dimensions. The dimension order was altered to Adoption, Reach, Implementation, Effectiveness and Maintenance to more accurately reflect the chronological order of occurrence within the research process.

5.1 Adoption

Four small/medium sized companies with offices in Edinburgh and Glasgow, United Kingdom agreed to participate in the study. Of the 18 companies that were approached via email, nine responded asking for more information, which was provided via email. Two companies decided not to participate at this stage and three companies did not respond to further emails. Companies that decided not to participate reported IT system changes, existing programs and workload pressures as reasons for not adopting the intervention. Companies that did not adopt were also significantly larger than companies that adopted the intervention and required significantly more email and phone meetings. After the analysis of the focus groups and interviews, one theme developed relating to the adoption dimension. The theme 'Company buy-in for wellbeing' is presented in Table 4.5, along with participant quotes which illustrate the theme.

Table 4. 5: Qualitative themes relating to indicators of Adoption.

Adoption Themes	Facilitator or Barrier	Quotes
Company buy-in for wellbeing	Facilitator	Participant—"*We have a mental health pillar it's driven by the people in the pillar who care…. like people do definitely care about it.*" Participant—"*It is quite high, wellness is quite high profile; we do have quite a lot of values, like mindfulness, we have done quite a lot of stuff on workplace wellbeing*."

5.2 Reach

5.2.1 Participation Rate

In total, of the 137 employees across the four companies who were eligible to participate in the study, 80 enrolled and completed the baseline questionnaire. This equalled to approximately 59% of the original eligible employee population. The individual company participation rates are presented in Table 4.6. In summary, Table 4.6 shows a high variation in participation rate between the four companies. Companies with higher participation rates were smaller and had more managers participating in the intervention.

Table 4. 6: Individual company participation rates.

Company	Eligible Office Based Employees Invited to Participate	Employees Who Signed Up	Participation Rate
Company 1	20	19	95%
Company 2	27	12	44%
Company 3	70	30	43%
Company 4	20	18	95%

5.2.2 Dropout rate

Of the 80 participants that completed baseline questionnaires, 60% (*n* = 48) completed one month follow-up, 42% (34) completed three month follow-up and 31% (25) completed six month follow-up. This information along with individual company dropout rates are presented in Table 4.7.

Table 4. 7: Individual company dropout rate.

Company	Total Employees Who Signed Up for Intervention	Total Employee Dropout Rate at One Month Follow-Up	Total Employee Dropout Rate at Three Month Follow-Up	Total Employee Dropout Rate at Six Month Follow-Up
Total group	80	40% (*n* = 32)	56% (*n* = 45)	68% (*n* = 54)
Company 1	19	37% (*n* = 7)	47% (*n* = 9)	57% (*n* = 11)
Company 2	12	25% (*n* = 3)	41% (*n* = 5)	50% (*n* = 6)
Company 3	30	20% (*n* = 6)	47% (*n* = 14)	67% (*n* = 20)
Company 4	18	89% (*n* = 16)	94% (*n* = 17)	94% (*n* = 17)

5.2.3 Barriers and Facilitators to Reach

One theme developed as a result of the analysis of the qualitative data relating to the reach dimension. The theme 'Existing awareness that sitting is a health issue to address' is presented in Table 4.8, along with participant quotes which illustrate the theme.

Table 4. 8: Qualitative themes relating to indicators of Reach.

Reach Theme	Facilitator or Barrier	Quotes
Existing awareness that sitting is a health issue to address	Facilitator	Participant—*"I think that in an office job you're always sitting down, and everyone knows that isn't good for you to sit down all day."*

5.3 Implementation

5.3.1 Cost

Welbot's monthly price ranges from £1 to £2.50 per person, depending on the size of the organisation, and length of the contract. Special category customers, such as social enterprises, charities and educational institutions qualify for the lowest price. Welbot did not charge the participating companies for using their program during the intervention; therefore, using the company characteristics, Welbot provided the estimated financial investment for each company over the intervention period. This is presented in Table 4.9. This estimate is based on 100% retention of the participant population. Additionally, each company self-reported the total hours of company time spent implementing the intervention and this is also presented in Table 4.9. The table illustrates the estimated financial cost of the intervention, as well as the time used by each company to implement the intervention. Additionally, the average cost and time used, per company, and per participant, is presented. Stakeholder interviews revealed that this time was allocated to the following tasks: IT set up and checks; emails and meetings with the primary researcher, and internal meetings and promotion of the intervention.

Table 4. 9: Estimated financial cost and time used to implement the intervention.

Company	Companies Estimated Financial Cost (£) (Six Months Use)	Company Time Used
Total	£702	18 h
Company 1	£171	1 h
Company 2	£72	4 h
Company 3	£270	10 h
Company 4	£189	3 h
Average	£175.50	4.5 h
Per-participant	£8.78	13.5 min

5.3.2 Facilitators and Barriers of Implementation

Four themes developed as a result of the analysis of the qualitative data relating to the implementation dimension of RE-AIM. The results are presented in Table 4.10. The table shows the four themes along with example quotes from participants and stakeholders which illustrate what participants shared in relation to each theme.

Table 4. 10: Qualitative themes and relating to indicators of implementation.

Implementation Themes	Facilitator or Barrier	Quotes
Getting started was easy and straightforward	Facilitator	Participant—"*It was really easy, we just downloaded it.*" Participant—"*It wasn't any time at all really*." Stakeholder—"*It was pretty straight forward*"
Minimal company resources needed to improve	Facilitator	Stakeholder—"*Actually the impact on my time in setting this all up was fairly minimal*."
In-house leadership helped	Facilitator	Stakeholder—"*We want to make this work so I felt like I was taking on the leadership aspect of that with Jenny certainly being like the advocate alongside that as well."*
IT crucial to successful implementation	Barrier	Stakeholder—"*People originally had a lot of problems getting the software uploaded. To that point, I think we didn't get nearly enough participants and they were even trying several times. So, I think that's a definite hurdle*." Stakeholder—"*Probably with the IT bit, that initial concern to how we actually got it into our systems*."

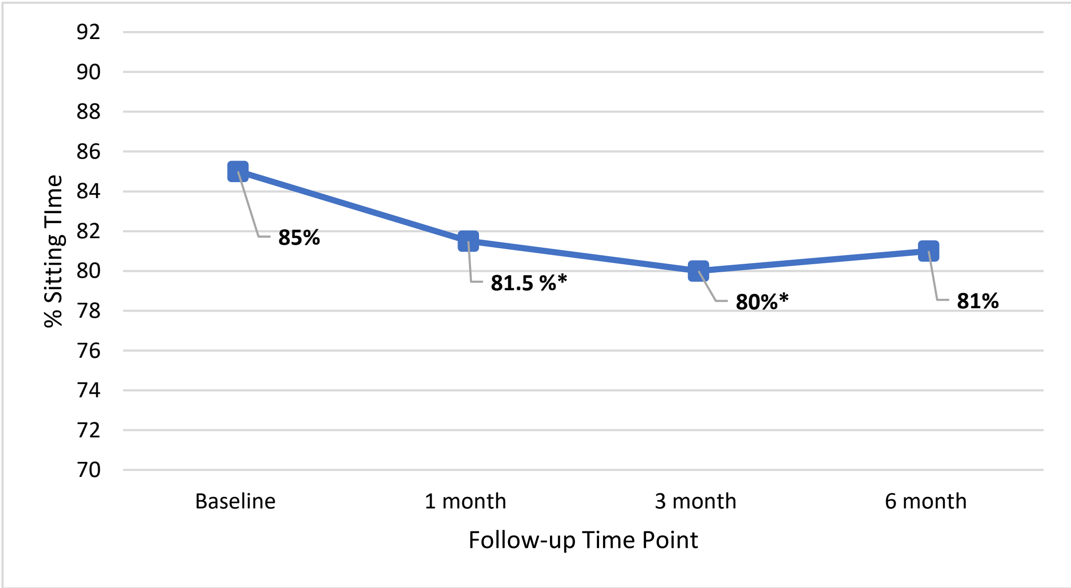
5.4 Effectiveness

5.4.1 Primary and Secondary Outcomes

Company 4 was not included in the individual company analysis because of the high dropout rate. Wilcoxon Sign Rank tests were deemed inappropriate to perform for absenteeism due to the high volume of zero values which were recorded at all time points. Mean values for absenteeism for each time point will be presented to show that there was no change throughout the study. The full results for all time points is available in appendix K.

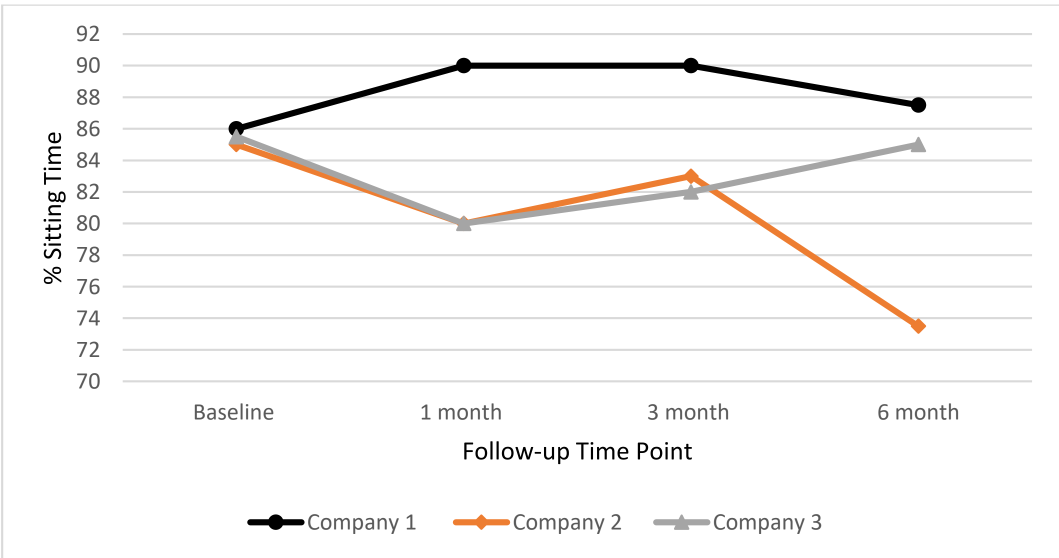
Sitting, Standing, Walking and Transitions

Figure 4.6 illustrates median sitting percentage for the total group (Figure 4.6a), and individual companies (Figure 4.6b) for all time points. In the total group the baseline median for matched pairs was 85%. Results show that the median sitting time reduced by 3.5% at one month follow-up, and by 5% at three month follow-up. Results of the related samples' Wilcoxon Sign Rank test indicated a trend towards significant change at both one month ($Z = -1.989$, $p = 0.047$), and three month ($Z = -2.191$, $p = 0.028$) compared to baseline. No trends were seen for other time points (Figure 4.6a) or individual companies (Figure 4.6b).



(a)

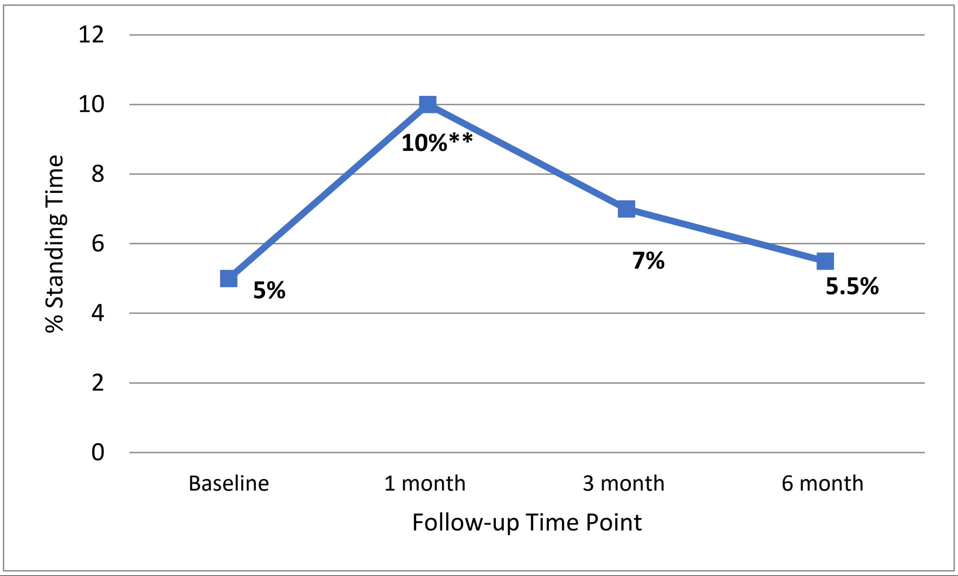
* = trend towards significant change.



(b)

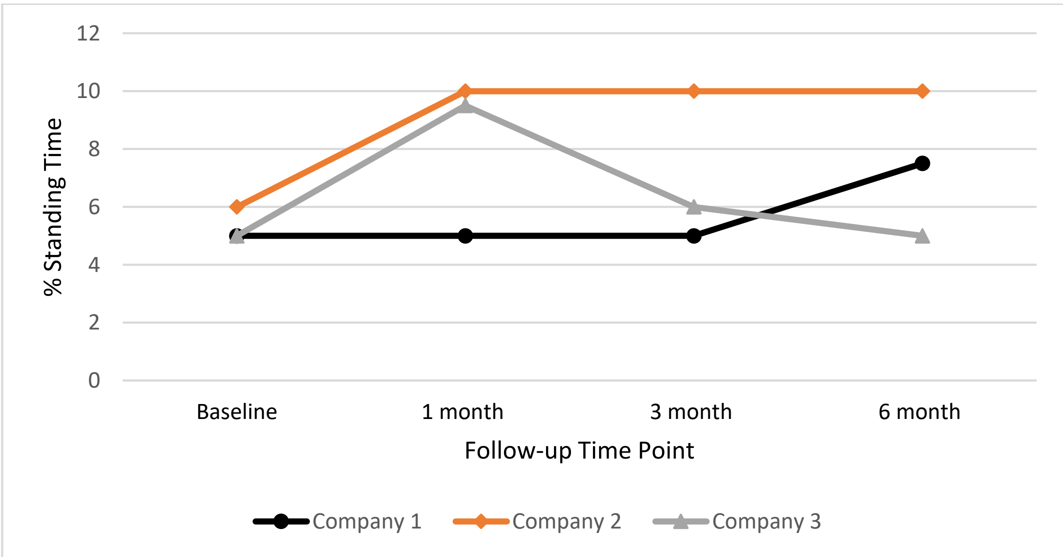
Figure 4. 6: Median percentage workplace sitting time for the total group (**a**) and individual companies (**b**) at baseline, one month, three month and six month time points.

In Figure 4.7, the median standing percentages for the total group (Figure 4.7a), and individual companies (Figure 4.7b), for all time points, are presented. Results show standing time significantly increased by 5% between baseline and one month follow-up for the total group ($Z = -2.716$, $p = 0.007$). In addition, there was a 4% increase in standing time between baseline and one month follow-up for Company 2 ($Z = -2.207$ $p = 0.027$). No other significant changes between baseline and follow-up were found for the total group or individual companies.



(a)

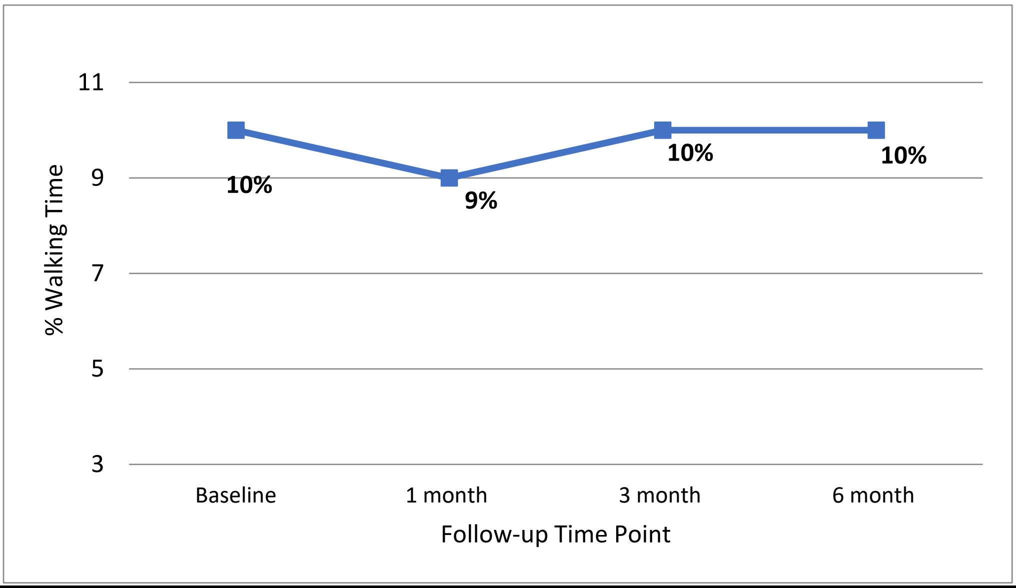
** = significant change.



