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Project Energise: Using participatory approaches and real time computer prompts to reduce occupational sitting and increase work time physical activity in office workers

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Abstract

Objectives: This efficacy study assessed the added impact real time computer prompts had on a participatory approach to reduce occupational sedentary exposure and increase physical activity.

Design: Quasi-experimental.

Methods: 57 Australian office workers (mean [SD]; age=47 [11] years; BMI=28 [5] kg/m^2; 46 men) generated a menu of 20 occupational 'sit less and move more' strategies through participatory workshops, and were then tasked with implementing strategies for five months (July-November 2014). During implementation, a sub-sample of workers (n=24) used a chair sensor/software package (Sitting Pad) that gave real time prompts to interrupt desk sitting. Baseline and intervention sedentary behaviour and physical activity (GENEActiv accelerometer; mean work time percentages), and minutes spent sitting at desks (Sitting Pad; mean total time and longest bout) were compared between non-prompt and prompt workers using a two-way ANOVA.

Results: Workers spent close to three quarters of their work time sedentary, mostly sitting at desks (mean [SD]; total desk sitting time=371 [71] mins/day; longest bout spent desk sitting=104 [43] mins/day). Intervention effects were four times greater in workers who used real time computer prompts (8% decrease in work time sedentary behaviour and increase in light intensity physical activity; $p<0.01$). Respective mean differences between baseline and intervention total time spent sitting at desks, and the longest bout spent desk sitting, were 23 and 32 mins/day lower in prompt than in non-prompt workers ($p<0.01$).

Conclusions: In this sample of office workers, real time computer prompts facilitated the impact of a participatory approach on reductions in occupational sedentary exposure, and increases in physical activity.

Key words: Office workers, occupational sitting, physical activity, computer prompts

1. Introduction

High levels of total time spent sitting, and prolonged periods of time without interrupting sitting, have been associated with increases in the prevalence of cardiovascular disease, type 2 diabetes and all-cause mortality. [1, 2] For many adults, high overall exposure and prolonged periods of sitting exposure occur at work. [3]

In Australia for example, large-scale surveys suggest that 81% of workers are exposed to sitting, [4] and that workers employed in offices sit the most. [5, 6] Smaller studies that have used accelerometers indicate that Australian office workers spend between 4-7 hours/day sitting during work time. [7, 8, 9]

While not as well advanced as the epidemiological and measurement based literature, evidence on the effectiveness of various strategies for reducing and interrupting occupational sitting is beginning to build. A recently published Cochrane review provides a comprehensive overview of studies up to February 2014, and highlights that there is a clear need to develop intervention strategies that target the physical workplace, policy changes and information and counselling. [10]

Computer software that utilises screen prompts is a novel information based intervention strategy for reducing and interrupting prolonged desk sitting. To date, four studies have investigated the impact computer prompts have on occupational sitting, standing and moving. [11, 12, 13, 14] Relative to a control or comparative group that did not receive prompts, the findings from three of these studies showed objectively measured changes in the duration of sitting bouts >30 minutes (n=14; significant decrease of 12%); [11] total sitting time at work (n=29; non-significant decrease of 7%); [13] and standing time at work (n=19; mean increase of 9%). [14] One study found a significant pre-post increase in self-reported energy expenditure (n=17; 188 calories) relative to a control group. [12] Intervention duration across all four studies

ranged from 3 days [13] to 13 weeks, [12] and all four studies used passive prompts whereby a reminder was given to break from sitting at a set time (e.g. 30 minutes) regardless of time spent sitting.

Use of passive prompts assumes that patterns of sitting in office workers are generic. Our research has shown that these patterns are highly variable, suggesting that to be most effective, the receipt of prompts for interrupting sitting should react to each worker's pattern of desk sitting throughout the day. [9] Consequently, we have developed a low cost device called the Sitting Pad (SP), which fits easily onto office chairs and has a real time, reactive feedback component that prompts employees to engage with sitting reduction strategies. [15]

The aim of this efficacy study was to test the additional impact of real time feedback and prompts on a participatory approach to reduce work time sedentary exposure and increase physical activity. In the context of the present study, a participatory approach [16] was used to engage two teams of Australian office workers in the identification of 'sit less and move more' strategies, with one of these teams provided with access to real time feedback.

