Sit–Stand Workstations

A Pilot Intervention to Reduce Office Sitting Time

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Background: Sitting time is a prevalent health risk among office-based workers.

Purpose: To examine, using a pilot study, the efficacy of an intervention to reduce office workers' sitting time.

Design: Quasi-experimental design with intervention group participants recruited from a single workplace that was physically separate from the workplaces of comparison group participants.

Setting/participants: Office workers (Intervention=18; Comparison=14) aged 20-65 years from Brisbane, Australia; data collected and analyzed in 2011.

Intervention: Installation of a commercially available sit-stand workstation.

Main outcome measures: Changes from baseline at one-week and three-month follow up in time spent sitting, standing, and stepping at the workplace and during all waking time (*activPAL3* activity monitor, 7-day observation). Fasting total cholesterol, HDL cholesterol, triglycerides, and glucose levels were assessed at baseline and three months (*Cholestech LDX Analyzer*). Acceptability was assessed with a 5-point response scale (8 items).

Results: The intervention group (relative to the comparison group) significantly reduced sitting time at one-week follow-up by 143 minutes/day at the workplace (95%CI= -184, -102) and 97 minutes/day during all waking time (95%CI= -144, -50). These effects were maintained at three-months (-137 mins/day and -78 mins/day, respectively). Sitting was almost exclusively replaced by standing, with minimal changes to stepping time. Relative to the comparison group, the intervention group increased HDL cholesterol by an average of 0.26mmol/L (95% CI: 0.10, 0.42). Other biomarker differences were not statistically significant. There was strong acceptability and preference for using the workstations, though some design limitations were noted.

Conclusions: This trial is the first with objective measurement and an appropriate comparison group to demonstrate that the introduction of a sit-stand workstation can substantially reduce office workers' sitting time both at the workplace and overall throughout the week.

Introduction

Prolonged sitting is detrimentally associated with several health outcomes.[1-3] For many full-time employed adults, the bulk of this sedentary time occurs at work,[4, 5] where typically they spend an average of over eight hours of their weekdays.[6] Given that workers represent half the world's population,[7] and most of the world's population spend an average one-third of their adult life at work,[8] the workplace is a key setting in which to introduce strategies to reduce sitting time and break up periods of prolonged sitting to improve health.[9-11] Office-based workers are one of the largest occupational groups[12, 13] and are also highly sedentary,[14] making them an important candidate group for preventive approaches .[15, 16]

Three studies have evaluated the impact of individual workspace modifications on workplace sitting time, with all reporting significant reductions,[17-19] while a separate study using standing 'hot desks' in an open-plan office did not report any significant change in workplace sedentary time.[20] However, none of these studies concurrently included appropriate comparison groups, adequate follow-up periods and/or objective measurement of sitting and activity time during both work and non-work time. Furthermore, none assessed the intervention effects on health outcomes that have been associated with prolonged sitting.

This pilot study assessed the short (one-week) and medium-term (three-month) changes in objectively-measured sitting time and activity levels at the workplace and during all waking time in office-based employees who had a sit-stand workstation installed (intervention), compared with employees without workspace modifications (comparison). Workstation acceptability and changes in health- and work-related outcomes were also assessed. It was hypothesized that workplace sitting time in the intervention group would be reduced by at least 30 minutes relative to the comparison group, and this would primarily be replaced by standing.

Methods

Study design

Data for this two-arm quasi-experimental trial were collected February – June 2011 and analyzed in August – September 2011. The study was approved by The University of Queensland's School of Population Health Research Ethics Committee.

Participant Recruitment

Office workers, aged 20-65 years who used a non-adjustable work surface and desktop computer were eligible. Exclusion criteria were: non-ambulatory, pregnant at baseline, working less than 0.5 Full Time Equivalent and/or planning relocation to another worksite during the study period.

Participants were recruited from public health research centers within two academic institutions in Brisbane, Australia. Intervention group participants (*n*=18) were recruited from a single Centre, which has a sedentary behavior research focus. To minimize contamination, comparison group participants (*n*=14; none who worked in physical activity research) were recruited from locations separated from intervention participants by at least one building level. All participants provided written informed consent.

Intervention Group

Following baseline assessment, intervention participants had a low-cost (~US$380 each) *Ergotron WorkFit-S*, Single LD Sit-Stand Workstation (www.ergotron.com) installed. The workstation facilitates regular transitions between sitting and standing postures. Brief (approximately 2 minutes) verbal instruction on its use, as well as written instructions on the correct ergonomic posture for both sitting and standing and the importance of regular postural change throughout the day, as recommended by the product affiliates (www.computingcomfort.org/educate1.asp), was given.