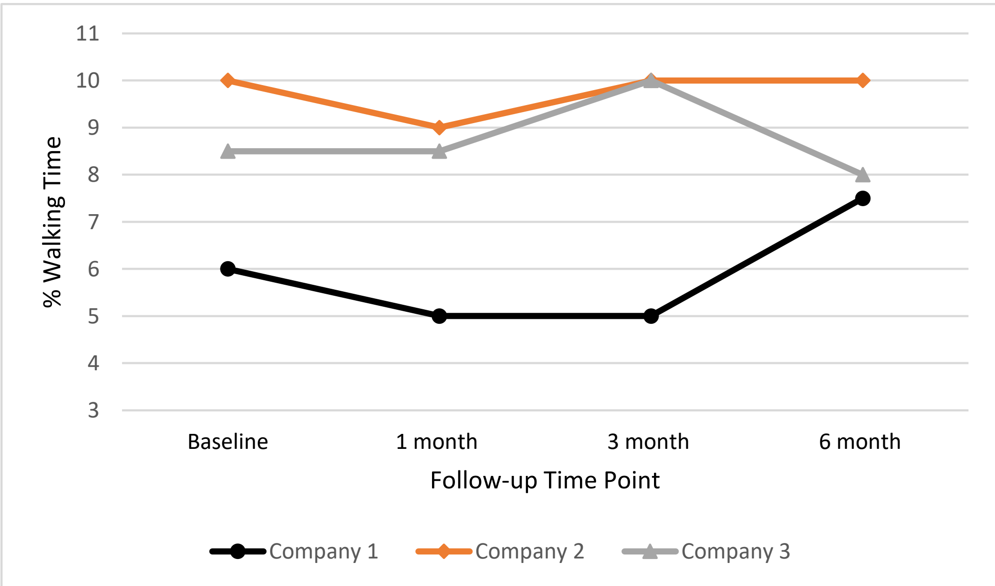
(b)

Figure 4. 7: Median percentage workplace standing time for the total group (**a**) and individual companies (**b**) at baseline, one month, three month and six month time points.

In Figure 4.8, the median walking percentages for the total group (Figure 4.8a), and individual companies (Figure 4.8b), for all time points, are presented. Wilcoxon Sign Rank test results indicated that there were no significant changes in median scores for walking at any time point for the total group or for individual companies.



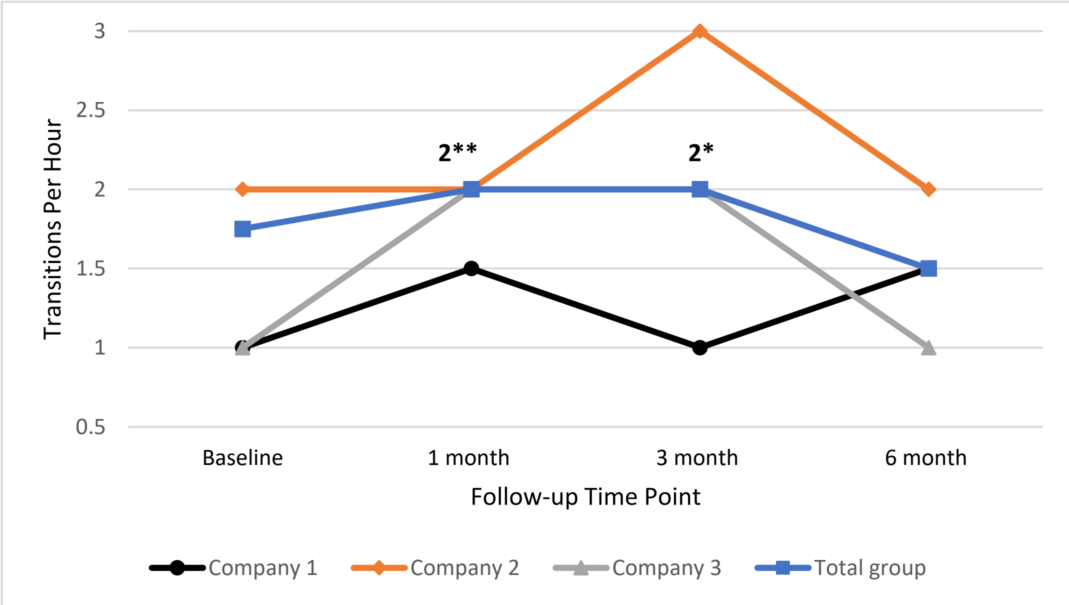
(a)



(b)

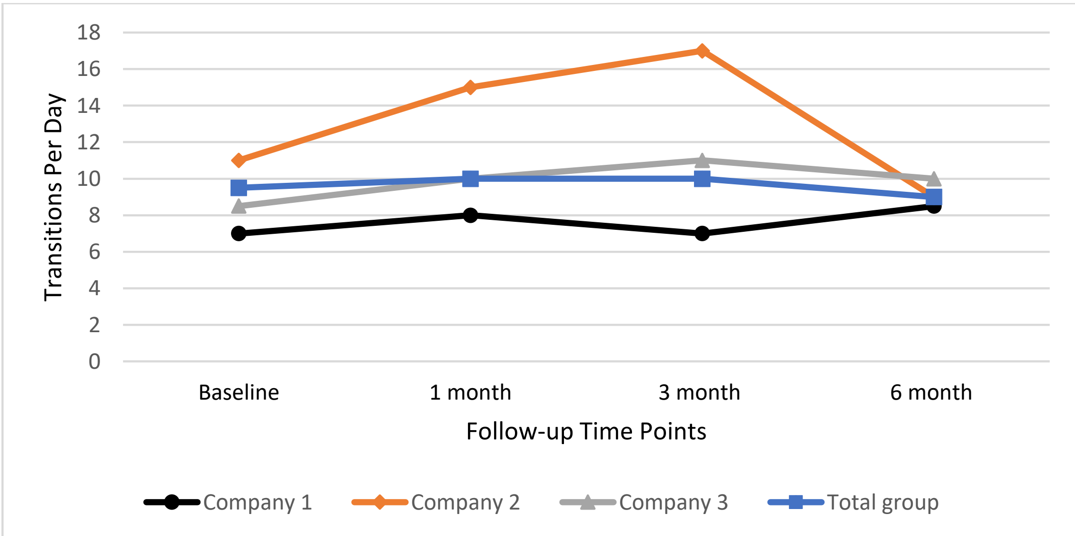
Figure 4. 8: Median percentage workplace walking time for the total group (**a**) and individual companies (**b**) at baseline, one month, three month and six month time points.

In Figure 4.9, the median values for transitions per hour (Figure 4.9a), and per day (Figure 4.9b), are presented for each time point. Results show that transitions per hour significantly increased in Company 3 by 1.00 between baseline and one month follow-up ($Z = -2.554$, $p = 0.011$). This increase remained stable and trended close to significant at three month follow-up ($Z = -2.333$, $p = 0.02$). No other significant changes between baseline and follow-up were found for the total group or individual companies.



(a)

** = significant change, *= trend towards significant change.



(b)

Figure 4. 9: Median transitions per hour (**a**) and day (**b**) for total group and individual companies at baseline, one month, three month and six month time points.

Musculoskeletal Pain

Figure 4.10 illustrates the median scores for self-reported musculoskeletal pain. Results of the Wilcoxon Sign Rank test indicate that there were no significant changes in median pain scores at any time point for the total group, and for individual companies.

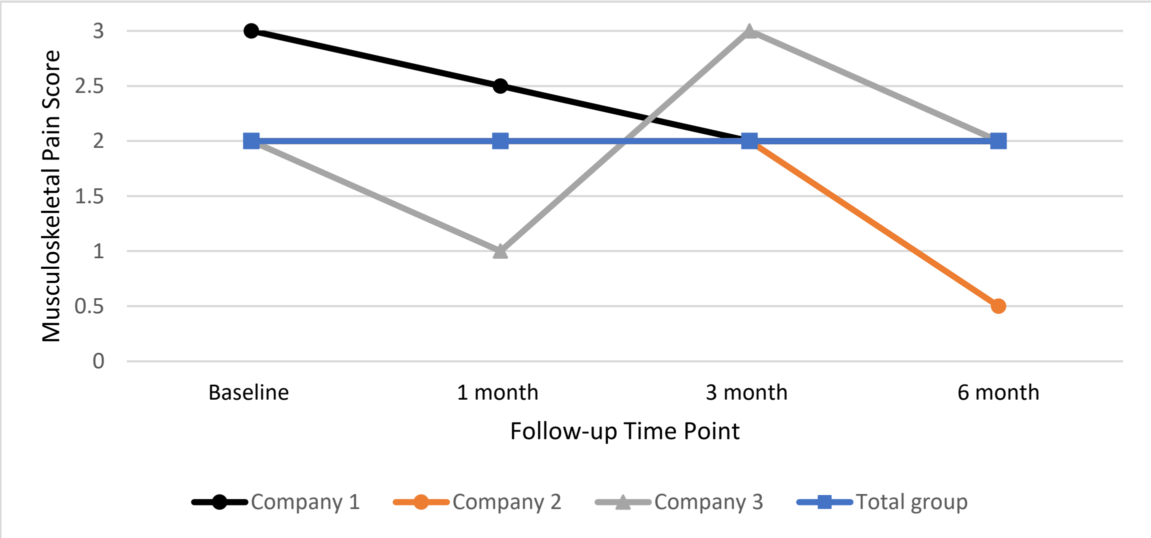
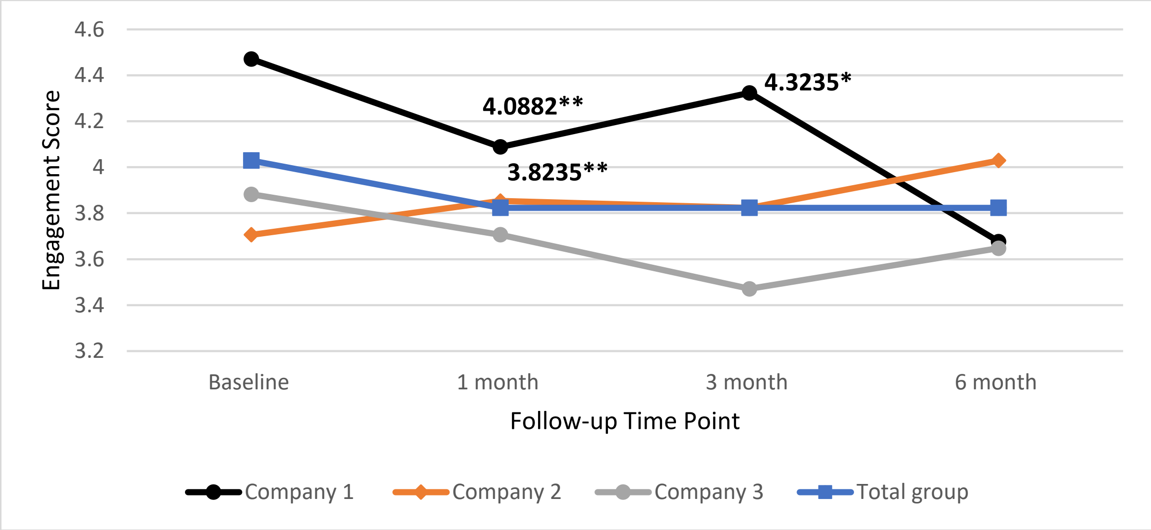


Figure 4. 10: Median musculoskeletal pain score for total group and individual companies at baseline, one month, three month and six month time points.

Work Engagement

In Figure 4.11 the median scores for work engagement are presented, for both the total group, and individual companies. Results show that that work engagement significantly decreased by 0.2059 at one month follow-up for the total group ($Z = -2.838$, $p = 0.005$). Work engagement also decreased significantly in Company 1 by 0.3824 at one month follow-up ($Z = -2.608$, $p = 0.009$). This also trended towards a significant decrease at three month follow-up ($Z = -2.197$, $p = 0.028$). No other significant changes between baseline and follow-up were found for the total group or individual companies.



** = significant change, *= trend towards significant change.

Figure 4. 11: Median work engagement scores for total group and individual company at baseline one month, three month and six month time points.

Health-Related Absenteeism

The mean hours missed for health for the total group and individual companies is presented in Table 4.11. The means are presented as all median values, and all but one IQR equalled zero. Results of the Wilcoxon Sign Rank test indicated that there was no significant change in health-related absenteeism for the total group or individual companies.

Table 4. 11: Mean health related absenteeism in hours for the total group and individual company at baseline, one month, three month and six month follow-up.

Title	Baseline	One Month	Three Month	Six Month
Total group	1.47 (SD = 5.2)	0.83 (SD = 2.957)	1.13 (SD = 1.93)	5.12 (SD = 12.54)
Company 1	0 (SD = 0)	0 (SD = 0)	0 (SD = 0)	0 (SD = 0)
Company 2	2.00 (SD= 4.75)	0 (SD = 0)	2.79 (SD = 4.78)	8.17 (SD = 11.21)
Company 3	1.07 (SD = 2.91)	1.63 (SD = 4.2)	1.20 (SD = 3.1)	8.78 (SD = 18.4)

5.4.2 Additional unintended effects, and facilitators and barriers to effectiveness

Several qualitative themes developed which highlighted participants' and stakeholders' perceptions of additional unintended effects of the intervention and facilitators and barriers of the effectiveness of the intervention. Table 4.12 shows that six themes developed which align to the effectiveness dimension. Example quotes are given to illustrate what participants and stakeholders shared in relation to each theme.

Table 4. 12: Qualitative themes related to indicators of effectiveness.

Effectiveness Themes	**Additional Unintended Effects, Facilitator or Barrier**	**Quotes**
Raised awareness and profile of workplace health	Additional effects (positive)	Participant—*"I think for me it made me more aware of how much I was sitting if that makes sense it made me want to stand up more but even if it wasn't like prompting me to stand."* Participant—"*There was a lot of helpful tips you know for stretches and things you wouldn't necessarily think about doing so."* Participant—*"It's just awareness for me just how much I've been sitting but also just the stretches I've got a bad back just now so I've also had some exercises from the physio so it's another wee reminder for me so yeah just more awareness."*
Created social unity	Additional effects (positive)	Participant—"*A good thing is you know that other people are using it and you can kind of see other people in the office getting up and doing the exercises and there is a sense of we are all aware that like this is an…..that kind of communal shared thing is a definite benefit of it as well."* Participant—*"We encourage each other to do things and maybe encourage and as you say seeing someone do it makes you think I better do it as well."* Participant—*"What will happen is you will see someone else doing it, so you do it along with."*

Limited variety and choice of nudges targeting sitting	Barrier	Participant—"*At the start you were a bit more active but as it goes on it gets a bit more repetitive."* Participant—*"It always tells you to sit or stand it says that one you're meant to stand up for but I've often found myself not standing up and just doing it sitting down."* Participant—"*To even just change them up weekly just like a variety of stuff I think that will get me more involved."*
Personal feedback on progress could have improved experience of participation	Barrier	Participant—"*For me if it was a bit more interactive I like to see like all stats if I could choose and see at the end of the day how much water I'd had and just like you know a bit more detail, you know?! You've done this many workouts throughout the week*." Participant—"*I would like it to be able to track the feelings*."
Perceived lack of time to engage with nudge	Barrier	Participant—*"You would be in the middle of something and you would be like okay I'll pause it, not got time to do it because you are concentrating on something."*
Company 1—rigid management style	Barrier	Stakeholder—*"Basically, like a call centre, yes. So, they're not free to just get up and wander about, you know?"*

5.5 Maintenance

All four companies maintained participation over six months. Each company self-reported information regarding institutionalisation of the digital intervention. Companies 2 and 4 have expressed interest in purchasing to institutionalise the intervention into existing health and wellbeing programming. Company 3 has purchased the digital intervention and expanded to all UK offices and Company 1 did not show interest in purchasing the digital intervention in its current form.

Table 4.13 shows that two themes developed as a result of the analysis of the qualitative data relating to the RE-AIM dimension of maintenance. In the table the themes 'Wellbeing important to company' and 'Need to create more buy-in with report on results at both individual and setting level' are presented along with example quotes from participants and stakeholders which illustrate what was said in relation to each theme.

Table 4. 13: Qualitative themes related to indicators of maintenance.

Maintenance Themes	**Facilitator or Barrier**	**Quotes**
Companies 2, 3 and 4—wellbeing important to company	Facilitator	Participant—*(P1): "Yeah, I think we are yes, I think the company are interested in the sort of how staff are how their wellbeing is." (P2) replies: "Anything that kind of improves your wellbeing."* Participant—"*It is quite a high…. wellness is quite high profile,….we do have quite a lot of values, sort of, like, mindfulness, we have done quite a lot of stuff on workplace wellbeing.*"
Need to create more buy-in with report on results at both individual level and setting level	Barrier	Stakeholder 1—"*For me the one thing that we haven't seen that we would get with our employee assistance thing was for me to get as the gatekeeper, get some data on how much it's being used*." Stakeholder 2—"*The type of business we are it's an analytical kind of company, so a lot of them like the detail and they'd like to almost see graphs in terms of movements and stuff*."

