Stress and work performance responses to a multicomponent intervention for reducing and breaking up sitting in office workers: a cluster randomised controlled trial

Abstract

Objective: To explore the potential of a sitting reduction workplace intervention for improving stress and work-performance. *Methods:* A cluster randomised controlled trial evaluated an intervention to reduce and break up occupational sitting in 12 clusters (n=89 office workers) over eight weeks. Outcomes were physiological stress (cortisol concentrations), perceived stress and work-performance. *Results:* Linear mixed model group x time interaction effects were non-significant. Exploratory analyses showed a trend, with a large effect, for lower cortisol concentrations over the day in the intervention group relative to controls at 8 weeks (-0.85; 95% CI -1.70, 0.03 nmol.L^{-1}; p=0.06; d=0.79). The intervention group had higher vigour and cognitive liveliness at eight weeks relative to controls (p≤0.05). *Conclusions:* This exploratory study suggests there could be meaningful changes in physiological stress and work-related outcomes that should be investigated in future studies.

Keywords: sedentary behaviour; cortisol; stress; workplace; physical activity; behaviour change; RCT

Learning outcomes:

- Critically evaluate the effects of a sitting reduction intervention on perceived and physiological stress in office workers.
- Discuss the feasibility of collecting cortisol samples in an occupational setting.
- Identify one key strength and limitation regarding the delivery or evaluation of the intervention in this study.

Introduction

Office workers spend approximately 80% of their working hours sitting, making them one of the most sedentary populations [1, 2]. Epidemiological evidence shows that high amounts of sedentary behaviour are associated with an increased risk of non-communicable diseases including Type 2 diabetes, cardiovascular disease and some cancers [3-5]. Occupational sedentary behaviour has also been adversely associated with mental health, stress, musculoskeletal problems and measures of work performance [6-8]. In addition to higher daily sedentary time, accumulating sitting in prolonged uninterrupted bouts may be associated with increased musculoskeletal symptoms, higher depression and reduced quality of life [9, 10]. Reducing and breaking up workplace sitting can thus be considered a primary intervention target for improving occupational health and worker productivity.

There are a growing number of studies demonstrating the effectiveness of interventions for reducing and breaking up workplace sitting [11]. Multicomponent interventions that incorporate individual (e.g. self-monitoring of sitting), organisational (e.g. step competitions and educational workshops) and environmental level strategies (e.g. height-adjustable workstations) appear to be the most effective [12]. The multicomponent intervention presented in the present paper led to significant reductions in workplace prolonged sitting (by 39 min/shift), increases in sit-upright transitions (by 8 per shift), and increased stepping time (by 12 min/shift) after 8 weeks [13]. Notably, these changes occurred without the use of height-adjustable workstations as part of the intervention, instead incorporating participant-led changes such as removal or relocation of personal bins and printers, and identifying meeting areas for non-computer-based work to encourage movement away from the desk. There is growing evidence that workplace interventions targeting reductions in sitting can improve musculoskeletal symptoms, wellbeing and work-related outcomes (e.g. job performance, work engagement and occupational fatigue) [14-17], although there is conflicting evidence [18]. Work-related stress is a particularly important target for occupational health interventions due to stress accounting for 35% of all work-related ill-health cases in the UK, leading to low productivity and poor organisational performance [19, 20]. When exposed to a physical or mental stress, stimulation of the hypothalamic pituitary adrenal (HPA) axis is a primary physiological response. The end-point of this axis is the synthesis and release of the primary glucocorticoid, cortisol [21]. This hormone holds important roles in a number of physiological systems; for example, an elevation of cortisol leads to an immune suppression via anti-inflammatory actions [22]. Excess cortisol levels are associated with an increased risk of cardiovascular disease due to interactions with mineralocorticoid receptors in the vascular [23] and can also increase triglyceride accumulation and appetite, leading to central obesity [24, 25].