Comparison Group

Workspaces were not modified and participants were advised to maintain their usual day-to-day activity.

Data Collection

Participants underwent three seven-day assessment phases: baseline, one week follow-up, and three-month follow-up. The one-week follow-up took place 1-3 days after the completion of the baseline assessment, with this assessment also corresponding with the first seven days following workstation installation for intervention participants. Participants wore an *activPAL3* activity monitor (PAL Technologies Limited, Glasgow, UK) and completed a self-administered questionnaire at all assessments; anthropometric and fasting (minimum 10 hours) blood assessments were conducted at the research center at baseline and three-month follow-up. For intervention participants, the first day of *activPAL3* observation (at one-week follow-up) was the first day of workstation usage.

Sitting, standing and stepping time and sit-to-stand transitions: were measured using thigh-mounted *activPAL3* monitors, worn 24-hours/day across a 7-day observation period. The *activPAL3* classifies posture directly (by inclinometer) and has excellent validity and reliability.[21] Participants recorded in a log all times at their primary workplace, awake/asleep and of monitor removals (if any).

Body Mass Index (BMI): was calculated as average weight (kg) / average height $(m)^2$. Weight (*Taylor* 7023WA Lithium Electronic Scale; Oak Brook, IL; nearest 0.1kg without shoes or heavy clothing) and height (PE087 Portable Height Scale, VIC, Australia; nearest 0.1cm without shoes) were measured in duplicate.[22]

Body composition: Fat free mass and fat mass (kg) were measured using the *Impedimed SFB7* bioimpedance spectroscopy (BIS) device (Pinkenba, QLD, Australia).[23]

Waist and hip circumferences: were measured in duplicate (nearest 0.1cm) using a non-expandable tape measure at the superior border of the iliac crest[24] and the greatest gluteal protuberance,[25] respectively.

Fasting blood lipids and glucose: Fasting total cholesterol, HDL cholesterol, triglycerides, and glucose levels were assessed using a 35µL whole-blood sample via finger stick and the *Cholestech LDX Analyzer* (Hayward, CA).[26, 27]

Self-report outcomes: For possible benefit or adverse outcomes, fatigue,[28] eye strain,[29] and self-rated work performance[30] were measured at all assessments; headaches, digestion and sleep problems,[28] musculoskeletal health[31] and absenteeism (sick days in the last three months) were assessed at baseline and three months. Workstation acceptability was assessed with eight items using a 5-point response format (strongly disagree to strongly agree). Socio-demographic and general office layout data were collected at baseline.

Data Processing

The *activPAL3* records for each 15-second epoch (version 6.0.8), the number of sit-to-stand transitions and seconds spent sitting/lying (referred to as sitting throughout), standing and stepping that occurred. Using SAS 9.1 (SAS Institute Inc., Cary, NC), self-reported removal and sleep times were excluded, then sit-to-stand transitions and time spent sitting, standing and stepping were summed for each day over the periods of interest (at the workplace and during all waking time). Averages were calculated from days when the monitor was not substantially removed (worn ≥90% at the workplace (n=377/377 days) and removed ≤90 minutes during waking time (n=609/637 days)). No restrictions were made on number of observed days. To account for variations in observed time, outcomes were standardized to an 8-hour workday or a 16-hour day; transitions are reported per hour of sitting.

Statistical analyses

Analyses were conducted in PASW Statistics, version 18.0.0 (SPSS, Inc., Chicago IL) and Stata Statistical Software, version 11.1 (StataCorp LP, College Station TX). To determine intervention effects, regression models were conducted separately for each outcome, adjusting for baseline values as covariates.[32, 33] Models were linear regression (one follow-up period), linear mixed models (two follow-up periods) or Tobit regression for truncated outcomes (triglycerides). Estimated marginal means with 95% confidence intervals are reported. Statistical significance was set at $p<0.05$ (two-tailed).

Results

Figure 1 shows participants' progress through the study. One participant (comparison) was excluded from sitting and activity analyses due to a monitor malfunction. Table 1 shows the participants' characteristics at baseline by group. Both groups were primarily Caucasian, female, married, working full-time and had completed tertiary-level education. Baseline sitting time and activity were similar for both groups during overall waking time; however, at the workplace, sitting time was markedly less in the intervention than comparison group.