2. Methods

The office teams were situated on different floors of a telecommunications worksite in the city centre of Brisbane. Following ethics approval, the managers of the teams distributed recruitment emails to their administrative and clerical workers (n=150). All members of each work team were eligible to participate, although the total number of workers recruited was capped at 60 because of available resources. The research targeted a relatively even number of workers within each team.

All recruited workers provided informed consent and met with researchers individually at work to complete a demographic survey and basic physical measures (height, weight, waist circumference and

blood pressure; April 2014). Workers then wore a GENEActiv wrist accelerometer (Activinsights Ltd, Cambridgeshire, UK) for one working week, 24 hours/day (30 Hz sampling rate). This device is a tri-axial, ± 6 g seismic acceleration sensor, which is small (36x30x12 cm), lightweight (16 g), and waterproof. GENEActiv validity studies have demonstrated strong correlations for criterion validity (Pearson's r = 0.79 to 0.98) against indirect calorimetry for both sedentary behaviour and physical activity. [17]

At baseline, the participants also had their office chairs fitted with the SP and this device remained on chairs for the duration of the study. The SP was used as a measure of desk sitting in both teams of workers and is described in detail elsewhere, [15] but in brief consists of a cushion and medical grade pressure sensor (43x32x2cm) which detects transitions of greater than 3 seconds to and from the seat. A microcontroller linked to the pressure sensor records a time stamp for each transition and these data are downloaded using a proprietary software package that summarises the total minutes spent sitting and the longest bout spent sitting each day.

Following baseline measures, workers attended a one-hour workshop (n=10-15) held at the worksite (June 2014). During the workshop, researchers reviewed evidence on the benefits of reducing sitting and increasing physical activity, and workers identified and discussed occupational strategies for 'sitting less and moving more'. These strategies were collated, then thematically analysed separately by two researchers, who then reached a consensus on the number of strategies, and the domains in which they should be categorised. Finally, a list of strategies was distributed to workers at the start of the trial for use during the five-month intervention period (July-November 2014).

The pilot study used a *posteriori*, quasi-experimental design, whereby between completion of the workshops and distribution of the strategies, teams were allocated to either *Intervention Protocol 1* (IP1) or *Intervention Protocol 2* (IP2). Both sets of workers were asked to implement 'sit less and move more'

strategies, but only workers in IP2 were provided with access to a software package that linked to the SP and gave real time prompts to break from desk sitting, via a traffic light system displayed in the right hand corner of computer screens.

A recently published expert statement from the United Kingdom has indicated that office workers should aim to accumulate 2-4 hours/day of standing and light intensity activity time during work hours. [18] However, the statement recognises the tentative nature of these recommendations and the need for more evidence to better inform viability. In the absence of definitive health guidelines for the frequency and duration of sitting breaks for adults, default settings for the SP software reflected pragmatic suggestions from the literature that propose at least a five minute break from desk sitting every 30-60 minute block of time. [19, 20] In this regard, prompts moved from green to amber, and then to red, after 30 and then 60 minutes of continuous desk sitting respectively, with the software re-setting to green after five continuous minutes of the SP not being activated. User functions accessed through the software enabled workers to reduce and tailor these thresholds to their own work time routine, and select an auditory as well as a visual prompt.

GENEActivs were worn again for one week at the end of the intervention. Baseline and end-intervention data were classified into mean percentages of waking time (work day) and work time spent in sedentary behaviour, and in light and moderate-to-vigorous (moderate+) physical activity, using validated cut-point thresholds. Monitors were initalised at 75Hz with cut-points of 362 (sedentary), 508 (light to moderate), and 1698 (moderate+). [17] Workers used the time stamp function on the wristwatch to denote when they arrived and left work; this was cross-referenced with self-reported work times. SP data were isolated for baseline and intervention periods, and the mean total sitting time and the longest bout spent sitting at desks (minutes/day) calculated for these periods.

