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An e-health intervention designed to increase workday energy expenditure by reducing prolonged occupational sitting habits

Scott J. Pedersen*, Paul D. Cooley and Casey Mainsbridge
University of Tasmania, Newnham Campus, Launceston, Australia

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Abstract.
BACKGROUND: Desk-based employees face multiple workplace health hazards such as insufficient physical activity and prolonged sitting.
OBJECTIVE: The objective of this study was to increase workday energy expenditure by interrupting prolonged occupational sitting time and introducing short-bursts of physical activity to employees' daily work habits.
METHODS: Over a 13-week period participants ($n = 17$) in the intervention group were regularly exposed to a passive prompt delivered through their desktop computer that required them to stand up and engage in a short-burst of physical activity, while the control group ($n = 17$) was not exposed to this intervention. Instead, the control group continued with their normal work routine. All participants completed a pre- and post- intervention survey to estimate workplace daily energy expenditure (calories).
RESULTS: There was a significant 2 (Group) $\times$ 2 (Test) interaction, F (1, 32) = 9.26, $p < 0.05$. The intervention group increased the calories expended during the workday from pre-test ($M = 866.29 \pm 151.40$) to post-test ($M = 1054.10 \pm 393.24$), whereas the control group decreased calories expended during the workday from pre-test ($M = 982.55 \pm 315.66$) to post-test ($M = 892.21 \pm 255.36$).
CONCLUSIONS: An e-health intervention using a passive prompt was an effective mechanism for increasing employee work-related energy expenditure. Engaging employees in regular short-bursts of physical activity during the workday resulted in reduced sitting time, which may have long-term effects on the improvement of employee health.

Keywords: Workplace health and wellbeing, sedentary behavior, employee health, physical activity, prompts

1. Introduction

Current research indicates that desk-based workers may face multiple workplace health hazards such as insufficient physical activity and prolonged sitting times [1]. These two cardiovascular disease (CVD) risk factors are independent of each other [2,3], yet they both contribute to a range of adverse health conditions such as type II diabetes, increased waist girth, high blood cholesterol, hypertension, and a range of musculoskeletal conditions [2,4–6]. Given that 21st century desk-based employees sit for most of their working day and are largely sedentary during working hours [7], there is a need for employers to provide preventative workplace health and wellbeing intervention (WHWI) options that address these risk factors. While many popular WHWIs address employee sedentariness by promoting voluntary exercise, there is a dearth of WHWIs that address the risk factor of prolonged sitting [8]. Thus, the aim of the current study was to prompt desk-based employees to stand and engage in short-bursts of physical activity using an e-health WHWI, thereby reducing their prolonged sitting.

Current WHWIs (e.g., pedometer-based challenges) based on theories of intentional behavior (i.e., the-

*Corresponding author: Scott J. Pedersen, University of Tasmania, Newnham Campus, Locked Bag 1330, Launceston, TAS 7250, Australia. Tel.: +61 3 6324 3554; Fax: +61 3 6324 3679; E-mail: Scott.Pedersen@utas.edu.au.

ory of planned behavior [9]) have limitations. For example, most WHWIs designed to improve employee health are predicated on dose-response recommendations (e.g., 30 minutes of physical activity each day). This strategy has typically resulted in low long-term adherence rates [10]. In contrast to voluntary participation in workplace physical activity (i.e., jogging during a lunch break); prolonged occupational sitting, although part of the job, should be considered a habit. Therefore, a different theoretical perspective may be needed to address this variable. Individuals who work in desk-based occupations normally sit for prolonged periods (> four hours [7]) to perform their typical workday activities. Sitting becomes habitual. Habits are behaviors that are performed repetitively and mostly without conscious thought [11,12]. However, habits are not only formed through attitudes and experiences, they are also influenced by environmental cues (i.e., office workspace arrangements) [13]. The habit of sitting at work can largely be attributed to both the physical and social office environments. This relates to subjective norms, or how the perceptions of significant others affect an individual's choice to participate in a behavior. This is an important factor that may influence an individual's decision to engage in a WHWI. Taken into account that office employees are expected to sit during the workday to accommodate desks locked at waist height, computer screens that are positioned such that standing and typing is not an option, and email that encourages sedentary intra-office communication; traditional psycho-social based WHWIs may be inadequate in changing workplace health habits.

