Title: Reducing sitting time in office workers: short-term efficacy of a multicomponent intervention

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ABSTRACT

Objective: To investigate the short-term efficacy of a multicomponent intervention to reduce office workers' sitting time.

Methods: Allocation for this non-randomized controlled trial (n=43 participants; 56% women; 26-62 years; Melbourne, Australia) was by office floor, with data collected during July-September 2011. The 4-week intervention emphasized three key messages: "Stand Up, Sit Less, Move More" and comprised organizational, environmental, and individual elements. Changes in minutes/day at the workplace spent sitting (primary outcome), in prolonged sitting (sitting time accumulated in bouts ≥30 minutes), standing, and moving were objectively measured (activPAL3).

Results: Relative to the controls, the intervention group significantly reduced workplace sitting time (mean change [95%CI]: -125 [-161, -89] mins/8-hr workday), with changes primarily driven by a reduction in prolonged sitting time (-73 [-108, -40] mins/8-hr workday). Workplace sitting was almost exclusively replaced by standing (+127 [+92, +162] mins/8-hr workday) with non-significant changes to stepping time (-2 [-7, +4] mins/8-hr workday) and number of steps (-70 [-350, 210]).

Conclusions: This multicomponent workplace intervention demonstrated that substantial reductions in sitting time are achievable in an office setting. Larger studies with longer timeframes are needed to assess sustainability of these changes, as well as their potential longer-term impacts on health and work-related outcomes.

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Introduction

Excessive sitting time – a risk factor for cardiovascular disease, type 2 diabetes, and premature mortality (Thorp et al., 2011; Wilmot et al., 2012) – is prevalent within the office-based workplace. An estimated two-thirds of work hours are spent sitting, with much of this time accumulated in prolonged unbroken bouts of at least 20 to 30 minutes (Evans et al., 2012; Ryan et al., 2011; Thorp et al., 2012). However, as noted in two recent reviews (Chau et al., 2010; Healy et al., 2012), relatively few workplace intervention trials have specifically addressed this prevalent health risk behavior.

To date, the evidence relating to reducing and/or interrupting sitting time at work is predominantly from the ergonomic literature, with a focus on musculoskeletal health outcomes (Healy et al., 2012; Husemann et al., 2009; Roelofs and Straker, 2002). Key research gaps identified (Healy et al., 2012) include the need for controlled trials that specifically target, and objectively measure, workplace sitting time. Furthermore, such trials should include assessment of the cardio-metabolic biomarkers shown in epidemiological and experimental studies to be detrimentally related to prolonged, unbroken sitting (Dunstan et al., 2012; Healy et al., 2011) in order to evaluate the potential health benefits of reducing workplace sitting time (and increasing standing). Finally, and consistent with best practice workplace health promotion frameworks (Carnethon et al., 2009; Department of Health and Human Services, 2008; World Health Organization, 2010), interventions should target not only the individual, but also the organisation and the work environment (Healy et al., 2012; Pronk, 2009). Although previous trials have incorporated one (e.g. Alkhajah et al., 2012; John et al., 2011; Kozey-Keadle et al., 2012), or some of these intervention elements (e.g. Ellegast et al., 2012; Pronk et al., 2012), none have integrated all components to specifically address and measure reductions in objectively-assessed workplace sitting.

The aim of this trial was to assess the short-term efficacy of an intervention integrating individual-, environmental-, and organizational-change elements to reduce workplace sitting. We examined whether participants receiving the multicomponent intervention, relative to control participants, would differ in overall objectively-measured workplace sitting time (primary outcome). We also assessed differences in sitting time accrued in prolonged bouts, in standing time, and in moving time, as well as health-related (cardio-metabolic biomarkers, anthropometric measures, musculoskeletal symptoms) and work-related (work-performance, absenteeism, presenteeism) outcomes.

METHODS

Study Design

Data for this two-arm, non-randomized controlled trial were collected between July-September 2011 and analyzed May-August 2012. The study was approved by the Alfred Health Human Ethics Committee (Melbourne, Australia). Assessments occurred at baseline, and following the final contact of the individual element of the intervention (approximately 4 weeks; follow-up). Research staff, participants, and assessors were not blinded to group allocation.