Regular moderate physical activity may repeatedly activate the HPA axis leading to a chronic adaptation that reflects a reduced HPA axis response and improved stress recovery [26, 27]. Indeed, higher levels of physical activity and lower volumes of sedentary time were beneficially associated with the diurnal rhythm of cortisol [28]. Given that high stress reactivity and repeated HPA axis activation have been linked with poor health outcomes [29], investigating the effects of sedentary workplace interventions is warranted. Yet, there has been limited research evaluating the effects of sedentary behaviour interventions on markers of physiological stress (i.e. cortisol) and perceived stress in office workers. Interspersing sitting with standing and walking significantly reduced cortisol levels over a single day in a simulated work environment [30]. Sedentary behaviour interventions delivered in workplaces have also led to reductions in perceived stress [16]. With regards to physiological stress, a treadmill desk intervention that significantly increased walking time (but no change in sitting) had no effect on diurnal or cortisol slope over 13 months [18]. In contrast, a height-adjustable workstation intervention that reduced weekly sitting time led to significant within-group unfavourable increases in cortisol after 23 weeks [31]. These intervention studies are limited by not including measurement of the cortisol awakening response (CAR), which represents the alteration in cortisol secretion in the first hour after awakening. Cortisol concentrations sharply increase by 50 to 156% in healthy adults upon awakening as the individual rapidly becomes conscious [32, 33]. There is also limited consideration of the normal diurnal pattern of cortisol in previous literature. A healthy diurnal pattern of cortisol is a steady decline during the few hours after the CAR and then a slower progressive decrease to its nadir at around bedtime [34, 35]. It is imperative that these physiological stress outcomes are evaluated in sedentary workplace interventions as they are associated with cardiovascular disease, diabetes and chronic work-related stress [36, 37].

The primary aim of this study was to explore the effects, at a cluster level, of a sitting reduction workplace intervention on perceived and physiological stress. Secondary objectives were to explore the effects on work-related outcomes and quality of life. The feasibility of collecting physiological stress data in the context of CAR and diurnal pattern of cortisol was evaluated given the novelty of collecting this data in an office workplace setting.

Methods

Study design

This was a cluster randomised controlled trial (RCT) and is reported in line with the CONSORT statement for cluster RCTs. Sitting, standing, stepping and cardiometabolic risk outcomes for this study have been reported previously [13]. Randomisation occurred at the worksite division level following completion of baseline measures. The research team and participants were blinded to group allocation until baseline measures were completed. Other than the members leading coordination of the intervention delivery, all other members remained blinded to participants' group allocations throughout the study. All data was collected in private rooms at the participating worksite after participants had provided written informed consent. The University of Bedfordshire Institute for Sport and Physical Activity Research Ethics Committee granted ethical approval for the study (approval number 2016ISPAR011).

Study setting and participants

Participants were recruited from offices of a national construction, services and property group organisation in Bedfordshire, UK. Approximately 600 staff worked in two buildings at this site. The research team worked with the worksite's Health & Wellbeing Specialist to recruit the organisation. This Specialist supported the team in coordinating the data collection and intervention procedures throughout the study. Participants were recruited by an all-staff email and the research team promoting the study in a communal area including distribution of flyers and conversations with employees. Potential participants expressed their interest using an online webform or adding their name to a sign-up sheet and were then screened by the research team over the phone. Staff were eligible to take part in the study if they were aged 18-70 years, self-reported sitting for ≥75% of their work day, worked at the same desk for ≥3 days each week with designated phone and internet access, and were able to stand and walk unassisted. Exclusion criteria were unable to communicate in English, worked night shifts, were pregnant, or had a planned absence for >2 weeks during the study. A £5 shopping gift voucher was provided to each participant at each measurement time point to incentivise participation and engagement with data collection procedures.

Cluster randomisation

Cluster randomisation occurred at the worksite division level in order to minimise contamination between study groups. Consent was given from managers for their division to be involved in the study prior to randomisation. Employees in each division worked in a separate office space to other divisions. Participants were asked not to disclose their group assignment during the study to further minimise contamination. Following baseline measures, clusters were randomised 1:1 to the control or intervention group by a member of the research team. All participants and researchers remained blinded until group allocation. An online tool (www.randomization.com) was used to generate a single block randomisation plan for the 12 clusters, which were then randomly matched to the plan using a list randomiser (www.random.org).