INSERT FIGURE 1 AND TABLE 1 ABOUT HERE

Intervention effects

Changes in sitting, standing, stepping time and transitions (Table 2): In the intervention group (relative to the comparison group), sitting at the workplace was reduced by more than two hours at both the one-week and three-month follow-ups ($p<0.001$ for both). Sitting reductions were driven primarily by increases in standing time, though beneficial intervention effects were also observed for transitions (both follow-ups) and stepping (one week). Changes in sitting time and activity during overall waking time also significantly favored the intervention group for all outcomes except stepping at both follow-ups and transitions at three-months.

INSERT TABLE 2 ABOUT HERE

Anthropometrics, fasting blood lipids and glucose outcomes (Appendix A): Relative to the comparison group, HDL cholesterol increased in the intervention group by an average of 0.26mmol/L (95% CI: 0.10, 0.42; p=0.003). Other differences were not statistically significant.

Self-report outcomes: Self-reported health and work performance outcomes did not change markedly within-groups or between-groups at either follow-up (Appendix B). At three-months, the majority of intervention participants either agreed or strongly agreed that the workstation was easy to use (94%), enjoyable (94%) and comfortable (83%). However, many noted insufficient support for their hands and wrists while typing (44%), insufficient room to use the mouse (67%), and 33% indicated changing their footwear due to workstation use. Despite this, none of the participants indicated that they would rather return to their original workspace set-up, with 83% disagreeing or strongly disagreeing with this statement. When asked if the new workstation improved their productivity, 33% agreed and 22% disagreed.

Discussion

This pilot study provides novel evidence that a low-cost sit-stand workstation can reduce sitting time in office workers. The intervention, which was highly acceptable, had substantial effect in the short- and medium-term on sitting and standing at the workplace and during all waking time. Epidemiologic evidence suggests that these reductions could have a considerable impact on cardiovascular disease and type 2 diabetes prevention.[3]

While studies are too heterogeneous to compare directly, this sit-stand workstation intervention (which reduced workplace sitting time by >27%) appears at least as successful as other workstation interventions.[17, 19] The intervention group also significantly increased (relative to the comparison group) the number of sit-to-stand transitions per sitting hour at the workplace, suggesting that sitting time was not only reduced but also interrupted more frequently. This improvement occurred despite the absence of quantified targets for postural change.[19]

This pilot study was not powered *a priori* to detect meaningful changes in secondary outcomes. Thus, lack of statistically significant differences should not be interpreted as ruling out potentially important benefits or harms of the intervention. Notably, the direction of effects for HDL cholesterol (+0.26, 95% CI 0.10, 0.42 mmol/L; p=0.003) and fasting glucose (-0.27, 95%CI: -0.65, 0.11 mmol/L; p=0.159) are congruent with inactivity physiology research.[34-36] Similarly, the average reduction in weight over three-months (-0.9, 95%CI: -1.9, 0.2 kg; p=0.675) is comparable to workplace physical activity interventions in a recent meta-analysis (mean change -1.08kg; 8-52 weeks follow-up).[37]

Strengths of the study are the real-world applicability, the objective, high-quality measure of sitting and activity in the context of interest (at the workplace) and overall (to demonstrate wider benefit). However, the study was not randomized and recruited small numbers of participants using convenience sampling. Thus, the sample is not widely representative of workplaces and workers, and some confounding is possible. Furthermore, models adjusted for baseline levels but not for other potential confounders due to insufficient sample size. Key issues may include workplace layout and the intervention participants' knowledge of the health impact of prolonged sitting. Larger, cluster-randomized trials are needed as these can better control confounding, improve generalizability, have capacity to explore effect modification, and will yield more precise estimates of potential effects on anthropometric, biomarker, health- and job-related outcomes.

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Figure Legends

Figure 1. Flow diagram of participant progress through the trial.

Table 1 – Baseline socio-demographic, workplace, sitting and activity characteristics of office workers in intervention and comparison groups a