Recruitment

Organization: A single workplace (*Comcare*: the government agency responsible for workplace safety, rehabilitation and compensation for Australian government workplaces) in metropolitan Melbourne, Australia was recruited. The *Comcare* office included 130 employees housed over two, open-plan floors. Management approval was obtained for employee recruitment, environmental changes in the office, and for study contacts to occur during work time.

Employees: An invitation email was sent by management to all potential participants (both intervention [n=80] and control [n=50]) to attend one of two 30-minute study information sessions delivered by research staff (see Figure). Participants who subsequently expressed

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interest were screened via telephone for eligibility: aged 18-65 years; working at least 0.6 full time equivalent; workplace access to a telephone, internet and desk; ambulatory; not pregnant; not having a pre-existing musculoskeletal disorder; and, not planning an absence of >1 week during the study. Participants provided written informed consent and attended the baseline assessment. Allocation of group was by floor, with intervention participants (primarily administrative staff) working on the floor above control participants (predominantly senior administrative staff).

Intervention

The intervention communicated three key messages: "*Stand Up, Sit Less, Move More*" and comprised organizational, environmental, and individual elements.

Organizational

The intervention began with a 45-minute researcher-led consultation with unit representatives from the intervention group and management. This provided background information and emphasized the importance of organizational support for successful intervention adoption. Representatives brainstormed and selected organization-specific strategies to the "*Stand Up, Sit Less, Move More*" approach (Supplemental Table 1). The research team then conducted a workshop for all intervention participants, providing further intervention details and information on the health consequences of excessive sitting, and discussing as well as adjusting the identified strategies. A liaison person from the organization (LG) served as the interface between the research team and the organization, with regular contact serving to troubleshoot any difficulties and reinforce active organizational support. Additionally, the liaison person sent two emails (template provided by research team) noting study progress and providing a "standing tip of the week".

Environmental

Dual display sit-stand workstations *(ErgotronWorkFit-S:* www.ergotron.com; ~US$400*)*, including the worksurface accessory, were provided and installed for the 4-week duration of the study (installation duration ~45 minutes/workstation). The workstations allowed employees to alternate their posture between sitting and standing. Participants received brief verbal instructions from research staff and an information sheet, which included ergonomic guidelines from the manufacturer (www.ergotron.com/tabid/305/language/en-AU/Default.aspx). An occupational therapist (provided by *Comcare*) was available for further advice and follow-up assessments.

Individual

Two master's level health coaches delivered an initial 30-minute face-to-face consultation with each intervention participant, followed by three telephone calls (one/week). Wherever possible, employees spoke to the same coach. These sessions emphasized behavior change strategies (goal-setting, self-monitoring, and use of prompts and problem solving: [Abraham and Michie, 2008]), consistent with the motivational interviewing approach utilized. The coaching session included feedback on participants' baseline activity monitor results, which were used to inform personally tailored goals regarding each of the intervention messages. Specific recommendations encouraged participants to: *Stand Up* at least every 30 minutes; *Sit Less* by using the workstation, aiming for approximately equal amounts of sitting and standing time, but emphasizing the need for gradual increases and frequent postural change; and, *Move More* by increasing incidental physical activity (Supplementary Table 1).

Control group

Control group participants were advised to maintain their usual work practices.

Data collection

At each assessment, all participants wore an activPAL3 activity monitor for seven days (PAL Technologies Limited, Glasgow, UK), completed a self-administered questionnaire, and underwent morning anthropometric and fasting (minimum 8 hours) blood measurement.

Measures

The activity monitor outcomes were directly measured over a seven-day period using the valid and responsive (Berendsen, 2011; Grant et al., 2006; Kozey-Keadle et al., 2011; Ryan et al., 2006) activPAL3 activity monitor (version 6.3.0: default settings used). Participants were requested to wear the monitor (53 x 35 x 7mm; 15g) 24 hours/day after it was waterproofed (with a finger cot and waterproof surgical dressing) and secured on the anterior mid-line of the right thigh using a breathable hypoallergenic adhesive patch. Participants recorded in a log time spent at their primary workplace, awake/asleep times, and monitor removal (if any).

Weight, fat mass, and fat-free mass were measured when voided without shoes and heavy clothing using a bioimpedance analysis scale (Model SC-330, Tanita Inc., Tokyo, Japan) to the nearest 0.1kg/ 0.1%. Seated blood pressure (HEM-907; Omron) and waist and hip circumference (nearest 0.1cm) measures were obtained in duplicate and averaged. A phlebotomist collected the fasting blood sample on-site, with samples sent immediately to an accredited testing laboratory (Melbourne Pathology) where plasma glucose (spectrophotometric-hexokinase) and cholesterol and triglycerides (enzymatic-colorimetric) were assessed. Serum for insulin assays was frozen at -80 degrees Celsius and measured in a single batch by electrochemiluminescence immunoassay.