Sample size

The sample size was based on a change in workplace sitting time (the overall trial's primary outcome) and not on the outcomes presented in this study [13]. Therefore, the results of this study are exploratory and should be considered so when interpreting the findings.

Beat the Seat intervention

The Beat the Seat intervention has been described in detail previously and results demonstrated significant beneficial effects of the intervention on prolonged sitting, sit-upright transitions, and stepping time during working hours after 8 weeks [13]. It is a multicomponent intervention comprising of individual, organisation and environmental-level strategies. The individual-level strategies included (a) a health check report, (b) written information on the risks of prolonged sitting and guidance on setting step goals, (c) sticky notes and prompt cards to place in their workspace to encourage reducing and breaking up sitting, (d) computer software and/or a phone app to deliver prompts to support breaking up sitting, (e) prompt posters displayed around the workplace, and (f) weekly one-to-one health coach support over the phone that were based on motivational interviewing and focused on supporting reducing and breaking up sitting. The organisational-level strategies included (a) an educational presentation and brainstorming workshop focused on the health risks of excessive sitting, the benefits of reducing and breaking up sitting, and the development of strategies to support behaviour change in the workplace, and (b) a step challenge in which each participant was provided with a pedometer and entered their daily steps onto a virtual leaderboard; weekly spot prizes were provided. The environmental-level strategies included participants being asked to make changes to their workspace based on the ideas generated in the brainstorming session e.g. identifying workspaces where non-computer standing work could be conducted and removal/relocation of personal printers and bins.

Demographic and anthropometric measures

At baseline, age, sex, marital status, ethnicity, smoking status and education level data were collected using a questionnaire. Height and weight were measured using a portable stadiometer (Leicester Height Measure; Seca, Birmingham, UK) and Tanita BC-418 device (Tanita Corporation, Tokyo, Japan), respectively.

Outcome measures

The following outcome measures were collected at baseline and 8 weeks after randomisation.

Work-related outcomes, perceived stress and quality of life

Job performance and job satisfaction were measured using single-item 7-point Likert scales [38, 39]. The Utrecht Work Engagement Scale shortened version nine-item 7-point Likert scale [40] was used to measure work engagement. Work engagement can be defined as a positive, fulfilling work-related state of mind characterised by high levels of energy while working (vigour), feeling that their work is significant and challenging, and being deeply engrossed in their work (absorption) [40]. The 8-item Work Limitations Questionnaire [41] was used to measure sickness presenteeism. The extent to which participants intentionally changed their work priorities and objectives to accommodate a change in sitting behaviour was assessed using a 6-point anchored scale ('Never', 'Rarely', 'Sometimes', 'Often', 'Most of the time', 'Always') for the following three questions: (1) "To what extent have you intentionally changed your work tasks and objectives to accommodate a change in sitting behaviour (i.e. designated certain tasks for sitting and certain tasks for standing)?", (2) "How aware are you of organisational and environmental changes to support breaking up your sitting time (i.e. new policies, central waste bins/printers)"?, and (3) "To what extent do you accept the organisational and environmental changes that support breaking up your sitting time?". Quality of life was measured using the WHO-QOL-BREF questionnaire [42]. Perceived stress was measured using the Cohen Perceived Stress 10-point Likert scale [43]. Feelings of physical strength, emotional energy and optimal cognitive functioning characterised by vigour were measured using the 12-item Likert scale Shirom-Melamed Vigor Measure [44].

Physiological stress

Salivary cortisol concentrations were used as a measure of physiological stress. Saliva samples were collected using Salivette® collection vials (Sarstedt, Numbrecht, Germany). Participants self-collected saliva samples over a single work day at the following time points: immediately after waking in the morning, 15 min after waking, 30 min after waking, and four more samples at 3 h intervals timed from the point of awakening i.e. 3, 6, 9 and 12 h [45]. This allows for the measurement of CAR, which describes the rapid increase in cortisol levels following morning awakening [34], and the diurnal decline in cortisol [33]. Participants were asked to set a reminder to notify them when to provide their samples, record the time each sample was taken and to store samples immediately or as soon as possible in a refrigerator.