6. Discussion

The aim of this study was to examine and understand the potential reach, effectiveness, adoption, implementation and maintenance of a digital health promotion application which targets reducing and breaking up SB across multiple workplace settings.

The RE-AIM QuEST mixed methods framework facilitated a robust evaluation across 21 indicators of reach, effectiveness, adoption, implementation and maintenance. Upon analysis of this data it is evident that the digital application has the potential to be adopted by small to mid-sized companies and reach a large proportion of employees using minimal resources and company allocated time. The digital application positively affected SB by significantly increasing standing time and transitions per hour in Company 1 with no negative effects on musculoskeletal pain in the short term. Additionally, three out of four companies are willing to maintain and institutionalise the application into existing workplace wellbeing initiatives. However, with positive effects short lived, and several barriers identified across RE-AIM, significant improvements can be made to the Welbot digital application. Addressing the barriers which have been identified, while maintaining the positive attributes of the application will be critical to producing an effective digital application which also has the potential for scale-up across settings. The following sections will focus on what has been learned about the five RE-AIM dimensions, in a bid to understand how to improve each. Again, the RE-AIM dimensions order has been changed to reflect the chronological order of occurrence within the research process.

6.1 Adoption

The companies that adopted the intervention were smaller, and required significantly less emails and meetings than larger companies who did not adopt the intervention. This suggests that there are barriers to larger companies implementing new health and wellbeing practices. Additionally, despite discussions of the high-level security features and compatibility of Welbot, larger companies that did not adopt the intervention reported concerns related to the IT security as a reason for not adopting the intervention. Evidence from other workplace health interventions indicates that to improve adoption, more assessments of the organisational culture may be needed to understand how to create “buy-in” at multiple levels of companies with complex management structures [16,38–41]. When recruiting larger companies, digital interventions may need to allocate further resources towards developing additional recruitment and engagement tactics aimed at building a relationship to create buy-in at all levels. If time is a limited resource, then targeting smaller to mid-size companies for recruitment may be warranted.

A second reason reported for not adopting the intervention was that the company had existing health programming. Although digital interventions can be effective on their own [42], it may be important that they are also adaptable and flexible in design, so that they can be added easily into existing programming by individual companies. As they evolve and build in new content, digital interventions, like Welbot, may be uniquely adaptive to tailoring content to individual company needs and contexts [8]. Finally, in companies that adopted the intervention, employees reported that they believed their employers were concerned about employee health and wellbeing. At the moment little is known about how a company develops an appreciation of employee health. Research is needed to develop a deeper understanding of why some companies prioritise staff wellbeing, and others do not. Assessments of this are warranted as understanding this could be central to increasing adoption of health interventions in the workplace [41].

6.2 Reach

6.2.1 Participation Rate

A large proportion (59%) of all employees signed up for the digital intervention. This is higher than other interventions in the workplace [39,43] and indicates that the SB intervention is considered accessible and feasible by employees. This is important to future scale-up, as companies may be more likely to engage with interventions that can be used by the majority of their workers. Uptake did differ substantially between companies with the smaller companies (Companies 1 and 4) having much higher recruitment than the other two companies. This supports the findings of a review of recruitment strategies which found that workplace studies with higher recruitment rates tended to target smaller cohorts of employees [43]. Additionally, Companies 1 and 4 also had management engagement compared to less management engagement in Companies 2 and 3. This aligns to other interventions in which the level of buy-in from management appeared to affect the participation rate within the intervention [16,39,44]. To improve future participation rates, it may be important in the future for digital interventions to build in strategies (e.g. targeted management incentives) to ensure management buy-in and participation.

6.2.2 Dropout Rate

Without context, the dropout rate appears to be high, with only 31% of the study population still completing six month follow-up. Qualitative data revealed that Company 4 suffered a significant IT issue which meant that most of the participants failed to access the digital application following baseline data collection. In other research studies, people who did not download the product may have been eliminated as participants and therefore not included when calculating the dropout rate. However, in this study, it was important to be transparent and understand issues such as this, to aid improvement. This particular issue will be further examined in the implementation section of the discussion. Additionally, the dropout rate reported may be higher than perhaps really is the case as the rate was calculated based on the number of questionnaires completed at each time point, rather than the actual number of participants who continued to use the program. It is likely that some participants continued to use the application, but did not continue to complete the questionnaire. Collecting and analysing company and individual usage data could improve Welbot's understanding of the dropout rate and engagement with the digital application.

6.2.3 Facilitators and Barriers to Reach

One qualitative theme developed which suggested that participants in the intervention had an existing awareness that sitting was a health issue and this directly influenced their motivation to participate in the study. This adds to the existing evidence that awareness of sitting as a risk factor appears to be important to eliciting motivation [45–47]. To improve the reach (and adoption) of digital interventions like Welbot, more investment may be needed to create targeted educational content (e.g. short videos) which is clearly focused on both building knowledge about the associated health risks of sitting, and how reducing sitting time can improve health and wellbeing at work.

6.3 Implementation

6.3.1 Cost

Indicators of cost within RE-AIM may be best explained as the financial investment and time needed to implement the intervention. In this evaluation, the estimated average financial cost per company was £175.50 and the estimated cost per participant was £8.78. This is significantly lower than the reported AU$431 or £230 per participant costs of a 12 month multi-component intervention, which installed standing desks costing AU$296 or £158 per participant. Furthermore, the estimated average company time used (4.5 h) to implement the intervention across four companies and 80 employees was presented. Reporting this time can give important insight into the labour costs which will be incurred by companies that adopt the intervention [48]. Given the relatively low estimated financial costs, and minimal hours used to implement the intervention Welbot may be considered “low cost”. Although knowing this information is important, it gives little insight into whether the companies themselves perceived this cost as affordable and acceptable. Two qualitative themes add this important contextual information and suggest that the companies perceived the implementation to be straightforward, and required minimal resources. This suggests that this digital intervention would require minimal resources to be widely implemented. This is in contrast to other types of workplace interventions that have been critiqued for being complex and expensive [14]. For example, Neuhaus et al.’s multi-component intervention was effective, however the authors acknowledged that participation was limited by funding and that findings may not be generalised across the wider population of workplace settings [49]. In here lies the balancing act of practical research. Do researchers continue to heavily resource interventions to produce an effect on behaviour which may not be generalisable or do researchers work within the constraints of the resources, to try to balance what is implemented, with the resources available in real-world office settings. We would argue that there is a need for a more balanced approach. An approach is needed that recognises that understanding the potential for real-world, wide-scale, implementation is important to understand and address this large-scale public health problem.

6.3.2 Facilitators and Barriers to Implementation

In addition to the two themes discussed above, in-house leadership within the companies appeared to be important to successful implementation. Participants and stakeholders both reported that a visible leader of the intervention helped to keep the implementation running smoothly. Interestingly, the intervention did not require or suggest leadership roles, yet they evolved naturally within three of the companies. This result is similar to other research studies in which team champions and visible leadership were reported as important to the success of the intervention [16,49].

The IT support became a significant aspect of implementation of the digital intervention. Three companies reported that their IT department supported the implementation, and this was straightforward. However, one company (Company 4) did not have sufficient IT support to overcome download issues and suffered significantly. In the end, only three participants overcame the barriers and downloaded the digital program. As mentioned above, this is reflected in the dropout rate. With regions of the world, and individual companies having varying degrees of data policy (e.g. European General Data Protection Regulation (GDPR)), and data security systems; it will be important for digital health interventions, such as Welbot, to align with policy, and build strategies to mitigate and overcome implementation barriers.

6.4 Effectiveness

6.4.1 Effects on Sedentary Behaviour

In relation to its effects on SB, the digital intervention increased standing time for the total group, and increased transitions per hour in Company 3 significantly in the short term. The digital intervention did not significantly reduce overall sitting time. As the Welbot application targeted breaking up sitting bouts with standing exercises and stretches, this can be almost expected and is similar to other prompt-based studies [50–52] [53,54]. There is evidence that suggests that even these small changes in number of transitions per hour may be important in reducing the disease risk associated with uninterrupted bouts of sitting [55–58]. Individual company results revealed that Company 1 saw reverse effects; with an increase in sitting, and a decrease in standing. This result may be partly explained by the qualitative finding that Company 1 stakeholders did not allow employees to get up from their desks when they pleased. This finding is not unique to this intervention [44,46], and suggests that, despite talk of concern for employee health, managers may not always buy into health promotion as health promoters would expect. In this study, it may have acted as a significant barrier to office workers in Company 1 feeling free to engage with nudges. Recent research has suggested that it will be important that broader contexts of the office are understood, and organisational level barriers are addressed to improve the potential for sustainable change [16,59]

6.4.2 Facilitators and Barriers to Effectiveness

Perceived lack of time was also a barrier for changing behaviour, suggesting that office workers do feel it is challenging to interrupt work-related tasks when busy. This is consistent across the qualitative literature [47], and both barriers suggest that it may take considerable shift in perception, for both employees and employers, to view health-related breaks as time well spent.

Participants also felt that a limited variety or choice of nudges that specifically targeted sitting was a barrier to effectiveness on the primary outcomes. This finding is similar to Taylor and colleagues' findings, in which office workers quickly tired of the provided health promotion break options, and called for more frequent change in the break routines provided, and more choice in the physical movement that was suggested [44]. To enhance effectiveness, similar nudge-based interventions may need to spend more time engaging in the development of material and find creative ways to expand the intervention content. For new digital interventions like Welbot, this may require a gradual approach in which new nudges are added as and when they are ready.

Additionally, participants shared that some exercises/stretches could be done while still sitting, and if not specially told to stand, they would often stay seated. Other researchers have noted the importance of being specific with instructions, learning that "taking breaks" often did not help office workers reduce SB, with participants more likely to choose a seated social or online break over an active break [60,61].

Both intervention participants and stakeholders suggested that more personal feedback on progress, both at the individual level and company level could have improved the experience of participation. More descriptive visual feedback, including data visualisation, may be very important for developing motivation and self-regulation for employees, and creating buy-in for companies [44,60,62,63].

6.4.3 Effects on Secondary Outcomes

Musculoskeletal pain is associated with long term sick leave, risk of disability and disability retirement [64,65]. In this intervention there was no significant change in musculoskeletal pain or health-related absenteeism. This is in contrast to several studies in the workplace that reported reductions in musculoskeletal pain after reducing office-based siting time [66–68]. Both results may be partly explained by the relatively low mean age of participants, and the low baseline score for both musculoskeletal pain and health-related absenteeism. Future interventions in sedentary office workers should continue to measure both outcomes to widen understanding of the potential attenuating effect reducing sitting may have on musculoskeletal symptoms. In future larger studies, subgroup analysis of these secondary outcomes, based on the presence of additional risk factors of musculoskeletal pain (e.g. age or obesity), may be needed to understand effects.

6.4.4 Additional Unintentional Effects

Employees and employers expressed that they believed the digital intervention helped to raise awareness in the company that sitting was a health issue they should be concerned about. Experts suggest that building awareness may be essential to building autonomous motivation, in which a person endorses or identifies with the value of performing a behaviour or health practice [63,69]. Office-based SB interventions may need to be more heavily focused on educational intervention components to help build sustained motivation. In this digital intervention, although some basic information is given, this may not be enough to build intrinsic value in the health behaviour [70]. In future iterations of this digital intervention, developing more in-depth educational prompts which target office workers' understanding of the associated risks, and potential benefits of reducing sitting time may help elicit more sustained motivation for behaviour change [60,63].

The qualitative data also suggested that the intervention created a sense of social unity in the office. This aligns with results of several other interventions [16,47,71] aimed at reducing sitting time and should be considered an additional benefit to health promotion programs in the workplace, particularly in offices where group cohesion is vital to the delivery of business. Researchers and start-up companies, like Welbot, should seek to further explore how and why positive social outcomes develop so that they may be specifically targeted, and promoted to stakeholders, as additional benefits of health promotion programs. For example, in the future Welbot program, a group of nudges could specifically target improving social interaction whilst reducing sitting. This may help to create more buy-in for interventions aimed at reducing sitting time in the workplace.

The intervention did appear to negatively affect worker engagement in the short term for the total group and Company 1. Research conducted on work flow has suggested that nudging workers at inopportune moments can negatively influence work engagement and productivity [72,73], and although there may have been other work-related factors affecting work engagement; addressing this issue is important to understand when best to prompt breaks. In a recent study, Luo and colleagues developed a prompting system which enabled workers to set up their preferred work and sitting break durations, to create healthy habits [60]. Their results indicated that, when compared to participants who did not set break times, participants who set consistent intended break duration had higher post study habit strength time [60], suggesting that the ability to create personalised routines could be important to the effectiveness of nudge-based interventions. Creating personalised options may also help to mediate negative effects on work engagement and productivity. Moving forward, nudge-based interventions, similar to Welbot, may need to balance the approach taken with engagement and productivity. This may be critical to sustaining long-term buy-in for SB interventions in workplaces.

6.5 Maintenance

Maintenance within RE-AIM is concerned with how behaviour change is maintained six months or more after the intervention, as well as long term sustainability of the intervention. No significant effects were maintained at six month follow-up. In the reach, implementation and effectiveness sections, barriers have been discussed in detail, and addressing these barriers will also be fundamental to maintaining participation and behaviour change. Additionally, as adaptations are introduced, continuing to measure across RE-AIM indicators will be important to track how adaptations to the Welbot application affect each dimension, including maintenance. Having employees complete questionnaires long-term may be burdensome, and as the digital application evolves, exploration of connectivity options to integrate participants' existing movement data (e.g. wearable technology data) could be explored as a more accurate and sustainable data source to understand long term behaviour change [8].

In relation to sustainability of the intervention, all four of the companies used Welbot for the six month intervention, and all four were continuing to use Welbot up until Covid-19 working at home measures came into place in the United Kingdom (U.K.). Additionally, even though Company 4 had significant issues with installation, they, along with Company 2 are seeking to permanently adopt the Welbot program. This suggests that they feel confident they can overcome the IT-related issues which affected the implementation of Welbot during this intervention. Furthermore, Company 3 purchased Welbot to continue and expand use to all U.K.-based employees.

6.5.1 Facilitators and Barriers to Maintenance

Participants from Companies 2, 3 and 4 perceived that employee health and wellbeing was important to their respective companies. This existing interest from company executives most likely helped to create the buy-in needed to adopt the program long-term. In contrast, as discussed in the effectiveness section, Company 1 managers were less receptive to employees engaging in the intervention, and the company has not expressed interest in engaging further. This suggests that interventions may also need to evaluate wider contexts of the office setting, such as assessing management support [41] and targeting company leaders to try and increase knowledge and understanding of the benefits to offering occupational health and wellbeing programs [16,39,40]. This may help to improve the potential for sustainability of behaviour change, and the potential institutionalisation of interventions [59].

Stakeholders in all four companies suggested that more feedback and data at the company level would be one way to improve buy-in for long-term use of the Welbot product. Producing a report on volume and frequency of use may help employers make decisions about maintaining and institutionalising digital health promotion applications like Welbot.

6.6 Implications

Based on the discussion, recommendations for improving the digital application are presented in Table 4.14. Although they are specific to the Welbot application many of the RE-AIM recommendations could be used to improve other digital interventions which aim to implement their intervention at scale, across multiple settings. Using the RE-AIM evaluation framework to plan, implement and conduct the evaluation has enabled the research team to test for effectiveness simultaneously with testing the potential for impact in real-world settings. This style of dissemination is rarely seen; however, it has allowed the research team to report on effectiveness within the frame of the real-world resources. This comprehensive evaluation early in development should allow

Welbot the ability to continue to understand and improve the digital application's effectiveness without compromising the potential adoption, reach, implementation and maintenance of the intervention. This is in contrast to interventions which need to make substantial alterations to the intervention components to try and improve adoption, reach, implementation and maintenance, with no guarantee that the effects seen in early phases will match the newly adapted intervention effects [14,16,49,74].

Table 4. 14: Recommendations to improve a digital application's reach, effectiveness, adoption, implementation and maintenance.