Data on socio-demographic characteristics were collected at baseline. General health (fatigue [Lawler, 1999], eye strain [May et al., 2004] headaches, digestion and sleep problems [Lawler, 1999], musculoskeletal health [Dickinson et al., 1992]), and work-related (self-rated work performance [Sundstrom et al., 1994], absenteeism and presenteeism) outcomes were measured at both assessments for possible benefit or adverse outcomes of the trial.

Activity monitor data processing

The activPAL3 continuously records the precise beginning and ending of each bout of sitting or lying (here termed sitting), standing, and stepping at a variety of speeds, and the estimated MET-hours expended during those bouts. Data were processed in SAS 9.2 (SAS Institute Inc., Cary, NC). Waking days were identified based on sleep/wake cycles, with bouts that were mostly (≥50%) asleep, non-wear, or not at the workplace according to participant self-report being excluded. Totals were calculated for each day and averages were calculated from valid days, i.e., worn ≥75% of the time at the workplace (109/168 days at baseline; 154/164 days at follow-up). To account for variations in schedules, the outcomes were standardized to an 8-hour workday [standardized minutes = outcome minutes*480/observed workplace minutes] and no minimum requirement for days at the workplace was imposed. Changes from baseline to follow-up in workplace outcomes were assessed for each of the following key intervention messages:

Stand up: Standing time; number of sit-to-stand transitions per hour of sitting;

Sit less: Sitting time (<u>primary outcome</u>) and prolonged sitting (time accumulated in prolonged, unbroken sitting bouts ≥30 minutes); and

Move more: Stepping time, number of steps, and MET minutes of moderate-to-vigorous physical activity (MVPA; at ≥4 METs [≥120 steps per minute]).

Statistical analyses

A sample size of 20 per group (recruiting 24 with an assumed 20% attrition) was necessary to ensure at least 80% power with 5% significance (two-tailed) for minimum detectable differences of: one hour (sitting, standing and prolonged sitting); 10 minutes (stepping), 10-MET-mins (MVPA) and 1.1 (sit-to-stand transitions). The study was not powered for health or work-related secondary outcomes. However, collection of these data enabled assessment of the feasibility of this data collection and the provision of effect size estimates to inform sample size for subsequent trials.

Analyses were conducted in PASW Statistics, version 20.0.0 (SPSS, Inc., Chicago IL). Significance was set at $p<0.05$ (two-tailed). Linear regression models, adjusted for baseline values (Barnett et al., 2005; Vickers and Altman, 2001), were used to determine intervention effects for continuous outcomes; sample size was insufficient to examine effects for categorical outcomes. Socio-demographic and workplace characteristics were tested as potential confounders, but were not associated with changes in sitting (i.e. $p>0.1$) and did not affect estimates of intervention effects (to within 20%). Within-group changes were assessed by paired t-tests (continuous outcomes) or McNemar test (categorical variables). Any change (baseline to follow-up) in health- or work-related dichotomous outcomes of ≥20% is reported.

RESULTS

Of the 44 employees enrolled in the study, 18 in each group provided primary outcome data at both assessments (Figure). The main difference between groups was the greater proportion of women in the intervention group (Table 1).

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Changes in sitting, standing, and moving

For both groups combined, the mean (±SD) monitored time at the workplace was 8.3±1.3 hrs/day at baseline. Standardized to an 8-hour workday, most time was spent sitting (5.6±0.7 hrs; 70.1% of work time) followed by standing (1.7±0.6 hrs; 21.1%) and stepping (0.7±0.2 hrs;

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8.8%). Prolonged sitting in bouts ≥30 minutes (2.2±1.1 hrs) accounted for more than a third of total sitting time (39%), and more than a quarter of total time (27%) at the workplace.