They were instructed to remain nil-by-mouth for 30 min prior to each sample (except water), no water was consumed 10 min prior to each sample and to refrain from brushing teeth until after the final post-awakening period sample (i.e. 30 min after awakening). Participants were asked to consume 500 mL of water immediately after the first saliva sample was taken to help to ensure a state of euhydration for subsequent samples. During the sample collection period, participants were asked not to consume caffeine. The research team collected samples from participants at their worksite. The samples were refrigerated and stored at -80ºC within a maximum of 24 hours after sample collection in preparation for batch analysis. Salivary cortisol concentrations were determined using commercially available Enzyme Linked Immunosorbent Assay kits (Salimetrics, PA 16,803, USA). Samples from each participant were analysed on the same plate and went through one freeze thaw cycle only. The mean inter-assay CVs were 13.9% for cortisol. The mean intra-assay CV was 9.6% for cortisol.

The cortisol outcomes that were analysed included absolute cortisol concentrations upon awakening, area under the curve with respect to ground CAR (cortisol concentrations at awakening and 15 and 30-min post-awakening [AUCg CAR]), cortisol concentrations over the course of the day, and cortisol diurnal slope (difference between peak cortisol and the end of day cortisol concentration). Area under the curve was calculated using the trapezoidal rule.

Data analysis

Feasibility of collecting physiological stress data in the context of CAR and diurnal pattern of cortisol was analysed in terms of data completion rates for cortisol outcomes. This was calculated as the number of complete datasets for cortisol/number of participants randomised × 100). Statistical analysis was completed using SPSS® v28.0 (SPSS Inc., Armonk, New York). Normality of the data was assessed using Q-Q plots and deemed plausible for each outcome. Linear mixed models were used to compare outcomes between groups. Study group and time (baseline and end of intervention) were entered as fixed factors for questionnaire and cortisol outcomes. Sample time point was added as an additional fixed factor for analysis of cortisol concentrations over the course of the day. Cluster and participant ID were entered as random effects and baseline values for each outcome were included as a covariate (fixed factor) in each model. Post-hoc analysis with Sidak correction was conducted for all outcome variables, which included outcomes where the main or interaction effects were non-significant. This approach was used to identify any potentially meaningful effects of the intervention on the secondary outcomes for which the study was not powered to detect. This exploratory analysis will help inform the relevance of conducting a definitive RCT to the evaluate the effectiveness of a sitting reduction workplace intervention powered to detect changes in physiological and perceived stress (primary outcomes in this study). All outcomes were analysed on a complete case basis. Data are presented as mean (95% confidence interval [CI]) unless otherwise stated. The level of significance was set as $p \leq 0.05$ (two-tailed). Magnitudes of difference in change from baseline to follow-up between groups were interpreted using Cohen's d effect sizes with < 0.2, 0.2 to 0.49, 0.5 to 0.79 and ≥ 0.8 indicating trivial, small, medium, and large effects, respectively [46].

Results

Participant recruitment took place between November 2016 and January 2017 with baseline measures between January – February 2017. Follow-up measures took place 8 weeks after randomisation, in March 2017. The participants took part in the study for 8 weeks from the intervention start date. The flow of participants throughout the study is shown in Figure 1. There were six clusters randomised to each of the control and intervention groups with an average cluster size of 7.4 (range 2-14). A total of 89 participants were fully assessed at baseline with n=48 and n=41 randomised to the intervention and control groups, respectively. All of the clusters took part in the follow-up measures. In the intervention and control groups, 90% and 85% of participants took part in follow-up measures, respectively. Using a complete case basis approach meant that all clusters (92% of intervention participants [n=44] and 83% of control participants [n=34]) were included in the analysis of questionnaire outcomes (work engagement, quality of life, perceived stress and vigour). For cortisol outcomes, all clusters were analysed, but there was low feasibility for collecting this data with 65% of intervention participants (n=31) and 56% of control participants (n=23) providing complete data for inclusion in the analysis. The descriptive characteristics of the participants can be seen in Table 1.