RE-AIM Dimension	Recommendation
Adoption	▪ Allocate resources towards developing additional recruitment and engagement tactics tailored for larger companies and district management levels aimed at building relationships and creating buy-in at all levels. ▪ Investigate and develop the adaptability of the application to add to existing workplace health programs and tailor to individual contexts. ▪ Investigate and assess how individual companies develop an appreciation of employee health.
Reach	▪ Build in strategies (e.g. targeted management incentives) to ensure management buy-in and participation. ▪ Collect and analyse company and individual usage data to build understanding of the dropout rate and engagement with the digital application. ▪ Create targeted educational content (e.g. short videos) which is clearly focused on both building knowledge about the associated health risks of sitting, and how reducing sitting time can improve health and wellbeing at work.
Effectiveness	▪ Allocate resources to the development and testing of creative ways to expand intervention content. This may require a gradual approach in which new nudges are added as and when they are ready. ▪ Specifically state in instructions the recommended posture and active nature of nudges as participants are more likely to choose a seated social or online break over an active break. ▪ Provide descriptive feedback, including data visualisation, to develop motivation and self-regulation within employees, and build buy-in with companies. ▪ Continue to measure both outcomes to widen understanding of the potential attenuating effect reducing sitting may have on

	musculoskeletal symptoms and absenteeism. In future larger studies, subgroup analysis of additional risk factors of musculoskeletal pain (e.g. age or obesity) may be warranted. ▪ Develop more in-depth educational nudges which target office workers' understanding of the associated risks, and potential benefits of reducing sitting time which may help elicit more sustained motivation for behaviour change. ▪ Develop content to specifically target improving social interaction whilst reducing sitting. ▪ Build in further personalisation in relation to frequency and intensity of nudges.
Implementation	▪ Allocate resources to building implementation strategies to mitigate potential barriers to implementation (e.g. I.T. implementation strategies). ▪ Promote and support companies in creating in-house leadership for the digital application. ▪ Produce estimates of financial cost and labour costs of the intervention.
Maintenance	▪ Investigate potential to integrate existing movement data (e.g. data captured by wearable technology) as a data source to understand long-term behaviour change. ▪ Assess management support and target company leaders to try and increase knowledge and understanding of the benefits to offering occupational health and wellbeing programs. ▪ Use data to report on the volume and frequency of use of the digital application to employers.

7. Strengths and Limitations

There are several strengths to this study. Firstly, the implementation under real-world conditions has allowed the researchers to gain understanding of the intervention's potential for wide scale implementation at an early stage of intervention development. This approach is novel, and this study may provide a template for other researchers seeking to understand the scale-up potential of SB interventions and other health-related interventions in the workplace. Secondly, using mixed methods to evaluate the intervention is a strength as it allowed the researchers to contextualise what happened, with how and why it happened. The ability to do this is critical to deciding what steps are needed to improve an intervention. Thirdly, using the RE-AIM Quest evaluation framework has been a strength as using the five dimensions, and the corresponding indicators of each dimension, helps to organise and pinpoint areas of an intervention which need improvement, allowing for the intervention value to be judged on all dimensions which are important to wide scale implementation/scale-up. The study has been limited by the small sample size, subjective measure of SB, lack of control group and dropout rate (details of which have been discussed in the paper). All of these played a part in limiting the statistical tests and interpretations of the effectiveness data. However, in relation to the objective measurement of SB and the lack of control group, as discussed above, the exclusion of these methods may have enhanced our understanding of the real world potential reach, implementation, adoption and maintenance of Welbot. Two employees suggested that the participant burden of the questionnaire was high, and although adjustments were made, limiting the data collection to just primary outcome data may be important to maximise data collection.

8. Conclusions

The evaluation showed that the Welbot application has the potential to reach a large proportion of office workers with minimal office resources needed. Welbot should continue to improve the application using feedback to help further the potential for impact at the individual level and the setting level. Adapting the intervention and evaluating new components across RE-AIM may be important to improving the effectiveness and maintenance of behaviour change at the individual level, while preserving adoption, reach and maintenance at the setting level.

9. Chapter 4 References

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Chapter 5: Discussion of Thesis

1. Outline

The aim of this chapter is to present an overall discussion of the implications of the PhD. The chapter will include a summary of the thesis, as well as reflections on how the individual studies addressed the aim of the PhD and the gaps in the literature. Additionally, there will be a critical reflection of using the RE-AIM evaluation framework, followed by the strengths and limitations of the PhD, and recommendations for future research.

2. Summary of thesis

The review of the literature in Chapter 1 identified that office workers accumulating large volumes of sitting time should be concerned with SB as a health issue. Through an examination of the published literature, several gaps for future research were identified. These included:

1) Investigation and reporting of effects of interventions on additional health outcomes and additional indicators of work engagement and performance (MacEwen et al., 2015; Neuhaus et al., 2014).

2) Investigation and reporting of the potential costs or resources needed for effective interventions to be maintained (Chu et al., 2016).

3) Evaluations of larger interventions with longer follow-up time to understand the maintenance of intervention effects over time (Chu et al., 2016; Shrestha et al., 2018).

4) Investigation and reporting which uses qualitative methods to understand employee and employer perceptions of feasibility and acceptability of intervention strategies (Hadgraft et al., 2018; Stephenson et al., 2020).

5) Investigations and reporting of intervention processes, and the potential for wider impact of interventions through mixed method investigation (Buckingham et al., 2019).

6) Use of evaluation frameworks to plan, conduct and report digital interventions targeting sedentary office workers (Huang et al., 2019).

When looking holistically at the gaps in the evidence base, it appeared there was minimal understanding of outcomes outside of effectiveness, and there was a lack of clarity in relation to what wider potential there was for effective interventions to be implemented without researcher involvement in the real world. Therefore, in order to investigate and better understand these gaps, there was a need to study wider dimensions of interventions and answer questions such as; What resources were used in the implementation?; Can employees and employers engage with and maintain an intervention long term? To understand these wider dimensions of interventions it was suggested that a more pragmatic, real world approach to intervention evaluation was needed. The RE-AIM evaluation framework was introduced as the evaluation methodology to facilitate the evaluation of interventions across five dimensions: reach, effectiveness, adoption, implementation and maintenance.

The first study of this PhD is an integrative systematic review (Chapter 2). The aim of the review was to include all types of relevant literature to identify whether gaps in reporting exist; and if so, which indicators of RE-AIM are underreported; and what methods have been used in the literature to collect data. In total 75 articles, representing 61 individual interventions, were included. The results indicated that 18 of 28 indicators of RE-AIM were reported in less than 30% of the interventions, identifying that many aspects or parts of an intervention are underreported. Within reach, effectiveness and implementation, seven indicators were reported less than 30%, and within adoption and maintenance all 11 indicators were reported less than 30%. Additionally, the results of the review highlighted that few studies are scaled up to multiple settings (26%). Recommendations to improve reporting were developed to provide researchers with guidance for collecting and disseminating often overlooked data and information vital to improving the translation of interventions into the real world.

In Chapter 3, study two, the process evaluation of the Springfield College SB intervention was presented. In this study, the RE-AIM framework, in conjunction with QuEST, was used to facilitate the collection of quantitative and qualitative data across 14 indicators of reach, effectiveness, implementation and maintenance to gain understanding of the potential for scale-up of a consultation-based workplace intervention which targeted both the reduction, and breaking up, of sitting time (Forman et al., 2017). A total of 148 individuals participated in the evaluation. Through measuring 14 indicators of RE-AIM, several facilitators and barriers to scaling up the consultation-based intervention were identified and discussed. In relation to reach, questionnaire data with non-participants helped to identify that they perceived the burden of data collection to be too high and this affected their willingness to participate. Two barriers (‘Lack of management support’ and ‘New working policy limited employees’ ability to reduce sitting time’) revealed that support or “buy-in” for the intervention affected participants’ ability to engage in the intervention components. Costs of the intervention were reported, and equated to 31 hours of implementation time for 87 employees. Interviews with key informants suggested that the existing health and wellbeing program could integrate aspects of the intervention. This was considered important as the resources dedicated to the intervention could not be maintained. Full recommendations for scaling up the intervention were made in table 3.5 in Chapter 3 and it was suggested that interventions should assess for potential scalability in earlier phases of research.

In Chapter 4, study three of the PhD is presented. The study evaluates a digital health application which targets reducing and breaking up SB across multiple workplace settings and utilised mixed methods to collect data on 21 indicators across the five RE-AIM dimensions. Eighty employees between the ages of 20-65 completed the baseline questionnaire. Upon analysis of this data, it was evident that the digital platform has the potential to be adopted by small to mid-sized companies and reach a large proportion of employees using minimal financial resources and company allocated time. The digital platform positively affected SB by significantly increasing standing time but only in the short term. There were no negative effects on musculoskeletal pain but there were negative effects on engagement in work in the short term. Additionally, three out of four companies were willing to maintain and institutionalise the platform into existing workplace wellbeing initiatives. An IT-related issue created a significant barrier to implementation and affected the dropout rate considerably in one company. In relation to effectiveness, lack of time was reported as a barrier for participants. Additionally, one company had little buy-in for health and wellbeing and this company expressed no interest in maintaining Welbot. The study concluded with recommendations to improve the Welbot application and a suggestion that addressing the identified barriers, while maintaining the positive attributes of the platform, would be critical to producing a scalable and effective digital platform.

3. Addressing the PhD aim and gaps in research

The aim of the PhD was to use pragmatic evaluation, and the RE-AIM framework to investigate SB in office workers, with an aim to inform and improve our understanding of how to disseminate (report) and implement interventions targeting SB in office workers for public health impact in the real world. Each of the studies that have been presented uniquely helped to address this aim.

Firstly, the systematic review built towards understanding dissemination (reporting) by confirming that gaps in reporting exist in the literature focus on SB interventions in office workers. Specifically, 18 of 28 indicators of RE-AIM were reported in under 30% of included interventions. Recommendations were derived from this, and gave direction and clarity to what type of measurement was needed to improve dissemination. Secondly, study two illustrated and exemplified how dissemination through process evaluation methods across RE-AIM indicators could inform a better understanding of the potential for impact in the real world. For example, in relation to the reach dimension of RE-AIM, qualitative data helped to identify that buy-in for participation was aided by having a visible leader of the intervention; however, the email recruitment strategies may not have been suitable for all employees. Understanding and acting upon this information should improve the reach and therefore potential impact of the intervention. Critically, the study design, methods and measures helped to inform how the intervention would need to adapt to improve its potential to have impact in the real world. Study three addressed the aim by informing and improving our understanding of how researchers can evaluate for public health impact while evaluating for effectiveness. Specifically, by limiting researcher involvement, and not pushing additional resources into the implementation, there was an early indication of the adaptations needed for the Welbot intervention to be successful in the real world. This study has exemplified how future interventions can seek to plan, implement and evaluate for public health impact in the real world.

The PhD also addressed several gaps in the research. Specifically, Table 5.1 demonstrates how the three studies contributed towards understanding and addressing the gaps in the research identified in the literature review in Chapter 1.

Table 5. 1: Study results adding evidence to research gaps

Gaps in sedentary behaviour in office workers research identified in the literature review (Chapter 1)	PhD learnings supporting gaps and added evidence filling gaps
Gap 1) Investigation and reporting of effects of interventions on additional health outcomes and additional indicators of work engagement and performance (MacEwen et al., 2015; Neuhaus et al., 2014)	**Supporting evidence** Study 1- 25% of SB interventions in office workers reported intervention effects on additional outcome measures which shows evidence of underreporting of additional outcome measures, supporting further investigation.
	Added evidence Study 2- Measuring additional outcomes revealed several additional effects of the intervention including four positive effects (e.g. intervention caused social changes that facilitated reducing sitting time), and three work-related barriers (e.g. lack of management support).
	Added evidence Study 3- Measuring additional outcomes revealed several additional effects including two positive effects (e.g. created social unity), one negative effect on work engagement and four barriers to effectiveness (e.g. rigid management style). Also, no negative or positive musculoskeletal health effects were detected.
Gap 2) Investigation and reporting of the potential costs or resources needed for effective interventions to be maintained (Chu et al., 2016).	**Supporting Evidence** Study 1- 5% of SB interventions in office workers report on cost of implementation, and 8% of included studies reported cost of adoption (per office setting). This builds evidence that it is underreported and supports the need for further investigation.
	Added Evidence Study 2- Added to the literature by reporting on resources (time) used for implementation and created a ratio of hours of implementation time used per participant (31 hours/87 participants).
	Added Evidence Study 3- Reported on estimated potential financial costs and resources (time) used for individual companies as well as the average financial costs and resources needed to implement the digital intervention (e.g. 19 participants of company 1= £171 [estimated financial cost] and 1 hour of time used to implement the intervention over 6 months).
Gap 3) Evaluations of larger interventions with longer follow-up time to understand the	**Supporting Evidence** Study 1- 8% of interventions report indicators of maintenance, with only 8% of interventions reporting long term follow up six months post intervention. This builds evidence that maintenance is underreported supporting further investigation.

maintenance of intervention effects over time (Chu et al., 2016; Shrestha et al., 2018).	**Added Evidence** Study 3 – Implementation across four settings with follow up measures at six months to understand maintenance of effects over time. No significant effects were detected at six months. Qualitative methods significantly improved understanding of the potential for maintenance.
Gap 4) Investigation and reporting which uses qualitative methods to understand employee and employer perceptions of feasibility and acceptability of intervention strategies (Hadgraft et al., 2018; Stephenson., 2020).	**Supporting Evidence** Study 1- Qualitative methods underreported across all RE-AIM dimensions (reach=7%, effectiveness=11%, adoption=3%, implementation= 13% and maintenance= 10%) which supports further investigation.
	Added Evidence Study 2- Used interviews and focus groups to investigate employee and employer perceptions revealing that the intervention was widely seen as feasible and acceptable by participants (e.g. qualitative themes “inclusive participation and feeling welcome” and “culture and philosophy facilitate long term behaviour change.”) however barriers were identified relating to feasibility and acceptability of the intervention by the employer (qualitative themes “lack of management support” and “new working policy limited employees ability to reduce sitting.”)
	Added Evidence Study 3- Used interviews and focus groups to investigate employee and employer perceptions revealing that facilitators and barriers to feasibility and acceptability existed. Facilitators included- “In house leadership” and “Minimal company resources needed”. Barriers included- “Regulatory management style affected behaviour.”; “Perceived lack of time to engage with nudges” and “Limited variety and choice of nudges".
Gap 5) Investigations and reporting of intervention processes, and the potential for wider impact of interventions through mixed method investigation (Buckingham et al., 2019).	**Supporting Evidence** Study 1- 18 indicators of RE-AIM are reported less than 30% of the time or underreported, with the majority of these indicators directly informing intervention processes and the potential for wider impact. Also, qualitative methods underreported across all RE-AIM dimensions (reach=7%, effectiveness=11%, adoption=3%, implementation= 13% and maintenance= 10%).
	Added Evidence Study 2- Used mixed methods to directly investigate process information and the potential for scale up of a consultation intervention at a university workplace. Collecting data and reporting in this way facilitated wider understanding of the potential for scale up, and suggested that the consultation interventions needed adaptations to scale up and have a wider impact.
	Added Evidence Study 3- Used mixed methods to report on intervention processes and the potential for wider impact of a digital intervention targeting sedentary behaviour in office workers across multiple workplaces. Collecting data and reporting in this way helped broaden understanding of the potential for the digital interventions to be implemented across a particular setting. Minimal adaptations are needed to scale-up the intervention, however improvements should be made to facilitate sustained behaviour change and limit negative effects on work engagement.

Gap 6) Use evaluation frameworks to plan, conduct and report digital interventions targeting sedentary office workers (Huang et al., 2019)	**Supporting Evidence** Study 3- Used the RE-AIM evaluation framework to plan, conduct and report a digital intervention. The framework was an essential part of planning, conducting and reporting the results of the intervention. This is evidence that using a framework can help improve these aspects of the research process.

When the three studies of the PhD are considered as a whole, it is evident that by adjusting the lens of scientific inquiry towards pragmatism and the fundamental objective of real world impact, the PhD student has been able to make pragmatic implementation and dissemination decisions which should ultimately improve the potential for impact of SB interventions in office workers in the real world. The application of pragmatic implementation and dissemination has helped to balance the focus on reducing SB at the individual level with reducing SB at the population level. This PhD has exemplified how researchers can evaluate interventions for their potential to achieve both objectives, and use the knowledge built to ensure interventions have the ability to have real world impact.

4. Reflections on using RE-AIM Framework

The RE-AIM framework has been the methodological foundation upon which the PhD has developed. In conjunction with QuEST, RE-AIM has been an effective evaluation tool throughout the PhD. In this section, a critical reflection of the experience of using the RE-AIM framework to evaluate SB interventions in the workplace will be presented.

The RE-AIM evaluation framework, in conjunction with QuEST, was effective in guiding implementation and dissemination of the evaluations undertaken in this PhD. Through its definitions of the five dimensions, RE-AIM helped identify what data or information would be useful to the evaluation. This in turn facilitated data collection prioritisation based on what was pragmatically achievable in the circumstances. For example, in study 2, using RE-AIM while developing the logic model helped to identify that there was a need to prioritise collection of non-participant data to more thoroughly understand the reach of the intervention. The clearly defined dimensions allowed the researcher to look to the framework for guidance when needed; firmly guiding the PhD student towards the relevant indicators to evaluate. This is a major strength of the RE-AIM framework. In a recent review of evaluation models, RE-AIM was described as being closely aligned to "operational evaluation models" as it contains several constructs that are detailed, including step by step actions for the completion of implementation and reporting processes. In this review, RE-AIM was considered much less aligned to "broad evaluation models"; which are less prescriptive in nature, however allow for greater flexibility to apply the model in different contexts (Tabak et al., 2012). As described above, the prescriptive nature of RE-AIM was an overwhelming strength of the framework, however; there were instances where greater flexibility was needed to fit the context of evaluating interventions targeting SB in office workers (Tabak et al., 2012). The adaptations made to RE-AIM to address the research questions of the PhD are discussed below.