Aarts and Dijksterhuis [11] proposed that to change health habits, individuals need to be prompted to re-engage in a conscious decision about performing or interrupting an existing habit. Furthermore, if this prompting is linked to new information that increases their awareness of the adverse effects of an existing habit, the probability of adopting a new behavior may increase. Nonetheless, research outcomes regarding the effects of WHWIs are mixed. For example, Taylor and colleagues [14] reported that when employees were cued through a speakerphone announcement to participate in a group exercise program there was a 97.5% adherence rate during a six-month study. Unfortunately, the researchers provided no follow up data. Whereas, Cooley, Foley, and Magnussen [15] showed that using a prompt in the workplace (e.g., signs posted encouraging stair use) was ineffective in changing employee behavior. One possible reason for the mixed results is the typical approach used in delivering the prompting mechanism is more active than passive [16]. In an active-based intervention approach, there is more individual freedom to engage in the alternative behavior. That is, individuals when confronted by the prompt (i.e., a sign) in previous studies could have chosen to simply ignore the prompt, or may have missed the prompt because they were focusing on other behaviors [17]. A more passive approach removes individual freedom of choice [16]. For example, removing high caloric foods from all vending machines at a worksite takes away unhealthy choices or makes it more difficult to continue the existing habit [18]. The e-health WHWI described in this study used both of these elements. First, periodically throughout the workday employees' computers were automatically taken over by the e-health software (Exertime) forcing them to stop work and stand. Once standing, the software then offered an active prompt by allowing employees the opportunity to choose and engage in a short-burst of physical activity, such as desk squats or a stork stand. These activities were provided to increase employee energy expenditure in the workplace with the aim of improving the health profiles of the employees involved in the study.

For the most part research connected to measuring energy expenditure in the workplace [14] has used the International Physical Activity Questionnaire [20]. Nonetheless, data emanating from this robust tool about energy expenditure associated with work is limited because it does not differentiate between the various sources of energy expenditure [20]. Researchers addressed this limitation with the development of the Occupational Physical Activity Questionnaire (OPAQ) [21]. This tool is a self-report measure of workplace energy expenditure determined by the time per week employees spend in three behavioral categories; sitting/standing, walking, and performing heavy labor. For each category a metabolic equivalent (MET) score is calculated using the employee's body weight, the self-reported amount of work hours per week spent in each category, and a constant MET value coefficient for each particular category (sitting/standing: 1.2 METs, walking: 3.0 METs, heavy labor: 7.0 METs). The sum score of the three MET values becomes the dependent variable which gives the average daily energy expenditure while at work. Substantial criterion validity, convergent validity, and moderate to high test-retest reliability coefficients have been reported for the OPAQ on a broad sample of occupations [21]. Nonetheless, we believe an important limitation of the OPAQ is that it does not distinguish between sitting and standing and combines these two postures into one behavioral category. In the *Compendium of Physical Activities* [22] MET intensities for sitting range from 1.0 (sitting quietly and watching television) to 2.5 (sitting and operating a forklift or crane at moderate intensity); and MET values for standing range from 1.8 (standing and reading or talking on the phone) to 3.5 (standing and participating in moderate intensity arts and crafts). Clearly sitting and standing MET values are not the same. In addition, Levine and colleagues [23] provided evidence to substantiate this difference by reporting that non-obese volunteers expended 50 percent more calories when standing versus sitting. Dividing sitting and standing into separate categories, and subsequently using separate MET values, may provide a more sensitive measure of the amount of energy expended during a workday. More recently Chau, van der Ploeg, Dunn, Kurko, and Bauman [24] developed the Occupational Sitting and Physical Activity Questionnaire (OSPAQ), which separates standing and sitting behaviors into two categories; however, beyond recording these values the OSPAQ does not incorporate a formula that yields workplace daily energy expenditure values. In the current study we have adapted these surveys to measure sitting and standing behaviors. Furthermore we incorporated an energy expenditure formula using the basal metabolic rate (BMR) to give a more accurate measure of workplace energy expenditure.

Despite the literature indicating that prolonged sitting is a potential occupational health risk [2,4–6], intervention data on this variable within the WHWI literature is scarce [8]. Moreover, WHWIs that do not address this variable may limit their effectiveness in maximising employees' health behaviors while at work. Thus, the purpose of this study was to increase workday energy expenditure by interrupting periods of prolonged sitting with short-bursts of physical activity during employees' daily work.