Physiological stress

Physiological stress outcomes can be seen in Table 2. The interaction effects and pairwise comparisons for cortisol concentration upon awakening and cortisol diurnal slope were not significant. The group x time interaction for AUCg CAR was not significant (p=0.29). Post-hoc analysis suggested a reduction in AUCg CAR in the intervention group from baseline to 8 weeks (p=0.03; d=0.90). For average cortisol concentrations over the day, there was a trend for a group x time interaction effect (p=0.09) with post-hoc analysis demonstrating a reduction from baseline to 8 weeks in the intervention group (mean difference -1.6 [95% CI: -2.3, -0.8] $nmol.L^{-1}$, p<0.01; d=1.45; see Figure 2). There was also a trend (p=0.06) for lower cortisol concentrations over the day in the intervention group relative to controls at 8 weeks (d=0.79; Table 3). The group x time x sample time point interaction was non-significant (p=0.51). Post-hoc analyses demonstrated a lower cortisol concentration 30 min after awakening in the intervention group relative to controls at 8 weeks (-3.0 [-5.2, -0.9] $nmol.L^{-1}$, p=0.01; d=1.00). Cortisol concentrations at 30 min after awakening (-3.8 [-5.8, -1.9] $nmol.L^{-1}$, p<0.01; d=1.39) and at 3 h (-2.3 [-4.3, -0.3] $nmol.L^{-1}$, p=0.02; d=0.85) also decreased in the intervention group from baseline to 8 weeks (data not shown). These comparisons all had large effect sizes.

Work-related outcomes, perceived stress and quality of life

Work-related, perceived stress and quality of life outcomes are shown in Table 3. There was a significant group x time interaction for the changing work priorities outcomes with the intervention group reporting increased intentional changes to work tasks to accommodate changes in sitting (p<0.01 for interaction) and increased awareness of organisational and environmental changes to support breaking up sitting (p=0.01 for interaction). The interaction for acceptance of organisational and environmental changes that support breaking up sitting was not significant (p=0.67). Despite the group x time interaction effect not being significant (p>0.05), post-hoc analysis suggested that the intervention group had higher vigour (p<0.01; d=0.62) and cognitive liveliness (p=0.05; d=0.42) at 8 weeks relative to controls, with medium effect sizes. There were also improved work limitations at 8 weeks in the intervention compared with controls. Specifically, mental-interpersonal demands were lower at 8 weeks in the intervention group compared with the control group (d=0.75). There were no significant group x time interaction or post-hoc differences in quality of life.

Discussion

This study explored the potential of a sitting reduction workplace intervention to improve stress, work-performance and quality of life. The main findings indicated that there were no significant changes in physiological or perceived stress during the intervention. Despite this, there was a trend for a reduced CAR and cortisol concentrations over the day in response to the intervention, which may indicate potential of the intervention to improve these outcomes.

Cortisol concentration upon awakening (AUCg CAR) and cortisol diurnal slope were not significantly affected by the intervention. Cortisol is considered to be a reliable and objective measure of subjective stress and has been shown to positively correlate with perceived stress in an occupational environment [47]. In the current study there was no effect of the intervention on the perception of stress. These findings are in line with Bergman et al [18] where neither cortisol diurnal slope or self-reported stress altered in response to a 13-month treadmill workstation intervention (18 min/day increase in daily walking time) in overweight or obese workers. However, similar to the present study, the study by Bergman et al [18] was not powered for these outcomes. With regards to cortisol concentration upon awakening, the trend for significance combined with a large effect size suggests that this may have been lowered in the intervention group from baseline to eight weeks. Similarly, cortisol concentrations over the course of the day may have been meaningfully lower in the intervention group than the control group at eight weeks. These data suggest that the intervention may have potential for positively affecting cortisol awakening response and reducing stress reactivity over the course of a day. A reduced cortisol reactivity has been reported to enhance productivity in a work setting [48]. In addition, elevated cortisol concentrations have been associated with increased life and work stress [49, 50]. Therefore, a lowering of cortisol over the course of a day may indicate a reduction in work/life stress. This warrants further investigation of interventions to reduce sitting and increase physical activity at work in fully powered studies to appropriately inform their use in health promotion strategies.