Minimum inclusion criteria for analyses of GENEActiv (24 hours) and SP data (≥6 hours) were three separate workdays at baseline and (end) intervention. If intervention data were missing, baseline values were carried forward, and a two-way repeated ANOVA was used to statistically compare between and within group changes in sedentary behaviour, light and moderate+ physical activity and desk sitting. Main outcome analyses focused on changes in these variables during work time; all statistical analyses were conducted in SPSS version 22 (IBM Corporation); p-values were based on two-sided tests and were considered statistically significant at $p<0.05$.

3. Results

Table 1 summarises the demographic characteristics of the sample. Participants tended to be mainly men, overweight and middle aged. At baseline, IP1 workers spent significantly more time in light intensity physical activity on workdays than IP2 workers ($p=0.024$), but no significant differences were observed for GENEActiv and SP baseline data collected during work time.

Insert Table 1 here.

Analyses of data collected from workers during workshops identified a menu of 20 'sit less and move more' strategies. As Table 2 shows, these were themed into the four occupational contexts of 'desk tasks' (5 strategies; e.g. deliver some messages in person rather than always sending emails); 'meetings' (4 strategies; e.g. use walk-talk rather than sit-talk meetings); work breaks (7 strategies; e.g. take a standing and stretching break); and travel (4 strategies; e.g. walk to and/or from work).

Insert Table 2 here.

Table 3 summarises work time GENEActiv and SP data, and describes changes relative to baseline and (end) intervention values. With regard to the carry forward of GeneActiv and SP baseline data, seven and three workers respectively did not meet minimal inclusion criteria for intervention data, while a further four workers withdrew from the study prior to completion of final measures. Recorded GeneActiv and SP work time for these phases ranged from 8.6 – 8.9 hours/day. The mean (SD) number of monitored days for the GENEActiv was 4 (1) for both groups at baseline and end-intervention. For IP1, mean (SD) monitored days for the SP at baseline and intervention were 10 (5) ranging from 4-17 days, and 15 (5) ranging from 3-24 days respectively. Equivalent SP baseline and intervention data for IP2 were 13 (5) ranging from 3-24 days, and 20 (8) ranging from 5-32 days.

Insert Table 3 here.

At baseline, workers spent 68-74% of their work time sedentary, and 19-25% in light and 7% in moderate+ physical activity. On average workers spent 370-372 mins/day sitting at a desk, with the longest bouts of desk sitting averaging 100-111 minutes/day.

Relative to baseline, end-intervention GeneActiv data indicated that IP1 workers reduced sedentary work time by an average of 2% (18 mins/day). Within group effects were significant and four times greater in IP2 workers (decrease of 8%; 72 mins/day; p=0.012). IP2 workers replaced sedentary work time with light intensity physical activity, with the proportional increase in light intensity work time significant for this group (p=0.018).

For the SP, comparisons of baseline and intervention data indicated that the mean total time spent sitting at desks across the intervention period increased for IP1 workers (10 mins/day) and decreased for IP2 workers (-13 mins/day; difference of 23 mins/day). This pattern was also observed for the longest bout

spent sitting at desks (IP1 = 17 mins/day; IP2 = -15 mins/day; significant difference of 32 mins/day; p=0.018).

4. Discussion

In this efficacy study, Australian office workers attended workshops and were asked to identify 'sit less and move more' workplace strategies through a participatory approach. In the ergonomics field, participatory approaches have been used to successfully engage workers, managers and employers in the development of strategies to address musculoskeletal issues. [21, 22] More recently, studies that have focused on sitting and chronic disease in office workers have advocated [23] and used [16] participatory approaches as a means of promoting ownership of occupational sitting reduction strategies and facilitating commitment to sedentary behaviour change.