4.1 Adding QuEST to RE-AIM

In the context of this research, unpacking all the dimensions required qualitative methods. RE-AIM authors acknowledged that qualitative data could compliment the quantitative indicators (Kessler et al., 2013); however, at the time of the development of this PhD, they remained vague on details related to what information may be important to further explore each dimension. The addition of Forman and colleagues' Qualitative Evaluation for Systematic Translation (QuEST) allowed for the evaluations to explore more contextual information in a flexible manner. In particular it guided the research as to the line of questioning that may be important to explore within each dimension (Forman et al., 2017). This enabled a critical examination of the context of implementation, and how this affects an intervention's generalisability and potential for successful translation.

4.2 Reporting cost within RE-AIM

Within effectiveness and adoption there are indicators relating to cost. Unlike most indicators of RE-AIM, very little information is given in relation to the indicators of cost other than that it is important to report on cost, and that cost referred to time and money. With minimal information on how to measure this indicator, the PhD student identified examples of practice (Blaiser, Behl, Callow-Heusser, & White, 2013; Lahiri, Gold, & Levenstein, 2005) which could be used as a blueprint on what might be important elements to report in the context of interventions in the workplace. However, in both evaluations within the thesis, measuring cost was challenging for contextual reasons. In study 2, there was hesitation to disclose financial cost information related to the salaries of the implementation team, and this affected the ability to fully report on the indicator of financial cost. In study 3, the participating companies were given free access to the Welbot program for the intervention. Therefore, no costs were financially incurred by taking up the intervention, and as such, only an estimate of financial costs could be reported. The challenges of measuring cost, such as the ones encountered in study 2 and study 3, are largely contextual. It is likely that the authors of RE-AIM have recognised this, and consequently have found it challenging to be as specific as they are in other parts of the framework. However, with stakeholders in workplace health suggesting that understanding costs is essential to institutionalising interventions, this indicator cannot continue to be ignored and poorly reported. To improve reporting of this indicator RE-AIM authors might consider using available literature to provide more information regarding types of measurement which could be performed to address this indicator of effectiveness and adoption. For example, reporting the average financial cost and average implementation time, as outlined in study 3, could be used as an example of how to report costs for stakeholders and decision makers who need to know if they have the available resources to implement and sustain an intervention.

4.3 Additional adaptations

There were also two smaller adaptations made to RE-AIM indicators throughout the PhD. Firstly, within RE-AIM, ‘characteristics of participants vs non participants’ is an indicator of the reach of an intervention. This particular indicator seeks to evaluate if the study sample is representative by comparing the characteristics of participants to those of eligible participants who did not participate. RE-AIM is quite prescriptive in what data should be considered, suggesting that basic demographics and/or outcome data (e.g. BMI or existing health conditions) should be collected from non-participants to compare to participants. However, in this PhD, this information proved very challenging to obtain as it raised ethical concerns from participating organisations regarding consent and data protection. In the context of the office setting, employers and employees challenged the necessity of collecting information and comparing results to co-workers who did not participate. This concern suggested that researchers should respect the choice of workers who decided not to be involved, and not contact them further. An opportunity to collect some non-participant information arose in study 2; therefore, an adaptation was made to the indicator. A group of employees, who had participated in an aspect of the study, but not the consultation intervention, were sent a separate consent form and questionnaire seeking information as to why they did not participate. Using this adaptation to the indicator was valuable to the study and did reveal insight into non-participants' perceptions. In the wider context of using the RE-AIM framework, adaptations to this indicator may need to be considered, as in this context, the ethical appropriateness of obtaining demographic and outcome data on non-participants was challenged by all involved. Secondly, in the Welbot digital intervention, measuring the adoption indicator, ‘level of expertise of delivery agent’ as written and described by RE-AIM authors would not have added valuable information to inform the evaluation. Specifically, as a digital intervention, Welbot did not require ‘agent’ (company) expertise to implement, and therefore in this example the ‘expertise of agents’ may play less of a role in informing the adoption dimension. Based on this, in the Welbot study this indicator was adapted to qualitatively explore the level of buy-in for health promotion expressed by delivery agents to try and more fully understand the adoption dimension, and potential for future adoption of the intervention. This is a good example of where RE-AIM authors could broaden their definitions to create more flexibility within the framework making the framework more adaptable to all types of interventions.

It is important to note that the original authors of RE-AIM acknowledge that adaptations to the framework have been important to its evolution of use across various settings (Glasgow et al., 2019). In a recent 2019 commentary entitled, ‘Adapting to New Science and Practice With a 20-Year Review’, the authors acknowledge that there is a need to expand upon, and emphasise the measurement of costs for replicating a program in different settings (Glasgow et al., 2019). They also explicitly stated that quantitative measures have been insufficient alone to predict dissemination, and therefore there is a new focus to expand guidance on qualitative approaches and methods (Glasgow et al., 2019;

Holtrop et al., 2018). Also, Glasgow and colleagues advocated for adaptation, and for the framework to be used in combination with other approaches which enhance RE-AIM's ability to determine how pragmatic a study is, and how generalisable it could be (Glasgow et al., 2019). Adaptations have been described as an important part of using any framework or model as it improves the appropriateness of the selected framework to the intervention, the population, and the setting (Allen et al., 2012; Tabak et al., 2012). This PhD may be used as an example of how small pragmatic adaptations and additions to the RE-AIM framework can improve the utility of the framework in examining potential for real world impact across research contexts.

5. Future research

Based on the knowledge built in this PhD towards informing and improving implementation and dissemination, several avenues for future research have been identified. More broadly, given that wide scale impact is so important to improving this public health problem there is a need for all studies of SB interventions in office worker to report more pragmatic indicators of potential for real world impact. For this reason, researchers should seek to implement interventions under real world conditions. This also means researchers should plan for and conduct more process evaluations using mixed methods study designs. More specifically, there is a need to more deeply and thoroughly investigate how organisational level barriers influence behaviour in the workplace. For example, future research should investigate and explore how managers influence an employee’s capability, opportunity and motivation to improve health behaviours in the workplace. Secondly, there is a need to thoroughly investigate how and why some companies buy-in to health and wellbeing while others do not. Understanding the key drivers and barriers to investment in health at the organisational level will help researchers, and health industry partners build stronger and more targeted interventions. Finally, there is a need for research to thoroughly investigate what resources are allocated to workplace health programs, for example, national surveys collecting data on current spending and available resources for health promotion. This data would be very valuable to improve researchers' ability to plan and conduct interventions which factor in the resource availability for wider implementation. It would also identify if there are differences in resource allocation based on company characteristics, further enhancing the ability to target and tailor intervention to resource availability.

6. Strengths and limitations of the thesis

The PhD has several strengths. Firstly, the PhD overall was novel and built around gaps in the literature, with the appropriate epistemology and methodology chosen to address the gaps that were identified. For example, the integrative review methods allowed for an examination of a large proportion of the published literature, and using the RE-AIM framework helped to identify where gaps in reporting for public health impact existed. Secondly, many methods, procedures and analysis tools were used/followed to enhance the validity, reliability and trustworthiness of findings throughout the PhD. For example: blinded double screening of included studies in the systematic review using the Covidence program; Braun and Clarke's Thematic analysis procedures for analysing qualitative data using the NVivo qualitative analysis tool; performing normality tests on quantitative data, adapting the testing to appropriate non-parametric tests, using a Bonferonni correction and using validated questionnaire measures. Thirdly, building a relationship with the Welbot start-up company has brought together diverse health knowledge, skills and resources to embed mixed methods real world evaluation into intervention development. This bridges a gap identified by other researchers as important for future health promotion improvement. Finally, developing recommendations to improve reporting across each study gives researchers something tangible to take away and use to improve their own practice. All three studies should help to raise the profile of pragmatic evaluation; with studies 2 and 3 serving as examples and foundations of practice which could be built on in this and other contexts.

There were also limitations to the PhD. Firstly, as the systematic review was focused on including as much of the research as possible to gain an understanding of reporting across all study designs, we did not include a quality assessment tool. This does mean that some included studies which were rated low across RE-AIM may have been considered high quality studies in other reviews or vice versa. For this reason, the communication and language used in the review did not directly state or suggest that studies were low or high quality across RE-AIM. Rather, the full breakdown of individual studies' rating across RE-AIM was published as a supplementary file so that those who were interested could look up individual studies' rating across RE-AIM. Additionally, there may have been room to adapt the coding sheet to better reflect the context of SB research studies. In this instance, it was thought that the validation of the elements of the coding sheet was important however there were some indicators that could have been refined to better suit the context. For example, one of the indicators within effectiveness (imputation procedures) could have been omitted as it was evident that in this research area very few studies need to preform imputation. Study 2 had a number of limitations which have been discussed in Chapter 3. One additional limitation worth noting is that the PhD student could not control when the evaluation took place. Data collection was scheduled over a 15-day period in July on a research trip to Springfield College. The limited time, alongside the summer holiday period, specifically limited the number of focus groups which could be conducted. Having more time may have allowed for a third or fourth focus group to take place. As this limitation unfolded on the research trip, the PhD student decided to adapt the topic guide to interview individual participants to add depth to the findings. Study 3 was limited significantly by recruitment challenges, and this combined with implementing the intervention over six months, meant that when there became an indication that numbers were dropping, there was not enough time to recruit more companies to take part in the study.

7. Conclusion

The thesis aimed to inform and improve our understanding of how to disseminate and implement interventions targeting sedentary office workers for public health impact in the real world. Using a pragmatic evaluation lens and the RE-AIM evaluation framework has enabled evidence to be built in several gaps in the literature. It has also helped build recommendations across all three studies to inform and improve dissemination of findings from SB in office worker interventions for their potential for real world impact. These recommendations can now be used to improve the implementation and evaluation of interventions and further address the gaps in the literature. Additionally, the approach to research used throughout the PhD can be used as an example of how to integrate mixed methods to facilitate more comprehensive implementation and dissemination of research. Most importantly, adjusting the lens of research in this PhD has enabled a more balanced approach to evaluating, not one, but two important goals of SB in office worker interventions, which are to reduce SB at the individual level, and the population level in the real world.

8. Chapter 5 References

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Appendices

Appendix A: Integrative review stage 1 – problem identification – analysis of systematic review evidence

Author/date	Title/objective	Included studies	Included studies continued	Results	Conclusion	My thoughts	Continued
A.H.Y Chu. May 2016	Systematic review and meta-analysis of workplace intervention strategies to reduce ST in white collar workers Objective: to compare intervention effects between different intervention designs.	26 studies- Only studies with a parallel control (or treatment-comparison group used), such as randomized controlled trials (RCTs), controlled trials or quasi-experimental studies.	Intervention: Studies assessing the effectiveness of workplace-based interventions. • Outcome: Sedentary behaviour measured by self-report (e.g. questionnaires and activity diaries) or objective Measures (e.g. accelerometry).	The pooled intervention effect showed a significant workplace sitting reduction of 39.6 min/8-h workday (95% confidence interval [CI]: 51.7, 27.5), favouring the intervention group. Multi-component interventions reported the greatest workplace sitting reduction (88.8 min/8-h workday; 95% CI:132.7, 44.9), followed by environmental (72.8 min/8-h workday; 95% CI:104.9, 40.6) and educational/behavioural strategies 15.5 min/8-h workday (95% CI:22.9,8.2).	Our study found consistent evidence for intervention effectiveness in reducing workplace sitting, particularly for multi-component and environmental strategies. Methodologically rigorous studies using standardized and Objectively determined outcomes are warranted.	It proves that all singing all dancing interventions show the best results, but again I feel we have missed the mark in terms of changing behaviour long term. Has the culture changed in this office for good. Do workers value sitting less? Who knows?	Need to look into how the authors defined educational/behavioural interventions. This produced the least intervention effect but it would be interesting to look at follow up information. What was the definition of “education”. Most seem to be reporting posters as education and I would argue that reading a poster is not education.

Shrestha 2016	Workplace interventions for reducing sitting at work Objective: To evaluate the effects of workplace interventions to reduce sitting at work compared to no intervention or alternative interventions.	20 studies We included randomised controlled trials (RCTs), cluster-randomised controlled trials (cRCTs), and quasi-randomised controlled trials of interventions to reduce sitting at work. For changes of workplace arrangements, we also included controlled before-and-after studies	The primary outcome was time spent sitting at work per day, either self-reported or objectively measured by means of an accelerometer-inclinometer. We considered energy expenditure, duration and number of sitting episodes lasting 30 minutes or more, work productivity and adverse events as secondary outcomes.	**Physical workplace changes** sit-stand desks- 30 min-2hours at short term follow up (6 studies VLQE) **Policy changes -2 studies MD 16 min** **Information and counselling-**2 studies MD – 28 (CI-51to -3) **Multi- component-inconsistent effect** – 12month follow up (MD-47 min CI 103 to 7 294 participants)	At present there is very low to low quality evidence that sit-stand desks may decrease workplace sitting between thirty minutes to two hours per day without having adverse effects at the short or medium term. There is no evidence on the effects in the long term	This was a cochrane review and there may be lots of research being excluded. It will be interesting to look at the policy change categories and information counselling to review the mechanisms	
Anne Martin 2015	Interventions with potential to reduce sedentary time in adults systematic review and meta-analysis	Study design: RCT only Objectively measured SB obtained from accelerometers Objectively measured sitting time	‣ Self-reported proxy measures of sitting time where it is not certain that people are sitting (eg, screen time and transport time) and proxy measures of	Meta-analysis of 34/51 studies showed a reduction of 22 min/day in sedentary time in favour of the intervention group (95% CI −35 to −9 min/day, n=5868). Lifestyle interventions reduced SB by 24 min/day (95% CI −41 to	There was evidence that it is possible to intervene to reduce SB in adults. Lifestyle and SB only interventions may be promising approaches.	This also is a Cochrane review. There may be an option to do glucose monitoring to try and show clinical meaningful	

		obtained from inclinometers ‣ Objectively or self-reported patterns of accumulation of SB ‣ Self-reported total sitting time	overall SB (eg, occupational sitting time) Other inclusion criteria	−8 min/day, n=3981, moderate quality) and interventions focusing on SB only by 42 min/day (95% CI −79 to −5 min/day, n=62, low quality). There was no evidence of an effect of PA and combined PA/SB interventions on reducing sedentary time.	More high quality research is needed to determine if SB interventions are sufficient to produce clinically meaningful and sustainable reductions in sedentary time.	reductions in blood glucose.	
Chau JY 2010	Are workplace interventions to reduce sitting effective	Intervention: any intervention study (pre–post, quasi-experimental, controlled and/or randomised) that aimed to increase energy expenditure (increase proor reduce sitting); 2. Setting: conducted in a workplace setting; Outcome measure: used a specific measure of sitting or activities ≤1.5	Six studies met the inclusion criteria (five randomised trials and one pre–post study).	Primary aim of all six was to increase physical activity; all had reducing sitting as a secondary aim. All used self-report measures of sitting; one specifically assessed occupational sitting time; the others used measures of general sitting. No studies showed that sitting decreased significantly in the intervention group, compared with a control or comparison group.	Currently, there is a dearth of evidence on the effectiveness of workplace interventions for reducing sitting. In light of the growing body of evidence that prolonged sitting is negatively associated with health, this highlights a gap in the scientific literature that needs to be addressed.	This review is out of date but it shows us how far the research has come in 7 years. In her review non of the papers were designed to target sedentary time and non were objectively measured.	