It is possible that a larger sample size powered to detect changes in cortisol, in addition to improved data collection rates for this measure, may have led to changes in cortisol parameters that reached statistical significance. The feasibility of collecting samples to measure cortisol may be compromised due to multiple samples being needed across the day, which may impose too much of a burden on participants. Although the research team attended the worksite to collect samples, participants needed to provide and store their saliva samples in a refrigerated environment until they were able to visit the research team. This may have not been possible with respect to competing work priorities. Future studies should consider methods for improving adherence to collecting cortisol samples. This could, for example, include alerts being sent to participants via their smartphone or computer reminding them to take their samples and pass them to the research team.

There was an increased awareness of organisational and environmental changes to support breaking up sitting in the intervention group. This may have reflected changes to the office layout and working spaces that participants identified during the brainstorming session (e.g. relocation of personal printers and identification of workspaces away from the desk), in addition to point of decision prompts being displayed to encourage less sitting and more steps. The intervention participants also reported intentionally changing their work priorities (i.e. designating certain tasks for sitting and certain tasks for standing) to accommodate changes in sitting. Importantly, these changes in work priorities did not appear to negatively affect self-reported work performance and stress-related outcomes. Instead, the findings indicated that the intervention could improve work engagement (perceived vigour), cognitive liveliness and work limitations (mental-interpersonal demands). Previous multicomponent interventions over that have shown that reduced total and prolonged occupational sitting can lead to longer-term improvements (after 12 months) in work engagement and work limitations [14, 15]. These findings may encourage employers to adopt interventions and policies to support reducing and breaking up occupational sitting.

In this short-term intervention, reductions in prolonged sitting and increased steps did not lead to changes in quality of life. In contrast, favourable changes were seen at 12-months following the Stand More AT (SMArT) Work intervention [14]. The SMArT Work intervention led to greater reductions in occupational sitting than the present study (-83 min/day vs. -15 min/day, respectively), although stepping remained unchanged. Longer-term, sustained reductions in occupational sitting may, therefore, be needed to improve quality of life. That said, quality of life at 12 months was not different following two other interventions (SMART Work and Life [17] and Stand Up Victoria [15]) that reduced workplace sitting by 64 min/day and 45 min/day, respectively. The reasons for inconsistency in the literature are unclear, especially as the SMArT Work and SMART Work and Life interventions were very similar in nature [14, 17]. The use of different measurement tools could offer some explanation as this could lead to different aspects of health being assessed that could be differentially affected by such interventions. Due to the limited number of studies evaluating the effects of sedentary workplace interventions on quality of life, further research using standardised measurement techniques is recommended.

The strengths of this study include employing a cluster randomised controlled trial. This addresses limitations of previous research in this area in which randomisation was at an individual level, therefore increasing risk of contamination across study groups [18]. The objective measure of stress (i.e. cortisol) is a further strength to appropriately inform the feasibility of collection this measure and the potential effect of an intervention on this outcome. The study also evaluated a sitting reduction workplace intervention that did not include the use of a height-adjustable workstation. This may be important in the decision making of employers who endeavour to reduce stress and improve work performance without the need to invest in such equipment. The study is limited by it not being powered to detect changes in the outcomes reported in this paper. A larger sample size could have resulted in significant condition x time interactions that would provide greater confidence in the significant post-hoc changes found for cortisol and work-related outcomes. Yet, moderate to large effect sizes suggest that the intervention led to potentially meaningful changes.

In conclusion, this exploratory study suggests that it may not be feasible to collect an objective measure of cortisol to evaluate the effects of a sitting reduction intervention on physiological stress in a workplace setting. Although there were limited statistically significant effects of the intervention on stress and work performance, there were statistical trends and meaningful effect size data to suggest that the intervention may have potential for reducing physiological stress and improving work-related outcomes. These findings warrant investigation in future RCT’s that are powered to detect statistically significant changes in these outcomes and implement strategies to address issues regarding the feasibility of collecting physiological stress data.

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Figure captions

Figure 1 Participant flow throughout the study.

Figure 2 Cortisol concentration over the day for intervention group at baseline and post-intervention. $P<0.01$ for difference between time points.