The Australian office workers involved in the participatory research undertaken by Parry et al [16] identified seven strategies within the overarching themes of 'active office work, traditional physical activity and office ergonomics'. In a more recent study, which used a prescriptive, top-down approach with Spanish office workers, Bort-Roig et al [24] also described seven strategies focusing on reducing and interrupting occupational sitting through incidental movement. A main finding of our study is that participants identified a more comprehensive 'menu' of 20 strategies, themed into four specific occupational contexts. This 'menu' is valuable for employers and practitioners interested in providing office workers with a range of choices and opportunities for reducing and interrupting sitting in different situations, and with occupational groups who have different job demands and daily routines. Ongoing testing now needs to occur to assess if the 'menu' is exhaustive and replicable with other office-based samples.

Linked to the emergence of strategies from the workshops, a key aim of the present study was to assess the added effect of using real time computer prompts to encourage positive changes in occupational

sedentary exposure and physical activity, over and above those seen when using a participatory approach alone. The more meaningful reductions in both the proportion of sedentary work time, and patterns of desk sitting found in IP2 compared to IP1 workers, together with the significant increase in work time light intensity physical activity observed in the strategy and real time prompts group, highlighted the efficacy of using this combined approach. The significant reduction in the mean longest bout of desk sitting in IP2 workers is particularly noteworthy, given that most occupational sitting time occurs at desks, [9] and frequent interruptions to sitting have been linked to a range of improved health indices. [25]

Technology based, real time feedback, provided through pedometers and smartphone applications for example, has been recognised as playing a key role in facilitating engagement in physical activity. [26] A main finding of the present study indicates that this type of feedback may also be an important approach for encouraging workers to engage in occupational sitting reduction strategies. Providing real time prompts to interrupt occupational sedentary exposure allowed workers in IP2 to self-monitor and regulate their desk sitting through a personalised feedback mechanism that reacted to variations in daily desk sitting patterns. In this regard, the SP and its associated software alerted workers to prolonged desk sitting as and when it occurred. Evidence concerning the impact individual level strategies such as education, counseling and prompts have on reductions in occupational sitting time are inconsistent. [10] Our data adds to the view that a participatory approach allied with real time prompts may be valuable. However, it is important to consider that multi-level interventions, that target the individual, environmental, organisational and policy domains of the office work system are more likely to have a comprehensive and sustainable impact on occupational sitting, than interventions that target any one domain in isolation. [27, 28]

The study had a number of strengths. For example, the SP provided a highly accurate assessment of desk sitting over multiple days, [15] and in conjunction with the accelerometers, enabled a comprehensive assessment of work time sedentary and physical activity patterns. Other study strengths included engaging workers in identifying strategies through participatory approaches, and the use of a quasi-experimental

606 design that allowed comparisons of work time changes during a five-month intervention period.

607

608 The study also had some limitations that future studies need to address. The research was undertaken at a
609 single worksite, with relatively small sample sizes in each group, which while in keeping with the remit of
610 efficacy research, presently restricts the applicability of the findings to office workers in general.
611 Furthermore, the lower and uneven number of participants in IP2 (N=24) relative to IP1 (N=33) impacted
612 the detection of statistically significant between group differences; for example based on an observed
613 group mean difference of 23 minutes/day for total time spent sitting at desks, analyses required at least 31
614 workers per group (α=0.05; β=0.80; ±46 minutes). Lastly, the intervention effects observed in our study
615 compare favourably to those reported in studies that have used passive computer prompts and objective
616 measures of sedentary behavior change, [11, 13, 14] although comparisons are problematic, given the
617 differences in study design and measurement techniques. The next study in this area needs to include both
618 a passive and reactive prompts group, to concurrently appraise the extent to which each approach impacts
619 on strategy uptake and occupational sedentary exposure. Future study designs may also consider mapping
620 strategy use in comparative groups to quantify the extent to which prompts encourage the uptake of
621 different types of strategies.

622

623 **5. Conclusions**

624

625 This efficacy study is the first to evaluate the impact of real time computer prompts on work time
626 sedentary behavior, physical activity and desk sitting in office workers. The main study findings provide a
627 comprehensive 'menu' of 'sit less and move more' strategies for application and ongoing investigation,
628 and begin to provide insights into the potential benefits of using real time individualised computer
629 prompts as feedback to facilitate reductions in occupational sedentary exposure and increases in work time
630 physical activity.