		METs (self-report or objective; including measures of sitting with or without duration) as a primary or secondary outcome.					
MacEwen 2015	A systematic review of standing and treadmill desks in the workplace	**treadmill walking intervention (standing desk or treadmill desk) compared to regular seated desk work or investigations that compared sitting to either standing or treadmill walking at work were eligible for inclusion** **physiological outcomes –** cholesterol,	**Psychological outcomes** –Job satisfaction –Mood states –Productivity (workplace performance) –Quality of life	A total of 23 studies were included in the review, 19 of which were quasi-experimental studies lacking appropriate randomization or control and 4 randomized controlled trials. Consistent with the outcomes of interest presented in Table 1, data are presented across the two dimensions of physiological and psychological outcomes	There is limited evidence to make conclusions regarding the physiological, more research is warranted in regard to their ability to illicit a physiological response. Further research should consist of randomized controlled trials addressing questions such as how these desks may influence specific health conditions, if	This review may be very helpful when trying find out what types of interventions have been done using physiological biomarkers. These would be mechanisms.	

		blood lipids, blood pressure, heart rate, chronic venous insufficiency, varicose veins, deep vein thrombosis			changes return to baseline after time even with continued use, and what impact does discontinuing the use of these desks have on the individual?		
Tew GA 2015	Systematic review: height adjustable workstations to reduce sedentary behaviour in office-based workers **Objective**- To provide an accurate overview of the controlled trials that have evaluated the effects of heightadjustable workstation interventions on workplace sitting time in office-based workers.	5 studies included n-rct 4 and 1 rct objectively measured workplace sitting time (primary outcome), self-reported workplace sitting time, cardiovascular events (e.g. stroke, myocardial infarction), musculoskeletal health (e.g. symptoms of back pain), mental health (e.g. depression, anxiety, stress) and objectively	Randomized and non-randomized controlled trials where the comparison group did not receive a height adjustable workstation were included. Non-randomized trials were also considered eligible because we anticipated a paucity of randomized trials. Single-arm studies were not included	All four of the two-arm studies reported reduced workplace sitting time at follow-up in the intervention group compared with the control group absolute reduction of 21% (95% confidence interval [CI] 18, 25) in the intervention period compared with the control period. Healy et al. [12] reduced workplace sitting time by −125 min (95% CI −161, −89; P < 0.001) three-arm study of Neuhaus et al. [16], the multicomponent group had lower workplace sitting time relative to	The findings suggest the evidence base for height-adjustable workstations is currently limited and includes only small studies with Important methodological limitations. data suggest that height-adjustable workstation interventions may offer a practical approach to reducing sitting time, but further research is warranted	These finding will be important to consider especially if we use height adjusted work stations as a part of the intervention. The healy et al multi arm intervention is also important to look at to pick apart. High reduction at follow up. They talk about methodological limitations. Need to find out what they were.	

		measured body composition fat).		the control group at 3-month follow-up (adjusted mean difference = −89 min; 95% CI −140, −38; P < 0.001)	true magnitude of the effect particularly over health-related and work-productivity outcomes.		
Nauhaus M 2014	Reducing occupational sedentary time: a systematic review and meta- analysis of evidence on activity permissive workstations **Objective -** The objective of our review was thus to systematically review the impact of activity-permissive workstations on office workers' sedentary time, adiposity and other health and work-related outcomes; and, feasibility outcomes	38 papers evaluated overall and/or workplace sedentary time, health-related (e.g. weight, musculoskeletal symptoms, blood risk markers), work-related (e.g. productivity, absenteeism) or feasibility outcomes (e.g. acceptability, adverse events) following the provision of an activity-permissive workstation; included an adult sample (aged ≥18	activity-permissive workstations; reported at least two data collection points (i.e. baseline and follow-up); and were published in an English-language peer-reviewed journal. As much of the documentation from the ergonomics research field is published in conference proceeding papers, only relevant studies published in peer-reviewed conference proceedings	**Results**- Across the 45 independent comparisons, 17 evaluated height-adjustable desks (of which 12 were fully adjustable desks and five were height-adjustable desk mounts for the computer only), two evaluated standing desks with height-adjustable chairs, eight evaluated standing desks without height-adjustable chairs, 12 evaluated treadmill desks, two evaluated pedal devices, two evaluated cycle ergometers, one evaluated a stepping device, while one study (54) evaluated both treadmills and cycle ergometers.	The installation of activity-permissive workstations in office-based workplaces is likely to be a feasible and acceptable means to reduce office workers' sedentary time, with mostly neutral or positive impacts on adiposity and other health- and work-related outcomes. Further intervention trials are required, particularly with more rigorously controlled	A lot of outcomes and a lot of variety of activity permissive work stations. The conclusions are consistent with what each review basically says that more rigorous methods in controlled trials are needed. I will need to dive into some of the interventions with the big effects to see what has worked and why as well as why other interventions	

	(acceptability to workers and potential adverse events).	years); engaged in administrative (i.e. not manufacturing, but with reliance on engagement with a computer) tasks while using.	Papers were also included.	Of the studies evaluating height-adjustable desks, only six (of 15) reported whether these were electric or operated via alternative mechanisms (16,18,34,43,45,56).	study designs, adequate statistical power and longer-term follow-ups to identify impacts on health related outcomes as well as long-term maintenance of sedentary time reductions.	have not worked. Sounding a lot like a RE-AIM review!	
Prince SA 2014	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 control trials	The review sought to identify all studies that examined the effects of an intervention that targeted PA and/or SB (including broader lifestyle or weight loss interventions), and that reported a SB-related outcome (e.g. sedentary time, sitting time, television [TV] time). Only	exposure (e.g. studies that validated accelerometers). All study designs were eligible (e.g. pre-post, quasi-experimental, randomized controlled trial [RCT], etc.) in the original search strategy as it was uncertain how many relevant studies would be identified. Because of the	**Results**- SB Results of the meta-analysis identified that overall, the SB interventions attributed to a significant and large reduction in sedentary time (SMD = −1.28 [95% CI: −1.68, −0.87]) equating to a mean difference of approximately 91 min/d of sedentary time fewer in the Intervention groups compared with the controls.	Current evidence supports that clinically meaningful reductions in sedentary time can be produced in interventions with some degree of focus on reducing SBs, but that interventions that focus solely on SBs result in much greater reductions.	A complicated review that shows us that SB targeted interventions seems to work better then SB and PA. However I wonder how this might look for health related outcomes rather than looking at reductions in ST. (glucose monitoring?)	

		adult populations were included (mean age ≥18 years). Both self-reported and objectively measured SB outcomes were included. A minimum follow-up time of 1 d was required so as to exclude studies that looked at one-time immediate effects of an	large number of papers identified in the initial search, only higher-quality study designs with a control group were included in this review. Both published (peer-reviewed) and unpublished literatures were examined.	The available evidence (Table 2) suggests that interventions that focus on SBs may result in large and clinically Meaningful reductions in daily sedentary time. The quality of the evidence from the RCT studies is moderate, largely because of issues with imprecision of study results (n = 2 studies). This suggests that further research has the capacity to impact on the estimate and/or the confidence in the estimate.			
Gardner 2015	How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults	26 studies/38 interventions. any behaviour change intervention was eligible where primary quantitative data were available pertaining to pre-post changes in at least one indicator of		Interventions were categorised as 'very promising', 'quite promising', or 'non-promising' according to observed behaviour changes. Intervention functions and behaviour change techniques were compared across promising and non-promising interventions. Twenty-six eligible studies reported	Self-monitoring, problem solving, and restructuring the social or physical environment were particularly promising behaviour change techniques. Future sedentary reduction	This review will be very important to understand if we go down a realist review road but may be less important if we go down a different road. The qualitative work done has yet to be looked at in	Divided the pie by looking at effectiveness in terms of behaviour change strategies. Expected rresults…

		sedentary behaviour among those receiving the intervention.		thirty-eight interventions, of which twenty (53%) were worksite-based. Fifteen interventions (39%) were very promising, eight quite promising (21%), and fifteen non-promising (39%). Very or quite promising interventions tended to have targeted sedentary behaviour instead of physical activity. Interventions based on environmental restructuring, persuasion, or education were most promising.	interventions might most fruitfully incorporate environmental modification and self-regulatory skills training. The evidence base is, however, weakened by low-quality evaluation methods; more RCTs, employing no-treatment control groups, and collecting objective data are needed.	any of the above. I would need to understand there definition of promising, quite promising and non- promising	
Torbeyns 2014	Active workstations to fight sedentary behaviour.	RCTs, nRCTs and nRnCTs on active workstations were conducted in the adult population. Also, both longitudinal and cross-sectional designs were	We included 32 studies, of which five were longitudinal studies in school-aged children, 10 were longitudinal studies in adults and 17 were non-longitudinal studies in	The general findings were decreased sitting time, increased energy expenditure, a positive effect on several health markers, no detrimental effect on work performance, no acute effect on cognitive function and no straightforward	The implementation of active workstations might contribute to improving people's health and physical activity levels. The effect of the use of these active	The review is quite complex and contrasts to findings of MacEwan and TEW reviews. The language is a strong and suggests that there is good evidence that these stations help with	

		used. The studies	adults. Sixteen studies investigated standing desks, 15 investigated walking desks, and one investigated a cycling workstation. The general findings were decreased sitting time, increased energy expenditure, a positive effect on several health markers, no detrimental effect on work performance, no acute effect on cognitive function and no straightforward findings concerning computer task performance.	findings concerning computer task performance.	workstations on cognition and applied work tasks, such as computer task performance, needs further investigation before conclusions can be drawn. Another aspect that needs further investigation is the implementation of the different active workstations in all age groups.	health bio markers. Obviously they included non rcts but maybe they are right to do this and the others are wrong to disregard such studies.	

Appendix B: Reporting of indicators of reach and effectiveness across all included interventions

	REACH							EFFICACY/EFFECTIVENESS					
Study Author & Year	Method to identify the target population	Inclusion criteria	Exclusion criteria	Sample size	Participation rate	Use of qualitative methods to understand the reach or recruitment	Characteristics of participants	Measure/results (at shortest assessment)	Imputation procedures (created data)	Quality of life measurements	Effects at longest (extra follow up)	Use of qualitative methods or data to understand outcomes	Per cent attrition rate (drop out rate)
Aittasalo et al. (2012) [29]	✓	✓	✓	✓	✓			✓			✓		✓
Alkhajah et al. (2012) [30]	✓	✓	✓	✓				✓			✓		
Arrogi et al. (2017) [31]	✓	✓		✓				✓	✓		✓		✓
Barbieri et al. (2017) [12]		✓		✓				✓					
Ben-Ner et al. (2014) [32]	✓		✓	✓	✓			✓			✓		✓
Bort-Roig et al. (2014) [33] connected to Puig-Ribera et al. (2015) [88], Puig-Ribera et al. (2017)[87]	✓	✓	✓	✓	✓	✓		✓		✓	✓		✓
Brakenridge et al. (2016) [34] connected to Brakenridge et al. (2017) [35]	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Carr et al. (2016) [36]	✓		✓	✓	✓			✓			✓		✓
Carr et al. (2013) [37]	✓	✓	✓	✓	✓			✓			✓		✓
Carr et al. (2012) [38]	✓	✓	✓	✓				✓		✓	✓		

Chau, Daley & Srinivasan et al. (2014) [39] Connected to Chau, Daley & Dunn et al. (2014) [40]	✓	✓		✓	✓			✓	✓		✓	✓	✓
Chau et al. (2016) [41]	✓			✓				✓			✓		✓
Cifuentes et al. (2015) [42]	✓			✓	✓	✓		✓		✓		✓	
Coenen et al. (2017) [43] Connected to Hadgraft NT, Willenberg L, LaMontagne AD, Malkoski K, Dunstan DW, Healy GN, et al. (2017) [64]; Hadgraft NT, Winkler EA, Healy GN, Lynch BM, Neuhaus M, Eakin EG, et al. (2017) [65]; Healy GN, Eakin EG, LaMontagne AD, Owen N, Winkler EA, Wiesner G, et al. (2017) [66]; Healy GN,	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓

Eakin EG, Owen N, Lamontagne AD, Moodie M, Winkler E, et al. (2016) [68].													
Coffeng et al. (2014) [44]	✓	✓	✓	✓	✓			✓			✓		✓
Cooley et al. (2014) [14] connected to Pedersen et al. (2014) [84]	✓	✓		✓	✓			✓		✓		✓	
Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup JSJSjow et al. (2017) [45] connected to Danquah Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll AK, et al. (2017) [46]	✓		✓	✓				✓	✓	✓	✓		✓
Davis et al. (2014) [47]	✓	✓	✓	✓	✓			✓		✓	✓		✓
De Cocker et al., (2015)[48]	✓	✓	✓	✓	✓		✓	✓			✓		✓
De Cocker et al., (2016) [49]	✓	✓	✓	✓	✓			✓			✓		✓

connected to De Cocker et al., (2017) [50]													
Dewa et al. (2009) [51]	✓			✓				✓			✓		
Donath et al. (2015) [52]	✓	✓	✓	✓	✓			✓			✓		✓
Ellegast. (2012) [53]	✓			✓				✓			✓		
Engelen et al. (2016) [54]	✓			✓				✓			✓		✓
Evans et al. (2012) [55]	✓	✓	✓	✓				✓			✓		✓
Fennel et al. (2016) [56]	✓	✓	✓	✓	✓			✓			✓		
Ganesan et al. (2016) [57]	✓	✓	✓	✓	✓			✓			✓		✓
Gao et al. (2016) [58]	✓	✓	✓	✓				✓			✓		✓
Gilson et al. (2009) [59]	✓			✓	✓			✓	✓		✓		
Gilson et al. (2016) [60]	✓	✓	✓	✓	✓			✓			✓		
Gorman et al. (2013) [61]	✓	✓	✓	✓	✓			✓			✓		✓
Graves et al. (2015) [62]	✓	✓	✓	✓	✓			✓	✓		✓		✓
Green et al. (2016) [63]	✓	✓		✓	✓			✓					✓
Healy et al. (2013) [67] connected to Stephens et al. (2014) [91]	✓	✓	✓	✓				✓			✓		
Hendriksen et al. (2016) [69]	✓	✓	✓	✓	✓			✓			✓		✓

Jancey et al. (2016) [70]	✓	✓	✓	✓	✓			✓			✓		✓
John et al. (2011) [71]	✓	✓	✓	✓				✓			✓		✓
Jones et al. (2017) [72]	✓	✓	✓	✓	✓		✓	✓					✓
Judice et al. (2015) [73]	✓	✓		✓	✓			✓			✓		✓
Kerr et al. (2016) [74]	✓	✓	✓	✓				✓	✓		✓		
Kozey-Keadle et al. (2012) [75]	✓	✓	✓	✓				✓			✓		
Kress et al. (2015) [76]	✓	✓		✓	✓			✓					✓
Li et al. (2017) [77]	✓	✓		✓	✓			✓					✓
MacEwen et al. (2017) [78]	✓	✓	✓	✓				✓		✓			✓
Mackenzie et al. (2015) [79]	✓			✓	✓		✓	✓				✓	✓
Mailey et al. (2016) [80] connected to Mailey et al. (2017) [81]	✓	✓	✓	✓	✓			✓		✓			✓
Mansoubi et al. (2016) [82]	✓	✓	✓	✓				✓			✓		✓
Neuhaus et al. (2014) [15]	✓	✓		✓	✓			✓		✓			✓
Parry et al. (2013) [83]	✓	✓	✓	✓			✓	✓					✓
Priebe et al. (2015) [85]		✓		✓				✓					✓
Pronk et al. (2012) [86]		✓		✓	✓			✓		✓			

Reece et al. (2014) [89]	✓	✓		✓				✓					✓
Schuna et al. (2014) [90] connected to Tudor-Lock et al. (2014) [96]	✓	✓	✓	✓	✓	✓		✓		✓		✓	✓
Straker et al. (2013)[92]	✓	✓		✓	✓			✓					✓
Swartz et al. (2014) [93]	✓	✓	✓	✓	✓			✓					✓
Taylor et al. (2016) [94]	✓	✓		✓	✓		✓	✓					✓
Tobin et al. (2016) [95]	✓	✓		✓				✓		✓			✓
Urda et al. (2016) [97]	✓	✓	✓	✓	✓			✓		✓			✓
vanBerkel et al. (2014) [98]	✓	✓		✓	✓			✓	✓		✓		✓
Venema et al. (2017) [99]				✓				✓			✓		✓
Verweij at al. (2012) [100]	✓	✓	✓	✓				✓					✓

Appendix C: Reporting of indicators of adoption, implementation and maintenance across all included interventions

	ADOPTION							IMPLEMENTATION				MAINTENANCE			
Study Author & Year	Method to identify target delivery agent	Level of expertise of delivery agent	Inclusion/ exclusion	Use of qualitative methods to understand adoption at the setting level or staff participation	Rate of adoption	Characteristics of setting and participants of adoption/ non-adoption (drop out participant/ setting characteristics	Measure of cost	Intervention type and intensity	Extent protocol delivered as intended (protocol reported)	Use of qualitative methods to understand the implementation	Measure of cost (protocol)	Was individual behaviour assessed at least six months following the completion of the intervention	Is the program still in place?	Use of qualitative methods to understand setting level institutionalisation	Was the program modified
Aittasalo et al. (2012) [29]	✓	✓	✓			✓	✓	✓	✓		✓				
Alkhajah et al. (2012) [30]							✓	✓	✓						
Arrogi et al. (2017) [31]		✓	✓					✓				✓			
Barbieri et al. (2017) [12]								✓	✓						
Ben-Ner et al. (2014) [32]					✓		✓	✓							
Bort-Roig et al. (2014) [33] connected to Puig-Ribera et al. (2015) [88], Puig-Ribera et al. (2017)[87]	✓	✓	✓	✓				✓	✓	✓				✓	
Brakenridge et al. (2016)	✓	✓		✓	✓			✓	✓	✓	✓	✓		✓	

[34] connected to Brakenridge et al. (2017) [35]															
Carr et al. (2016) [36]	✓	✓					✓	✓	✓						
Carr et al. (2013) [37]							✓	✓	✓						
Carr et al. (2012) [38]							✓	✓	✓						
Chau, Daley & Srinivasan et al. (2014) [39] Connected to Chau, Daley & Dunn et al. (2014) [40]								✓	✓	✓				✓	
Chau et al. (2016) [41]								✓	✓						
Cifuentes et al. (2015) [42]						✓		✓	✓	✓				✓	
Coenen et al. (2017) [43] Connected to Hadgraft NT, Willenberg L, LaMontagne AD, Malkoski K, Dunstan	✓	✓						✓	✓	✓				✓	