Table 2 shows changes in the *Stand Up, Sit Less, and Move More* outcomes for the intervention and control groups. At baseline, there were no significant differences between groups for any of these outcomes. At follow-up, there were significant intervention effects (favoring the intervention group) for all of the *Stand Up* and *Sit Less* outcomes, but not the *Move More* outcomes. The changes in the intervention group (relative to the control group) were over two hours per eight-hour workday (of increased standing [95% CI 92, 162mins] and decreased sitting [95% CI -161, -89mins]). Further, there were nearly two additional sit-stand transitions per hour of sitting (95% CI 0.7, 3.0) and approximately one less hour of prolonged sitting (95% CI -105, -40mins).

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Changes in health and work-related outcomes

No statistically significant intervention effects (beneficial or adverse) were observed for any of the anthropometric or cardio-metabolic health outcomes, or for other continuously measured health and work related outcomes, including work performance (Supplemental Table 2). Glucose improved significantly within the intervention group; all other within-group changes were non-significant. There was some weak evidence ($p<0.2$) of potential beneficial effect for insulin, and potentially adverse effects for triglycerides, fat mass, and diastolic blood pressure. Supplemental Table 3 shows the sample sizes required to detect intervention effects (whether benefit or harm) of the magnitude observed in this study with 5% significance, not accounting for attrition or design effects, should a cluster-randomized design be used.

There were no statistically significant within-group changes in musculoskeletal symptoms, other categorically measured health symptoms, presenteeism, or absenteeism (Supplemental Table 3). Although the prevalence of several symptoms varied over time within controls (by $\geq$ 20%), only "trouble waking up" varied by at least this extent in the intervention group (47% baseline; 72% follow-up).

DISCUSSION

This study demonstrated, for the first time, that a multicomponent workplace intervention, utilizing organizational, environmental, and individual elements, was achievable within an office context. It achieved sizeable (>2-hrs per 8-hr workday) reductions in workplace sitting. The intervention group's sitting reduction (-26.5% of workplace time) is consistent with previous workplace interventions that have specifically targeted sitting (range -0.1% to -40%; (Alkhajah et al., 2012; Ellegast et al., 2012; Evans et al., 2012; Gilson et al., 2011; Hedge, 2004; Pronk et al., 2012; Winkel and Oxenburgh, 1991). Importantly, these changes occurred without indication of a corresponding decrease in work performance or adverse musculoskeletal outcomes.

A message to get up at least every 30 minutes is widely advocated within the ergonomic and occupational health and safety disciplines (Worksafe Victoria, 2006). The significant increase in sit-stand transitions and approximately 50% reduction in prolonged sitting time suggest such regular postural changes may be feasible amongst office workers performing administrative tasks. The lack of meaningful change in the *Move More* outcomes may reflect the limited opportunities for physical activity in the office setting, the typically short duration of these activities (e.g. walking to see a colleague), and/or the nature of the workspace modification (sit-stand vs. treadmill desk). Future studies could explore how strategies utilized in successful workplace physical activity interventions (Conn et al., 2009) could be integrated into the *Move More* message.

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We cannot assess the relative contribution of the different intervention elements to improvements in activity-related outcomes. However, the relatively short intervention period suggests most of the change is likely to be attributable to the environmental (sit-stand workstation) and individual strategies, acknowledging that organizational *support* for these changes was also essential (i.e., the intervention occurring during paid work time). Organizational *change*, evidenced through changes in job design, physical work environment, workplace social norms, or workplace culture, is likely to take longer than the four-week study timeframe to become institutionalized. However, this element was still important to include in the current study, not only to determine feasibility of delivery, but also because organizational change is necessary for sustained adoption of workplace behavior change and control of work-related risk factors (Noblet and LaMontagne, 2009). Notably, Comcare has now developed and disseminated their own sedentary work practices toolkit (Comcare, 2012).

While mechanisms remain to be further elucidated, reducing prolonged sitting time may improve health via beneficial action on lipoprotein lipase activity (Hamilton et al., 2007) and skeletal muscle gene expression (Latouche et al., 2013; Zderic and Hamilton, 2012), and may improve productivity via both long-term (reduced absenteeism / presenteeism [Healy et al., 2012; Nerhood and Thompson, 1994]), and short-term (e.g. enhanced blood flow; reduction in muscle fatigue pathways [Canadian Centre for Occupational Health & Safety, 2010; Visser and Straker, 1994]). While this study was not powered for health and work-related outcomes, the findings do provide some guidance regarding the magnitude of potential effects and the resultant sample sizes needed, as it is one of the few to examine the impact of changing workplace sitting on cardio-metabolic biomarkers (Alkhajah et al., 2012; John et al., 2011). Notably, the direction of the effects was not consistently beneficial and these findings need to be explored in larger, adequately powered trials.