631

Practical Implications

- Office workers can choose from a 'menu' of 'sit less and move more' strategies.
- Real time computer prompts, which react to day-to-day variations in desk sitting patterns, may facilitate the uptake of 'sit less and move more' strategies.
- The next phase of studies in this area should concurrently compare the efficacy of passive and reactive computer prompts.

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Tables

Table 1 Baseline sample characteristics (frequency or mean [SD]) relative to intervention protocol

	IP1	IP2	Total
Age (years)	47 (13)	48 (13)	47 (11)
Sex (n)			
Men	27	19	46
Women	6	5	11
BMI (kg/m^2)	28 (4)	29 (5)	28 (5)
Waist Circumference (cm)			
Men	95 (13)	100 (15)	98 (14)
Women	86 (15)	89 (14)	88 (13)
Blood Pressure (mm Hg)			
Systolic	127 (14)	130 (13)	128 (13)
Diastolic	86 (9)	87 (10)	86 (9)
GENEActiv (hrs/day) [1]			
Workdays			
Sedentary	9.4 (2.2)	10.1 (1.5)	9.7 (2.0)
Light [2]	5.5 (1.7)	4.3 (1.4)	5.0 (1.7)
Moderate+	1.7 (0.8)	1.6 (0.6)	1.6 (0.7)

IP1=Intervention Protocol 1 (strategies and no prompts, N=33); IP2=Intervention Protocol 2 (strategies and prompts, N=24).

[1] Total time for the waking day; [2] $p<0.05$ IP1 vs IP2.

738 Table 2 Sit less and move more strategies (x20) identified by workers

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Theme 1: Standing and moving during desk tasks
Stand up and move while talking on the phone. Stand up to read or review documents. Use centralised office equipment (e.g. photocopier or printer) and spread these tasks across the day. Deliver some messages in person, rather than always sending emails. Drink more water at your desk and take frequent toilet breaks.
Theme 2: Standing and moving in or between meetings
Try to organise walk-talk, rather than sit-talk meetings. Spend some of your time standing in meetings. Schedule stand up meetings. Schedule meetings away from your desk or use a meeting venue outside the office.
Theme 3: Standing and moving during work breaks
Schedule regular activity breaks in your weekly work calendar. Use morning and afternoon work breaks to undertake a stand and stretch routine. Don't eat lunch at your work desk. Tea or coffee break away from the desk. Plan lunchtime walks either on your own or with colleagues. Include inclines in your walks or use the stairs between floors. Take advantage of corporate gym memberships and work out at a facility close to the office.
Theme 4: Active travel to and from work
Aim to stand rather than sit on public transport. Include a walk in your travel to and from work. Park the car further away from the office, or use a public transport stop further away from home or the office to increase your walk time. Cycle into work.

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746 Table 3 Mean (SD) baseline, (end) intervention and changes ([end] intervention – baseline) in work time
747 sedentary behaviour, physical activity and desk sitting relative to intervention protocol
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	Baseline		(End) Intervention		Change	
	IP1	IP2	IP1	IP2	IP1	IP2
GENEActiv (%)						
Sedentary [1]	68 (14)	74 (7)	66 (16)	66 (15)	-2	-8
Light [2]	25 (11)	19 (7)	26 (12)	27 (14)	+1	+8
Moderate+	7 (4)	7 (3)	8 (5)	7 (3)	+1	0
Sitting Pad (mins/day)						
Total time sitting	370 (84)	372 (53)	380 (81)	359 (71)	+10	-13
Longest bout sitting [3]	100 (42)	111 (45)	117 (49)	96 (30)	+17	-15

749
750 IP1= Intervention Protocol 1 (strategies and no prompts, N=33); IP2=(Intervention Protocol 2 (strategies
751 and prompts, N=24)
752 [1] $p<0.01$ IP2 baseline vs end intervention; [2] $p<0.01$ IP2 baseline vs end intervention; [3] $p<0.05$ IP1 vs IP2
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