DW, Healy GN, et al. (2017) [64]; Hadgraft NT, Winkler EA, Healy GN, Lynch BM, Neuhaus M, Eakin EG, et al. (2017) [65]; Healy GN, Eakin EG, LaMontagne AD, Owen N, Winkler EA, Wiesner G, et al. (2017) [66]; Healy GN, Eakin EG, Owen N, Lamontagne AD, Moodie M, Winkler E, et al. (2016) [68].															
Coffeng et al. (2014) [44]	✓	✓						✓	✓			✓			✓
Cooley et al. (2014) [14] connected to Pedersen et al. (2014) [84]					✓			✓		✓				✓	

Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup JSJSjow et al. (2017) [45] connected to Danquah Danquah IH, Kloster S, Holtermann A, Aadahl M, Bauman A, Ersbøll AK, et al. (2017) [46]						√		√							
Davis et al. (2014) [47]								√	√						
De Cocker et al., (2015)[48]								√	√						
De Cocker et al., (2016) [49] connected to De Cocker et al., (2017) [50]								√	√						
Dewa et al. (2009) [51]	√							√							
Donath et al. (2015) [52]								√	√						

Ellegast. (2012) [53]								√							
Engelen et al. (2016) [54]								√	√				√		
Evans et al. (2012) [55]								√							
Fennel et al. (2016) [56]	√	√					√	√	√						
Ganesan et al. (2016) [57]	√						√	√	√				√		√
Gao et al. (2016) [58]								√							
Gilson et al. (2009) [59]								√	√						√
Gilson et al. (2016) [60]								√							
Gorman et al. (2013) [61]								√					√		√
Graves et al. (2015) [62]							√	√	√						
Green et al. (2016) [63]								√							
Healy et al. (2013) [67] connected to Stephens et al. (2014) [91]	√	√					√	√	√						
Hendriksen et al. (2016) [69]	√	√				√		√				√			
Jancey et al. (2016) [70]								√	√				√		
John et al. (2011) [71]								√	√						

Jones et al. (2017) [72]								✓							
Judice et al. (2015) [73]								✓							
Kerr et al. (2016) [74]								✓	✓		✓				
Kozey-Keadle et al. (2012) [75]								✓							
Kress et al. (2015) [76]															
Li et al. (2017) [77]								✓	✓						
MacEwen et al. (2017) [78]								✓							
Mackenzie et al. (2015) [79]							✓	✓		✓					
Mailey et al. (2016) [80] connected to Mailey et al. (2017) [81]								✓	✓						
Mansoubi et al. (2016) [82]								✓							
Neuhaus et al. (2014) [15]								✓	✓						
Parry et al. (2013) [83]	✓							✓	✓				✓		
Priebe et al. (2015) [85]								✓							
Pronk et al. (2012) [86]								✓	✓						
Reece et al. (2014) [89]								✓							

Schuna et al. (2014) [90] connected to Tudor-Lock et al. (2014) [96]								✓	✓	✓					
Straker et al. (2013)[92]	✓		✓		✓			✓							
Swartz et al. (2014) [93]								✓	✓						
Taylor et al. (2016) [94]						✓		✓	✓						
Tobin et al. (2016) [95]	✓							✓	✓						
Urda et al. (2016) [97]								✓	✓						
vanBerkel et al. (2014) [98]								✓				✓			
Venema et al. (2017) [99]	✓							✓							
Verweij at al. (2012) [100]	✓	✓	✓		✓	✓		✓							

Appendix D: Participant information sheet

Participant Information Sheet

An evaluation of an intervention to reduce sedentary time in the workplace

You are invited to take part in an evaluation of the Sedentary Behaviour at Springfield College study.

Introduction

My name is Brad MacDonald and I am a PhD student at the University of Strathclyde in Glasgow, Scotland. I will be leading an evaluation of the Sedentary Behaviour at Springfield College study you were a part of at Springfield College recently. This evaluation is part of a growing international collaboration between Springfield College and the University of Strathclyde in Scotland. As a part of this evaluation, I will be travelling to Springfield (July 5-15, 2017) to work with Dr Jasmin Hutchison and Prof Sam Headley. During this period I will conduct focus groups with participants who completed the study and I would like to invite you to take part.

What is the purpose of this investigation?

The purpose of this aspect of the evaluation is to gain an understanding of participant views of the study. We believe you have insightful knowledge about your experience that may help improve future interventions with this population.

Do you have to take part?

No, you do not have to take part in this study. If you do decide to take part, you are free to withdraw your participation at any time, without having to give a reason and without any consequences. In addition, you are free to withdraw any information about you that has been collected as part of the study, without having to give a reason and without any consequences. If you wish to withdraw your information, you can do this <u>up to two weeks</u> after you have completed the study.

What will you do in the project?

After signing up you will receive an email about the time, date and location of your focus group or interview. You will be asked to make your own way to Springfield College campus where the focus group or interview will take place. When you arrive you will be asked to complete a short demographic questionnaire before you we start the focus group. Each focus group will last approximately 60 minutes. The conversation will be recorded on a password-protected device.

How do I sign up for the focus group?

If you would like to take part please return your consent form (attached to this email) and the completed sign-up sheet to me by June 18th. The sign-up sheet is attached to this email. Please note down all the times in which you are available. It is really important that you fill in as many times as possible to ensure focus groups can be arranged around times most people are available. There will be several focus groups so there is a good chance you will get to participate. If for some reason you cannot make any of the chosen focus group times but still want to participate, a short individual interview may be arranged to discuss your experience. The closing date for sign up will be June 18th. After this time I will pick the most popular times for the groups and email you with the information you need to attend (e.g. date, time, location).

Do you have to take part?

No, you do not have to take part in this evaluation. If you do decide to take part, you are free to withdraw your participation at any time, without having to give a reason and without any consequences. In addition, you are free to withdraw any information about you that has been collected as part of the study, without having to give a reason and without any consequences. If you wish to withdraw your information, you can do this up to two weeks after you have completed the study.

What are the potential risks to you in taking part?

There are no known risks associated with the focus groups

What happens to the information in the project?

With your permission, the sedentary behaviour focus group will be audio recorded. Immediately after the focus groups have finished, the audio files will be transferred to a password protected university laptop computer. The audio files will be deleted from the recording device as soon as the files have been transferred. The focus groups will be transcribed and then anonymised using your study code. Hard copies of the anonymised transcriptions will be stored in a locked filing cabinet separately from the consent forms and the demographic questionnaires, and electronic copies of the anonymised transcriptions will be stored on a password protected computer based at the University. Only the researchers involved in the project will have access to your information. We will retain your information for publication and will securely store your information (including the transcriptions) for up to 5 years following the project end, after which your information will be destroyed. Once the evaluation is completed, it will be passed on in the form of a report to the Springfield College campus recreation department. It will also inform part of my PhD project and be written up for publication in an international journal. Your identity will remain confidential in any presentations, publications or reports arising from this study.

The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 1998.

What happens next?
As previously mentioned, if you do wish to take part in the focus group please fill out the attached forms and return to Bradley.macdonald@strath.ac.ukby June 18th.

Researcher Contact Details:
If you have any questions about this study please contact myself Brad MacDonald via email Bradley.macdonald@strath.ac.uk. By phone contact Dr Jasmin Hutchison (413) 748-3601.

Chief Investigator Details:
If you have any questions or concerns about this study, please contact:

Dr Jasmin Hutchison, Associate Professor of Exercise Science and Sport Studies, Springfield College, 263 Alden Street, Springfield Massachusetts, 01109-3739, Telephone 413-748-3601

OR

Dr Alison Kirk, Senior Lecturer in Physical Activity for Health, University of Strathclyde, 50 George Street, Glasgow, G1 1QE, Telephone: 0141 548 4153 (direct line), email: alison.kirk@strath.ac.uk

This study was granted ethical approval by the School of Psychological Sciences and Health ethics committee.

University of Strathclyde

If you have any questions/concerns, during or after the study, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Dr Diane Dixon

(Convener of the ethics committee)
School of Psychological Sciences and Health
University of Strathclyde

University of Strathclyde
Graham Hills Building
40 George Street
Glasgow
G1 1QE

Email: diane.dixon@strath.ac.uk, Telephone: 0141 548 2571

Appendix E: Paper 2 questionnaires

Email to participants who did not participate in the SURVEY.

At the beginning of the Fall 2016 semester you received an invitation to participate in a campus wide survey about your activity patterns during your work day. Not all members of the campus community chose to answer this survey. In order to try to reach all parts of the community in the future we are conducting a follow-up survey to assess reasons for non-participation. If you are willing to give your feedback, please answer the following question. This survey is anonymous.

I did not participate in the survey because:

- I did not receive the survey
- I was too busy
- I forgot to respond
- I'm not interested
- I thought it would take too long
- I feel as though this information (how I spend time at work) could be used against us
- Other (please specify) ________________________

Please add here any relevant detail to explain your answer:

Email to participants who answered the survey but did not participate in the study.

At the beginning of the Fall 2016 semester you participated in a campus wide survey about your activity patterns during your work day. At the end of the survey you were offered the opportunity to participate in a follow-up study by wearing an accelerometer. In order to improve future outreach efforts, we are conducting a follow-up survey to assess reasons for non-participation. It would be very helpful for us to know why you chose not to participate in the follow-up study. If you are willing to give your feedback, please answer the following question. This survey is anonymous.

I did not participate in the accelerometer study because:

- I did not understand what it would entail
- I'm not interested in the information
- I was too busy
- I forgot to respond
- It was not convenient for me
- I felt uncomfortable with having the device attached to my body
- I was worried about a skin reaction to the device
- I feel awkward or embarrassed about coming to the lab
- I already stand/move a lot in my occupation
- I feel as though this information (how I spend time at work) could be used against us
- Other (please specify) ________________________

Please add here any relevant detail to explain your answer:

<u>Email to participants who did not participate in the INTERVENTION</u>.

In the Fall 2016 semester you participated in a study about your activity patterns during your work day. Following this you were offered an opportunity to receive a personalized intervention to go over your results and discuss strategies to potentially incorporate more movement into your working day. In order to make future programs more accessible to all members of the campus community, to would be helpful for us to know why you chose not to participate in the follow-up intervention. If you are willing to give your feedback, please answer the following question. This survey is anonymous.

I did not participate in the intervention because:

- I was not interested in the information
- I was too busy
- I forgot to respond
- It was not convenient for me
- I already stand/move a lot in my occupation

- I feel as though this information (how I spend time at work) could be used against us
- Other (please specify) ________________________

Please add here any relevant detail to explain your answer:

<u>Questions for participants who completed the intervention</u>

1. How would you rate your overall health?

Excellent Good Fair Poor Very poor

2. Did your awareness of time spent sitting change following the intervention?

A lot A fair amount Moderately A little Not at all

3. Did you change your work activity patterns following the intervention?

A lot A fair amount Moderately A little Not at all

4. Overall, how would you rate the "Sit Less" intervention?

Excellent Good Fair Poor Very poor

5. How helpful was the one-on-one or small group meeting?

Very helpful Fairly Helpful Somewhat helpful Minimally helpful Not at all helpful

6. How informative was the one-on-one or small group meeting?

Very informative Fairly informative Somewhat informative Minimally informative Not at all

7. How useful were the weekly emails?

Very useful Fairly useful Somewhat useful Minimally useful Not at all useful

8. Would you change anything about the intervention?
    a. Yes

b. No

If yes, please explain (open) ________________________________ ______

9. Any other comments or suggestions? (open) ________________________ ____________

Appendix F: Qualtrics questionnaire

Company three baseline survey

Start of Block: Welbot

Q45 Please add your participant identification number below:

____

Q19 School of Psychological Sciences and health, University of Strathclyde, Graham Hills Building, G1 1QE **Feasibility, acceptability and indicative effect of the Welbot Intervention on sedentary behaviour, physical activity and physical and mental wellbeing.**

Thank you for agreeing to take part in our study. Thank you for reading the participant information sheet and privacy notice for participants.

Please can you provide consent to your involvement in this study
(please select all of the following statements)

- ☐ I confirm that I have read the information sheet and understood the information about the study (2)
- ☐ I have had a chance to discuss this study, ask questions and received satisfactory answers to all of my questions (52)
- ☐ I confirm that I understand how the information I provide will be used and what will happen to it (i.e. how it will be stored and for how long) (9)
- ☐ I understand that my participation is voluntary (10)
- ☐ I understand that I am free to withdraw from the study, up to the point at which my data is anonymised, without having to give a reason and without consequences (64)
- ☐ I understand that anonymised data (i.e. data that does not identify me personally) cannot be withdrawn once they have been included in the study (11)
- ☐ I understand that any information recorded in the research will remain confidential and there will be no information that identifies me publically (12)
- ☐ I understand the above information and consent to my participation in the study (40)

Q60 Do you have the freedom at work to stand up from your desk when you choose?

- Yes (1)
- No (2)
- Sometimes (4)

About you

We would like to begin by asking you a few questions about yourself.
Please select the option which best describes you:

- Male (1)
- Female (2)
- non-binary (3)
- Prefer not to answer (4)

How old are you (in years)?

____

Q38 What is your height (cm or feet & inches)?

____

Q39 What is your weight (kg or stones & pounds)?

____

How would you describe your ethnicity?

- White British (1)
- White Scottish (2)
- White English (14)
- White Irish (3)
- White other (15)
- Mixed race/multiple ethnic group (4)
- Afro-Caribbean (5)
- Black African (6)
- Indian (7)
- Pakistani (8)
- Bangladeshi (9)
- Chinese (10)
- Other Asian (11)
- Other (12)
- Prefer not to answer (13)

Q10 Do you consider yourself to have experienced any of the following in the last 5 years?

- ☐ Diagnosed mental illness (1)
- ☐ Long term physical health condition (3)
- ☐ None of these (5)
- ☐ Prefer not to answer (4)

Q17 How would you describe your working status?

- ☐ Full time (1)
- ☐ Part time (2)
- ☐ Don't know (3)
- ☐ Prefer not to answer (4)

Q44 What is your occupation?

____

Page Break

Q47
About your work environment

We are interested to know about the environment in which you work, for example, are you in an open plan office, seated or standing desk, close vicinity to a printer etc)
How would you describe your working environment?

____

Q48 What floor do you work on?

____

Q50 At work do you tend to use any of the following on a regular basis?

- ◯ Elevator (1)
- ◯ Stairs (2)
- ◯ Escalator (4)
- ◯ not applicable (5)

Q59 Do you have or have access to a height adjustable work station or standing desk in your office?

- ◯ Yes (1)
- ◯ No (2)

Q51 Where do you tend to take your lunch break?

- ○ At work desk area (1)
- ○ Go out for lunch (2)
- ○ Go to work canteen (3)
- ○ Other (4)

Q52 Do you have a green space near your work that you can access during breaks?

- ○ Yes (1)
- ○ No (2)

Q34 **Occupational Sitting and Physical Activity Questionnaire (OSPAQ)**

*

Q35 How many hours did you work in the last 7 days?

____

____

____

____

____

*

Q36 During the last 7 days, how many days were you at work?

____

____

____

____

____

Q37

We would like to ask you about your physical activity and sitting levels in the last 7 days.

Example:

Jane is an administrative officer. Her work day involves working on the computer at her desk, answering the phone, filing documents, photocopying, and some walking around the office. Jane would describe a typical work day in the last 7 days like this:

Sitting (including driving) 90 %
Standing 5 %
Walking 5 %
Heavy labour or physically demanding tasks 0 %
Total 100 %

How would you describe your typical work day in the last 7 days? (This involves only your work day, and does not include travel to and from work, or what you did in your leisure time - it must add up to 100% across all categories below)

	0 10 20 30 40 50 60 70 80 90 100
Sitting ()	
Standing ()	
Walking ()	
Heavy labour or physically demanding tasks ()	

Q64 At the moment, on average how many times do you stand up from your desk at work....

	Average number of times you stand up (3)
Per hour? (4)	
Per day? (5)	

Q27 **Work & Well-being Survey (UWES)** The following 17 statements are about how you feel at work. Please read each statement carefully and decide if you ever feel this way about your job. If you have never had this feeling, select the 'never' in the space after the statement. If you have had this feeling, indicate how often you feel it by selecting one of the other options to describe how frequently you have had this feeling.

	Never (1)	About Never (9)	Rarely (2)	Sometimes (6)	Often (3)	Very often (4)	Always (7)
At my work, I feel bursting with energy (1)	○	○	○	○	○	○	○
I find the work that I do full of meaning and purpose (153)	○	○	○	○	○	○	○
Time flies when I'm working (154)	○	○	○	○	○	○	○
At my job, I feel strong and vigorous (155)	○	○	○	○	○	○	○
I am enthusiastic about my job (156)	○	○	○	○	○	○	○
When I am working, I forget everything else around me (157)	○	○	○	○	○	○	○
My job inspires me (158)	○	○	○	○	○	○	○
When I get up in the morning, I feel like going to work (159)	○	○	○	○	○	○	○

I feel happy when I am working intensely (160)	○	○	○	○	○	○	○
I am proud on the work that I do (161)	○	○	○	○	○	○	○
I am immersed in my work (162)	○	○	○	○	○	○	○
I can continue working for very long periods at a time (163)	○	○	○	○	○	○	○
To me, my job is challenging (164)	○	○	○	○	○	○	○
I get carried away when I'm working (165)	○	○	○	○	○	○	○
At my job, I am very resilient, mentally (166)	○	○	○	○	○	○	○
It is difficult to detach myself from my job (167)	○	○	○	○	○	○	○
At my work I always persevere, even when things do not go well (168)	○	○	○	○	○	○	○

Q62

The World Health Organisation Health and Work Performance Questionnaire (absenteeism questions)

The following questions are about absenteeism at work. Now please think of your work experiences over the past 4 weeks (28 days). In the spaces provided below, write the number of days you spent in each of the following work situations.