2. Methods

2.1. Study site and participants

To test the effectiveness of a WHWI a field-based, randomized controlled trial was launched through a research partnership between the Tasmania State Police Department and the University of Tasmania; funded by the Tasmanian government's Healthy@Work grant scheme. Participants ($N = 34$) were randomly selected from approximately 460 desk-based Tasmania Police employees from across several metropolitan sectors. Due to the pilot nature of this field-based investigation this sample size was deemed adequate by the research team. These volunteers (female = 26, male = 8) were pre-screened to ensure they had desk-based job responsibilities, daily use of a desktop computer, were free from existing health conditions [25], and were ready to engage in behavior change. That is, they were in one of three categories (contemplation, action, or relapse) of the five stages of behavior change [26]. Participants worked an average of 41.46 ± 11.82 hours per week.

2.2. Orientation

All participants attended an orientation session where they discussed the study procedures, completed a survey to measure self-reported energy expenditure at work, and were measured for height and weight using a Seca stadiometer and a Tanita digital scale [14]. Before any data collection, participants provided informed consent in accordance with the university's ethics clearance requirements. Participants were then randomly to assigned with replacement to an intervention group ($n = 17$; M age $= 41.50 \pm 12.39$ years) that was exposed to the WHWI (Exertime) for 13 weeks during the workday, or to a control group ($n = 17$; M age $= 43.88 \pm 9.65$ years) that did not have the e-health software loaded on their computers for a 13-week period. To prevent any type of Hawthorne effect, participants in the control group were told that at the conclusion of the first 13-week intervention period they too would receive the e-health software for a second 13-week intervention period. During the orientation session all participants were exposed to a 15-minute educational session on the negative health effects associated with prolonged sitting, general instructions on performing appropriate workplace physical activity (20 minutes), and an information session on using the Exertime software (30 minutes). During this session participants were told how the passive prompting e-health software would work and were reminded that their involvement in the study was strictly voluntary and they could withdraw at any time. Interestingly, there was a 100% adherence rate with no employee from either group withdrawing throughout the intervention period.

2.3. Description of intervention (Exertime e-health program)

The participants who had been randomly assigned to the intervention group had the Exertime software installed on their desktop computers. This software was designed to prompt employees to periodically break long periods of sitting by standing up to engage in a short period of physical activity during their work hours. The prompting intervention automatically de-activated employees' computer screens every 45 minutes and the end-users were unable to exit the program or ignore the prompt. The 45-minute prompting time was proposed by the occupational health and safety manager who based this decision on recommendations in the *Guidance note for the prevention of occupational overuse syndrome in keyboard employment* [27], which specified that all computer-based employees should remove themselves from a sedentary position for a short period every 60 minutes. At the point of de-activation, employees received a new screen that included a message prompt to stand up and engage in a short burst of physical activity such as one-legged squats, desk push-ups, or climbing the office stairs. Employees in the intervention group were able to view more than 60 short-burst physical activity video demonstrations of a model performing an Exertime activity in an office environment. It did not matter which Exertime activity was chosen by the employee, because any time employees were not seated during work was considered Exertime, and the software recorded their progress.

Once employees selected an activity it was up to them to decide how to engage with the prompted suggestion. There was no set requirement placed on employees in terms of repetitions or exercise intensity. At the very least, employees were simply asked to stand during the Exertime sequence. When the employees completed the chosen Exertime activity they were prompted to record the amount of time that they had engaged in the activity so the software could log their daily progress. This progress was then graphically presented to employees indicating the amount of time they had spent out of their chairs to engage in the Exertime activity, and the amount of calories expended for that activity. Research has shown that feedback and regular monitoring reinforces health behavior change [12,13]. Once employees' data were recorded, the Exertime sequence terminated and they were able to regain control over their computer screens to continue with their work responsibilities.

2.4. Control group

Participants in the control group did not have access to the Exertime program on their desktop computers during the first 13-week intervention period. These employees were encouraged to maintain their current fitness levels outside of work, but not to engage in any new work-based physical activities during the intervention period. To monitor this behavior the research team conducted random telephone checks with an emphasis on ensuring that employees had not engaged in new activities. Five employees indicated they had initiated leisure time physical activity following the orientation session, but their workplace physical activity had not changed throughout the intervention period.