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The accurate, objective measurement of *"Stand Up, Sit Less, Move More"* and cardio-metabolic outcomes was a key strength. Limitations of this study include the short duration, the inability to randomize intervention allocation, and the small sample size. Allocation was by floor to minimize contamination, but contamination may have been present, attenuating results. Although we adjusted for baseline values and tested for confounding, unmeasured confounders may have affected the results. Furthermore, potential differences in job tasks between the groups may have impacted on activity levels, though the lack of meaningful baseline differences in activity measures suggests this is less likely. Although participants from the current study were recruited from a non-research, non-academic setting, they were employees from a government agency for workplace safety, rehabilitation and compensation. As such, results here may represent a best case scenario in terms of intervention effects. To address these limitations, future trials should be implemented in settings that are more representative of the general working population and incorporate: cluster-randomized controlled designs, factorial designs or multiple arms to evaluate each intervention component, longer follow-up, and sample sizes that can detect health and work-related benefits or adverse impacts. Future investigations should also assess cost-effectiveness, as well as examine time-of-day effects and potential mediators and moderators. One such trial (Stand Up Victoria: http://www.ANZCTR.org.au/ACTRN12611000742976.aspx) is currently underway. Nevertheless, this present study provides important preliminary evidence that a multicomponent intervention is not only achievable to deliver in an office setting, but can result in sizeable reductions in workplace sitting time – at least in the short term.

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Figure: Flow diagram of enrolment, participation, and analyses of participants (Comcare, Melbourne, Australia, 2011).

Table 1 –Socio-demographic, work, and health characteristics of office-based employees in intervention and control groups at baseline

	Intervention (n=22)	**Control (n=21)**	**All (n=43)**
Age, years	42.4 ± 10.6	42.9 ± 10.3	43.2 ± 10.3
Men	23% (5)	67% (14)	44% (19)
Caucasian	77% (17)	100% (21)	88% (38)
Married/ living together	68% (15)	76% (16)	72% (31)
Tertiary education	68% (15)	52% (11)	61% (26)
Tenure at current workplace			
≤ 1 year	32% (7)	48% (10)	40% (17)
1 to ≤ 3 years	18% (4)	19% (4)	19% (8)
>3 years	50% (11)	33% (7)	42% (18)
1.0 Full Time Equivalent	86% (19)	100% (21)	93% (40)
Staff type			
Permanent	82% (18)	81% (18)	81% (35)
Contract	18% (4)	19% (4)	19% (8)
Job Category [a]			
Managers/professionals	43% (9)	86% (18)	64% (27)
Clerical/service/sales	57% (12)	14% (3)	36% (15)
Never smoker	86% (19)	86% (18)	86% (37)
Body Mass Index,kg/m^2	27.5 ± 6.1	26.2 ± 4.6	26.8 ± 5.4
History of high cholesterol	14% (3)	24% (5)	19% (8)
History of diabetes	0% (0)	0% (0)	0% (0)

Table presents means (standard deviations) or % (n) of group
[a] One intervention participant did not complete this question
Note: Participants (recruited July 2011) were employees of Comcare (Melbourne, Australia)

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Table 2: Baseline, follow-up, and adjusted between-group differences for the *Stand Up, Sit Less, Move More* outcomes

Measure	Intervention (n=18) mean (SD)		Control (n=18) mean (SD)		Intervention – Control [a]	
	Baseline	Follow-up	Baseline	Follow-up	mean (95%CI)	*p*
Workplace monitor wear, hrs/day	8.4 (0.6)	8.3 (0.8)	8.2 (1.6)	8.5 (0.7)		
Stand Up						
Standing time, mins/8-h workday	99.9 (26.2)	221.1 (68.1)*	102.6 (48.2)	95.8 (46.1)	127.2 (92.0, 162.4)	<0.001
Sit-to-stand transitions, N/hour workplace sitting	5.7 (1.6)	7.2 (2.3)*	6.4 (3.7)	5.8 (2.8)	1.9 (0.7, 3.0)	0.003
Sit Less						
Sitting time, mins/8-h workday	338.5 (35.3)	216.7 (67.9)*	334.7 (52.4)	339.3 (51.4)	-125.2 (-161.4, -88.9)	<0.001
Time accrued in prolonged sitting ≥30 minutes, mins/8-h workday	138.2 (64.6)	73.7 (32.4)*	124.3 (73.1)	141.8 (72.6)	-73.7 (-107.5, -39.8)	<0.001
Move More						
Stepping time, mins/8-h workday	41.6 (13.1)	42.2 (11.8)	42.8 (13.8)	44.8 (12.5)	-1.8 (-7.3, 3.6)	0.496
MVPA MET minutes, mins/8-h workday	19.7 (15.4)	20.3 (18)	13.5 (19)	13.8 (18)	0.08 (-6.25, 6.41)	0.981
Steps, n/8-h workday	1997 (678)	2019 (645)	1924 (549)	2038 (531)	-70 (-350, 210)	0.614