In the past 4 weeks (28 days), how many days did you...

	Number of Days (1)	Total Number of Hours (5)
...miss an entire work day because of problems with your physical or mental health? (Please include only days missed for your own health, not someone else's health.) (1)		
...miss an entire work day for any other reason (including vacation)? (2)		
...miss part of a work day because of problems with your physical or mental health? (Please include only days missed for your own health, not someone else's health.) (3)		
...miss part of a work day for any other reason (including vacation)? (4)		
...come in early, go home late, or work on your day off? (5)		

Q63 About how many hours altogether did you work in the past 4 weeks (28 days)? (See examples below.)

Examples for Calculating Hours Worked in the Past 4 Weeks

40 hours per week for 4 weeks = 160 hours
35 hours per week for 4 weeks = 140 hours
40 hours per week for 4 weeks with 2 8-hour days missed = 144 hours
40 hours per week for 4 weeks with 3 4-hour partial days missed = 148 hours
35 hours per week for 4 weeks with 2 8-hour days missed and 3 4-hour partial days missed = 112 hours

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Q67 Standardised Nordic questionnaire for analysis of musculoskeletal symptoms

The following questions are related to body pain. Please read each statement carefully before answering the questions.

	Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:		Have you had trouble during the last 7 days:		During the last 12 months have you been prevented from carrying out normal activities (job, housework, hobbies) because of this trouble:	
	No (1)	Yes (2)	No (1)	Yes (2)	No (1)	Yes (2)
Neck (1)	○	○	○	○	○	○
Shoulders (2)	○	○	○	○	○	○
Elbows (3)	○	○	○	○	○	○
Wrists/hands (4)	○	○	○	○	○	○
Upper back (5)	○	○	○	○	○	○
Lower back (6)	○	○	○	○	○	○
One or both hips/thighs/buttocks (7)	○	○	○	○	○	○
One or both knees (8)	○	○	○	○	○	○
One or both ankles/feet (9)	○	○	○	○	○	○

Q53 If you have any further comments, please use this space:

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Appendix G: Participant information sheet

Participant Information Sheet

Name of department: School of Psychological Sciences and Health

Title of the study: Evaluation of the Welbot workplace wellness application

Introduction
My name is Bradley MacDonald and I am a PhD student in the school of psychological sciences and health at the University of Strathclyde. I would like to invite you to take part in a research study. Before you decide if you would like to participate it is important for you to understand why the research is being done and what it will involve for you. Please take time to read the following information carefully and if there is anything you are unsure about please contact me if you would like additional information.

Sedentary behaviour or sitting time is associated with an increased risk of chronic diseases such as cardiovascular disease and diabetes mellitus. Adults spend large amounts of their time sedentary. It has been established that office-based workers accumulate more than 70% of their daily sitting time at work. Welbot is a desktop application designed to deliver prompts and nudges to break up your sitting time and promote positive physical and mental wellbeing at work.

Purpose of this research?
We are looking to recruit male and female staff aged between 18 and 65 years, to take part in a study to explore the feasibility, acceptability and effect of the Welbot workplace wellness application on sedentary behaviour, physical activity and physical and mental wellbeing.

Do you have to take part?
Participation in this study is completely voluntary. The participant can withdraw themselves from the study at any point without any consequences. The participant does not have to state why they are withdrawing from the study.

What will you do in the project?

In order to understand your current behaviour before you start using Welbot, you will be asked to complete a series of questionnaires exploring your perceived physical and mental wellbeing and sedentary behaviour and physical activity. You will fill these questionnaires online and they can be completed at a convenient time and place. After the baseline questionnaire is competed you will receive an email with a link to download the welbot application. You will be given access to the Welbot desktop application to use over the next six months. After the first, third and sixth month of using Welbot, you will be asked to complete the same online questionnaire. You will be invited to take part in a focus group to discuss your views of using the welbot application. This is not mandatory and you can choose not to attend the focus group.

Why have you been invited to take part?
You are being asked to take part in this research because you are an office-based employee between 18 and 65 years.

What information is being collected in the project?
We will collect some basic demographic information in addition to perceived physical and mental wellbeing, sedentary behaviour and physical activity. Some participants will also be invited to participate in a semi structured interview to explore their perceived facilitators and barriers towards using the WelBot application.

Who will have access to the information?
The information collected will be anonymised and each person will be given a unique research number. The focus groups will be transcribed; these transcriptions will be anonymised. Hard copies of the anonymised transcriptions will be stored in a locked filing cabinet, and electronic copies of the anonymised transcriptions will be stored on a password protected University computer. All members of the research team will have access to this anonymised data. The findings of the study may be written up for publication in research journals, presentations at conferences. No individual participants will be identifiable in these publications.

Where will the information be stored and how long will it be kept for?
Data from this study will be stored (password protected) securely on the university server. Participants will be allocated a participant code and the data will remain anonymous at all times. The data will be stored for 3 years after the study is completed before the data is destroyed.

What happens next?
if you would like to participate, please complete the baseline survey which will be emailed to you shortly. In the survey, you will be asked to read and complete a consent form stating you are happy with the requirements of the study. If you are not willing to participate in this study, thank you for taking the time to read our information sheet.

Researcher contact details:
Bradley MacDonald
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Chief Investigator details:
Dr Alison Kirk, Dr Xanne Janssen and Dr Ann-Marie Gibson
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G1 1QE
Telephone: 0141 548 4153
Email: alison.kirk@strath.ac.uk

This investigation was granted ethical approval by the University of Strathclyde Ethics Committee.

If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Dr Diane Dixon
Convenor
School of Psychological Sciences and Health Ethics Committee
University of Strathclyde
Graham Hills Building
40 George Street
Glasgow
G1 1Q

Appendix H: Consent form

Consent form:

Name of department: School of Psychological Sciences and Health

Title of the study: Evaluation of a digital workplace health and wellbeing application.

Please tick the boxes to confirm your consent.

☐ I confirm that I have read the information sheet and understood the information about the study

☐ I have had a chance to discuss this study, ask questions and received satisfactory answers to all of my questions

☐ I confirm that I understand how the information I provide will be used and what will happen to it (i.e. how it will be stored and for how long)

☐ I understand that my participation is voluntary

☐ I understand that I am free to withdraw from the study, up to the point at which my data is anonymised, without having to give a reason and without consequences

☐ I understand that anonymised data (i.e. data that does not identify me personally) cannot be withdrawn once they have been included in the study

☐ I understand that any information recorded in the research will remain confidential and there will be no information that identifies me publicly

☐ I understand the above information and consent to my participation in the study

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Print name ______________________________
Company:_________________________________

Signature____

Please provide your email address so you can be contacted about starting the study. _____________________

Appendix I: Draft emails

Thanks for your interest in being a part of my PhD study, and using Welbot. Before you download Welbot I need you to fill in a baseline questionnaire so that I can track your behaviour over the next 6 months. Below is a link to the questionnaire. You will need a participant identification number (PIN) to fill in this questionnaire and all other questionnaires, so please keep this email or take note of your PIN.

https://hass.eu.qualtrics.com/jfe/form/SV_9N3aMm8FSgxgtQF

Once you complete the baseline questionnaire, please click the link and follow the instructions provided below.

Many thanks,

Brad

Instructions:

To join Welbot and install the software please click here
https://join.welbot.io/login/merkleinccom

Follow steps 1-3 and register your **merkleinc email address.** Choose the appropriate download and enter "Welbot installation" as justification in the CyberArk pop up.

Once installed, sign in and enter the product key which should have been emailed to you.

Any issues contact the DOIT team.

Hi ,
Thank you again for your interest in this study. We are now ready to start. I have provided a **link below** which will take you to an online Qualtrics survey (the first questionnaire you need to complete). This questionnaire needs to be filled out by you, prior to downloading the Welbot application. Please complete this questionnaire as soon as possible.

I have stated below your **participant identification number**; you will be asked for this number at the start of the Qualtrics survey. I will be in touch shortly after you have completed the Qualtrics survey with a link to download Welbot.

If you have any questions or concerns, please feel free to email me at any time.
Many thanks,
Brad MacDonald
Participant identification number:
Qualtrics survey link:

Appendix J: Focus group topic guide

Opening	Introduction. Thanks participants for coming along. Housekeeping- respect each other opinions and try not to speak over each other. For the tape- say how many participants are present and then each participant introduces themselves	
RE-AIM Framework		
Reach	What are the barriers and facilitators to enrolment and how can they be addressed in real time? What explains variation in reach, number of employees enrolled and the decline rate across studies retrospectively. What are the barriers to participating for employees? What are employees reasons for not participating?	Why did you sign up for the study? Did anyone stop using the welbot app altogether? Why did you stop?
Effectiveness	What are the conditions and mechanisms that lead to effectiveness? What explains variation in outcome measures across sites?	What was the most useful part of welbot for you? What was the least useful part of welbot What would have made the least useful part more effective for you? How did using the program effect your motivation? Did it change in any way as you used it? Why do you think it changed? Did your use the product consistently or did it fluctuate? Why did this change do you think? Do you think you were prompted enough by welbot? To frequently? Where there times/jobs or tasks where you were more or less likely to engage with welbot?
Adoption	More for other stakeholders	Do you feel the company is interested in workplace health?
Implementation	What were the modifications and why did they occur	Were there any issues getting started using welbot?

	What were the barriers to fidelity What are the contextual factors and processes underlying barriers to implementation and how do we address them?	How could the implementations been better for you?
Maintenance	In what form are the components of the intervention sustained? What are the modifications made at each site? What are the barriers to maintaining the program?	Do you think that you could use the product long term? Why or why not? What are the barriers to maintaining the program? What changes would you make to make the product better for long-term use?

Appendix K: Median differences for all outcomes between baseline and 1 month, 3 month and 6 month follow up.

n=valid data m=median change *=significant change q=quartiles		Sitting %	Standing %	Walking %	Heavy labour %	Trans per hour	Trans per day	Hours missed for health	Total Engagement	Pain Score
	Baseline	N=75 M=80.00 IQR=70.00, 90.00	N=75 M=5.00 IQR=5.00, 15.00	N=75 M=10.00 IQR=5.00, 15.00	N=75 M=0 IQR=0,0	N=80 M=1.750 IQR=1.00, 2.00	N=80 M=10 IQR=7.00,15.00	N=80 M=0 Mean=1.469hrs IQR=0, 1.00	N=80 M=3.6973 IQR=3.5329,4.4559	N=80 M=2.00 IQR=0,3.000
Total group	**1 month**	N=42 M%=81.50 IQR=70.00, 90.00	**N=42 M=10.00* IQR=5.00, 10.00**	N=42 M%=9.00 IQR=5.00, 10.00	N=42 M%=0 IQR=0, 1	N=42 M=2.00 IQR=1.00, 3.00	N=42 M=10.00 IQR=7.75, 15.25	N=40 M=0 IQR=0, 0	**N=40 M=3.8235* IQR=3.1912, 4.3382**	N=40 M=2.00 IQR=0, 3.00
	3 month	N=29 M%=80.00 IQR=73, 90	N=29 M%=7.00 IQR=5.00, 10.00	N=29 M%= 10.00 IQR=5.00, 11.00	N=29 M%=0 IQR=0, 1	N=30 M=2.00 IQR=1.00, 3.00	N=30 M=10.00 IQR=6.50, 20.00	N=30 M=0 IQR=0,0	N=29 M=3.8235 IQR=3.4706, 4.4706	N=29 M=2.00 IQR=0.50, 4.00
	6 month	N=22 M%=81.00 IQR=71.50, 90.00	N=22 M%=5.50 IQR=5.00, 10.00	N=22 M%=10.00 IQR=5.00, 15.50	N=22 M%=0 IQR=0, 0	N=24 M=1.50 IQR=1.00, 2.00	N=24 M=9.00 IQR=6.25, 14.75	N=24 M=0 IQR=0, 5.25	N=24 M=3.8235 IQR=3.4265, 4.3088	N=24 M=2.00 IQR=0.25, 3.00
Company 1	**1 month**	N=10 M=90.00 IQR=69.75, 90.00	N=10 M=5.00 IQR=5.00, 10.00	N=10 M=5.00 IQR=5.00,10.00	N=10 M=0 IQR=0, 4.25	n=10 m=1.5 q= 1.000,2.250	n= 10 m=8.00 q=5.00, 18.75	N=10 M=0 IQR=0, 0	n=10 **m=4.0882*** IQR=3.0588, 4.6324	n=10 m=2.5000 IQR=0.0000, 3.0000
	3 month	N=9 M=90.00 IQR=65.00,90.00	N=9 M=5.00 IQR=4.00,12.50	N=9 M=5.00 IQR=5.00, 15.00	N=9 M=0 IQR=0, 5.00	n=10 m=1.000 q=1.000, 2.500	n=10 m=7.00 q=5.00, 12.50	N=10 M=0 IQR= 0, 0	n=10 m=4.3235 IQR=3.6912,4.8824	n=10 m=2.000 IQR=0.000, 5.0000
	6 month	N=6 M=87.50 IQR=70.00, 90.25	N=6 M=7.50 IQR=5.00,10.00	N=6 M=7.50 IQR=3.75, 20.00	N=6 M=0 IQR=0, 2.50	n=8 m=1.500 q= 1.000, 2.750	n=8 m=8.50 q=5.00, 14.75	N=8 M=0 IQR= 0, 0	n=8 m= 3.6765 IQR=3.4118, 5.1029	n=8 m=2.000 iqr=.2500, 4.5000
Company 2	**1 month**	N=9 M=83.00 IQR=62.00, 87.50	N=9 M=10.00 IQR=8.50,24.50	N=9 M=9.00 IQR=5.00,10.00	N=9 M=0 IQR=0, 2.50	n=9 m=2.000 IQR=2.000, 3.000	n=9 m=15.00 IQR=12.00, 17.50	N=8 M=0 IQR=0, 0	N=8 m=3.8529 IQR=2.9853, 4.0735	N=8 M=2.000 IQR=1.0000, 2.7500

	3 month	N=7 M=80.00 IQR=70.00,80.00	N=7 M=10.00 IQR=10.00, 10.00	N=7 M=10.00 IQR=10.00, 20.00	N=7 M=0 IQR=0, 1.00	n=7 m=3.000 IQR=2.000, 4.000	n=7 m=17.00 IQR=14.00, 25.00	N=7 M=0 IQR=0, 9	N=7 M=3.8235 IQR=3.6471, 4.2353	N=7 M=2.000 IQR=0, 3.0000
	6 month	N=6 M=73.50 IQR=70.00,82.50	N=6 M=10.00 IQR=5.75, 20.00	N=6 M=10.00 IQR=5.00,17.50	N=6 M=0 IQR=0, 1.00	n=6 m=2.000 IQR=.875, 4.250	n=6 m=9,00 IQR=6.75, 17.00	N=6 M=3.50 IQR=0, 17.50	N=6 M=4.0294 IQR=3.8235, 4.2206	N=6 M=0.5000 IQR=0, 2.2500
Company 3	**1 month**	N=20 M=80.00 IQR=75.00,90.00	N=20 M=9.50 IQR=5.00,10.00	N=20 M=8.50 IQR=5.00,10.00	N=20 M=0 IQR=0, 0	N=20 M=2.00* IQR=1.00, 2.00	N=20 M=10.00 IQR=7.25, 15.00	N=19 M=0 IQR=0, 0	N=19 M=3.7059 IQR=3.1765, 4.0588	N=19 M=1.00 IQR=0, 3.00
	3 month	N=12 M=82.00 IQR=76.25,90.00	N=12 M=6.00 IQR=3.50, 10.00	N=12 M=10.00 IQR=5, 11.50	N=12 M=0 IQR=0, 1.00	**N=12** **M=2.00** **IQR=1.00, 2.75**	N=12 M=11.00 IQR=5.50,18.75	N=12 M=0 IQR=0, 0	N=11 M=3.4706 IQR=3.1765, 4.1765	N=11 M=3.00 IQR=1.00, 3.00
	6 month	N=9 M=85.00 IQR=80.00, 90.50	N=9 M=5.00 IQR=4.50,7.50	N=9 M=8.00 IQR=5.00, 12.00	N=9 M=0 IQR=0, 0	N=9 M=1.00 IQR=1.00, 2.00	N=9 M=10.00 IQR=7.50, 15.00	N=9 M=0 IQR=0, 11.50	N=9 M=3.6471 IQR=3.1765, 3.9706	N=9 M=2.00 IQR=1.00, 3.50