3. Measurement

3.1. Workplace daily energy expenditure

To estimate workplace daily energy expenditure we developed a survey built upon the OPAQ and the OSPAQ, but without the limitations of these measures. First, we separated sitting and standing into two categories since the WHWI described in this study was created to encourage the latter, and interrupt the former. Now that we had four categories of workplace behavior (sitting, standing, walking, and heavy labor), we applied MET coefficients for each category using the *Compendium of Physical Activities Tracking Guide* [22]. More specifically, we used the following MET coefficients for our analysis: 1.5 METs for sitting, 2.3 METs for standing, 3.3 METs for walking, and 7.0 METs for heavy labor. The criteria for choosing these coefficients was based on the definitions fit with white-collar, office-based work (e.g., compcode – 11580, METS – 1.5, heading – occupation, description – sitting (light office work)). Finally, we updated the formula for calculating daily workplace energy expenditure to include BMR based on the widely used Harris-Benedict equation [19]. This equation is calculated separately for males and females using each participant's age, weight, and height. Thus, to arrive at our dependent variable of daily workplace energy expenditure (calories) all participants were asked to report the average number of hours per week spent sitting, standing, walking, and performing heavy labor before and after the 13-week intervention period. At this point we omitted the last category from further analysis because no one in the sample reported engaging in heavy labor during work hours. The remaining data were transformed into hours per day by dividing the recorded data (weekly hours) for each category by five (workdays). This value was then multiplied by the respective category MET coefficient, and then multiplied by the participant's hourly BMR. This was calculated separately for each participant in each of the three behavioral categories (sitting, standing, walking), and then summed to arrive at the dependent variable of daily workplace energy expenditure (calories).

3.2. Analysis of data

Descriptive statistics for three workplace behavior categories are reported in Table 1. Cronbach's alpha coefficient was calculated to report the reliability of our data set. A 2 (Group: Intervention/Control) $\times$ 2 (Test: Pre-test/Post-test) mixed design ANOVA was used to determine significant differences on the dependent variable, using a critical alpha level of 0.05. Cohen's d statistic was used to calculate the effect size of the experimental procedures for both groups separately between pre-test and post-test. No *a priori* power analyses were conducted because of the absence of relevant intervention research. All data were analysed using PASW version 18.0 (SPSS Inc., Chicago, IL, USA) [28].

4. Results

Cronbach's alpha ($\propto$= 0.96) indicated that the self-report of working hours in the three behavioral categories was a highly reliable measurement. There was a significant interaction between group and test, F (1,32) = 9.26, $p < 0.05$. Follow-up simple main effects indicated that the intervention group significantly, F (1,32) = 8.44, $p < 0.05$, increased their calories expended during the workday from pre-test ($M = 866.29 \pm 151.40$) to post-test ($M = 1054.1 \pm 393.24$) with a medium effect size ($d = 0.63$); whereas the control group decreased daily expended calories from pre-test ($M = 982.55 \pm 315.66$) to post-test ($M = 892.21 \pm 255.36$) with a small effect size ($d = 0.31$). This decrease exhibited by the control group was not significant, F (1,32) = 1.95, $p > 0.05$.

In terms of the effect of the passive prompt on workplace sitting habits, through the Exertime software, employees in the intervention group reported standing an additional 7.99 ± 4.44 minutes by engaging in short-burst physical activities 6.28 ± 3.59 times per workday, taking only 1.34 ± 0.74 minutes of work time for each endeavour.

5. Discussion

The aim of this study was to determine if an e-health passive prompting WHWI primarily focussed on reducing prolonged sedentary work behaviors could improve workday energy expenditure in a cohort of desk-based employees. The intervention group, who were introduced to Exertime over a 13-week period, significantly increased their energy expenditure between pre-test and post-test; whereas the control group, who did not receive the WHWI, decreased MET expenditure over the course of the intervention period. However, this latter finding was not statistically significant. While both groups reported a reduction in sitting time, which can be viewed in Table 1, this significant interaction may be attributed to the increase in self-reported standing or walking exhibited by the intervention group; whereas the control group, who were not prompted to engage in movement during the workday, did not demonstrate increases in these areas. This demonstrated that short duration, office-appropriate, physical activities performed periodically throughout the workday may increase desk-based employee energy expenditure during working hours. Moreover, it appears that the use of a passive prompt approach was successful in encouraging employees to regularly stand and engage in short-bursts of physical activity. We infer from these results that participants exposed to the intervention regularly broke their sitting periods and thus possibly stood to gain health benefits during their working hours. Furthermore, it appears that a simple e-health solution, such as prompting employees to perform regular short-bursts of physical activity, can be included in WHWIs. This may be attributed to employees being able to reconceptualise the stigma of workplace physical activity from "huff and puff" lunchtime exercise, to incorporate a broader spectrum of office-appropriate short-burst activities, providing employees with a wider range of opportunities.