	Intervention (*n*=18)	**Comparison (*n*=14)**[d]
Age, *years*	33.5 ± 8.7	39.9 ± 7.2
Women, % (*n*)	94.4 (17)	85.7 (12)
Caucasian, % (*n*)	94.4 (17)	78.6 (11)
Married, % (*n*)	66.7 (12)	100.0 (14)
Doctorate, % (*n*)	27.8 (5)	71.4 (10)
Tenure at current workplace, % (*n*)		
≤ 1 year	16.7 (3)	14.3 (2)
1 to ≤ 3 years	44.4 (8)	28.6 (4)
3 to ≤ 5 years	16.7 (3)	28.6 (4)
> 5 years	22.2 (4)	28.6 (4)
1.0 Full Time Equivalent, % (*n*)	72.0 (13)	57.0 (8)
Staff type, % (*n*)		
Student	27.8 (5)	7.1 (1)
General staff	44.4 (8)	21.4 (3)
Academic staff	27.8 (5)	71.4 (10)
Office shared with, % (*n*)		
0 others	16.7 (3)	35.7 (5)
1-3 others	83.3 (15)	14.3 (2)
>3 others (Open Plan)	0.0 (0)	50.0 (7)
Never smoker, % (*n*)	77.8 (14)	78.6 (11)
Body Mass Index, kg/m^2	22.6 ± 2.6	21.5 ± 2.6
At the workplace [b]		
Sitting, *mins/8-h workday*	329 ± 55	377 ± 56
Standing, *mins/8-h workday*	110 ± 48	73 ± 48
Stepping, *mins/8-h workday*	41 ± 14	29 ± 16
Sit-to-stand transitions, *N/hr sitting*	9 ± 9	4 ± 2
During overall waking time [c]		
Sitting, *mins/16-h day*	551 ± 75	607 ± 82
Standing, *mins/16-h day*	260 ± 52	219 ± 62
Stepping time, *mins/16-h day*	150 ± 38	134 ± 41
Sit-to-stand transitions, *N/hr sitting*	7 ± 1	6 ± 3

[a] Table presents means ± standard deviations or % of group (*n*)

[b] Mins/8-hr workday = minutes at the workplace, standardized to 8 hours of work time (i.e. standardized minutes = minutes * 480 / observed minutes at the workplace)

[c] Mins/16-h day = minutes during overall waking time, standardized to a 16-h waking day (i.e. standardized minutes = minutes * 960 / observed minutes)

[d] Sitting and activity data excluded for one comparison participant with a monitor malfunction

Table 2 – Changes in sitting, standing, stepping and sit-to-stand transitions at the workplace and during overall waking time a

	Intervention	**Comparison**	**Intervention - Comparison**	
	***n*=18**	***n*=13[b]**	**Difference**	***p***
At the workplace				
Sitting time, *mins/8-h workday*				
One week	-137 (-162, -111)*	6 (-24, 36)	-143 (-184, -102)	<0.001
Three months	-125 (-150, -99)*	12 (-20, 44)	-137 (-179, -95)	<0.001
Standing time, *mins/8-h workday*				
One week	130 (105, 155)*	-4 (-34, 25)	134 (95, 174)	<0.001
Three months	124 (99, 149)*	-6 (-37, 24)	131 (90, 171)	<0.001
Stepping time, *mins/8-h workday*				
One week	6 (3, 9)*	-1 (-4, 3)	7 (2, 11)	0.005
Three months	0 (-4, 4)	-5 (-10, 0)	4 (-2, 11)	0.194
Sit-to-stand transitions, *N/hour sitting at work*				
One week	3 (2, 5)*	-2 (-4, 0)	5 (3, 7)	<0.001
Three months	1 (-1, 2)	-2 (-4, 0)	3 (0, 5)	0.039
During overall waking time				
Sitting time, *mins/16-h day*				
One week	-69 (-98, -39)*	28 (-7, 63)	-97 (-144, -50)	<0.001
Three months	-79 (-109, -50)*	-2 (-38, 35)	-78 (-125, -30)	0.002
Standing time, *mins/16-h day*				
One week	71 (51, 91)*	-17 (-41, 7)	88 (56, 120)	<0.001
Three months	90 (61, 118)*	7 (-27, 42)	83 (37, 128)	<0.001
Stepping time, *mins/16-h day*				
One week	-1 (-10, 8)	-13 (-23, -2)*	11 (-3, 25)	0.112
Three months	-10 (-19, -1)	-7 (-18, 4)	-2 (-17, 12)	0.750

Sit-to-stand transitions, *N/ h sitting*				
One week	0 (0, 1)	-1 (-1, 0)*	1 (1, 2)	0.002
Three months	0 (-1, 1)	0 (-1, 1)	0 (-1, 1)	0.946

[a] Mean change from baseline (95% Confidence Interval), adjusted for baseline value

[b] *n*=13 due to exclusion of one participant with a monitor malfunction; *n*=12 at 3 months due to drop-out (*n*=1).

* $p<0.05$ for change from baseline