The success of a passive prompt in changing habits within the workplace over the short term indicates that if WHWIs seek to change health habits, then a computer prompting system coupled with appropriate health information may be an effective strategy. Moreover, given that the control group in our study reported a decrease in energy expenditure over the 13-week intervention period, even though they were exposed to the information about the adverse effects of prolonged sitting, education alone (i.e., information about adverse or beneficial health effects of a habit) may not be sufficient to change work-related health habits [29]. This finding has implications for generic WHWIs that use education as a mechanism for recruitment or initiation of exercise behavior. WHWIs that couple new behaviors with "education-only" as a means of improving the

Table 1
Daily workplace energy expenditure as a function of category, group, and test. Calories per workday are presented as *means (standard deviations)*

	Exertime ($n = 17$)		Control ($n = 17$)	
Category	Pre	Post	Pre	Post
Sitting	578.48 (122.65)	473.49 (113.91)	598.93 (155.90)	576.74 (119.85)
Standing	145.32 (124.22)	249.55 (220.70)	152.30 (103.93)	154.15 (106.47)
Walking	142.49 (135.19)	331.06 (264.99)	231.31 (222.62)	161.32 (150.14)
Total Energy	866.29 (151.40)	1054.10 (393.24)	982.55 (315.66)	892.21 (255.36)

health culture in work places may be ineffective and have limited reach and sustainability. Although WHWIs are the zeitgeist of the white collar working world, our findings indicated that for improvement in health-related habits, passive prompts were needed to effect change.

A discussion of the limitations of this research study is warranted. First, all data collected were based on self-reports of energy expenditure at work. One large scale study [30] has used accelerometer-based data in this area; however we felt that as this was our first investigation it would be best to be less intrusive with our field-based measurements to avoid any issues associated with surveillance and how they might influence behavior [31]. We plan to explore accelerometer data to record short-burst physical activity while at work in the near future. Second, our field-based research only included a small sample of employees. Although the effect size of our new treatment was acceptable, this study should be replicated on a larger sample of desk-based employees across several worksites before generalizations about the effectiveness of this e-health solution can be made.

Rightfully, there is concern about the sustainability of physical activity interventions for prolonged periods [32]. Most of these concerns relate to voluntary participation in exercise-based interventions. Nonetheless, our study sought to replace an existing habit with a new habit. A number of factors are related to the sustainability of new habits over time, but it appears 95 per cent of individuals reach automaticity for new habit between 18–254 days after initiation [33]. Unlike voluntary participation-based interventions, in our intervention, once habit change has occurred, there may no longer be the need for the intervention; as the old habit has been extinguished. Given that employees in this study were exposed to 65 days of repetition, we believe there is generally good optimism for sustainability. Although this study did not address post intervention retention of gains or issues around sustainability, we did report [29] that after the completion of the study period employees had continued to add movement to their daily work flow and had transferred their new habit to their leisure time (i.e., watching T.V.).

The introduction of short-burst physical activity during work hours appears to be a catalyst for not only reducing prolonged sitting, but also increasing daily energy expenditure. Moreover, an e-health passive prompting system was an effective mechanism for improving workplace health habits. In this study it was evident that it is possible to introduce periodic short-burst physical activity to desk-based employees in the workplace if the activities are appropriately targeted for the audience. More research is warranted on this reconceptualisation of appropriate WHWIs to determine any long-term impact on prevention of related adult-onset disease and disability.

6. Conclusion

Increasing daily energy expenditure is a valid way to improve overall health and wellbeing in adult workers. While the workplace has been identified as an environment to promote changes in health behavior, for the most part WHWIs have only dealt with decreasing sedentary behaviors through programs that focus on employee-initiated voluntary physical activity. Modest increases in employees' energy expenditure were achieved by prompting them to engage in regular short duration movements as part of their work. Employees were accepting of an e-health intervention that used a passive rather than active approach to participating in office-appropriate short-bursts of physical activity. By regularly moving during work, employees regularly interrupted their prolonged sitting. The use of a passive e-health approach may be an alternative mechanism to changing other health habits given that it is cost effective and has the potential to enhance adherence.

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