[a]Mean change from baseline (95% Confidence Interval), adjusted for baseline value (ANCOVA)
* $p<0.05$ for within-group change from baseline (paired t-test)
MVPA MET: Metabolic equivalent minutes spent at a moderate-vigorous intensity of physical activity (≥4 METS).
Mins/8-hr workday = minutes at the workplace, standardized to 8 hours of work time (i.e. standardized mins = mins * 8/ observed hours at the workplace)
Note: Participants were employees of Comcare (Melbourne, Australia). The intervention was undertaken July-September 2011.

Supplemental Table 1: Organizational and individual behaviour change strategies used

Organizational strategies	**Individual behaviour change strategies**
• “laps” around office - defined circuit • introduction of more standing into meetings (initiated by Chairperson from the outset) • use printers further away • ergonomically sound exercises at scheduled times • wireless / hands free headsets for telephone calls (to enable standing) • breaks compliance software • use the stairs (reduced access at the moment) • “no bins” policy – no personal bins • timed walking routes in vicinity of building	**Stand Up (**postural change at least every 30 minutes) • Set a timer (online, through outlook, etc) • Stand up when the phone rings or when someone enters the office • Stand up when someone else does • Stand Up to get water regularly • When looking at the ‘Tracker’ • Pick up printing more often • Used my body as prompt when I got uncomfortable and changed position **Sit Less (**replace blocks of sitting time with standing time) • Determine certain ‘standing times’, i.e. every morning and after lunch • Stand during meetings • Stand Up during particular tasks (e.g. checking emails, formatting, at the beginning of long tasks, when working on the computer etc) • Stand Up during phone calls **Move More** (increase incidental activity) • Use the stairs instead of the lift • Walking laps • More active lunch breaks (e.g. walking around the block) • Fill water bottle/ pick up printing more often • iMails (walking to see a colleague) • Using printer across the other end of the office • Pick up printing more often

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	• Walking colleagues as cue to walk more myself • Walk to a toilet that is further away • Wearing “rocker” shoes to help move more while standing

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Supplementary Table 2 – Baseline, follow-up and adjusted between-group differences for anthropometric and cardio-metabolic biomarkers, and self-reported fatigue, eyestrain, and work performance

	Intervention mean (SD)		Control mean (SD)		Intervention – Control [a]	
Measure	**Baseline**	**Follow-up**	**Baseline**	**Follow-up**	**mean (95%CI)**	***p***
Anthropometric (n=19 per group)						
Weight, kg	77.6 (15.6)	77.6 (15.8)	82.7 (18.4)	82 (17.3)	0.47 (-1.00, 1.95)	0.519
Waist circumference, cm	91.1 (12)	90.9 (11.7)	91.2 (15.0)	90.6 (14.6)	0.39 (-1.70, 2.47)	0.710
Hip circumference, cm	107.5 (13.6)	108.3 (12.8)	103.4 (8.4)	103.6 (7.3)	1.03 (-0.86, 2.93)	0.276
Fat free mass, kg	51.4 (9.8)	51.5 (10.0)	60.7 (12.7)	60.8 (12.6)	-0.09 (-1.14, 0.95)	0.855
Fat mass, kg	26.3 (12.3)	26.1 (12.4)	22.1 (10.1)	21.2 (9.2)	0.85 (-0.41, 2.10)	0.180
Cardio-metabolic (n=18 per group)						
Cholesterol-total (mmol/L)	4.81 (0.92)	4.80 (0.92)	5.13 (0.85)	4.94 (0.70)	0.07 (-0.32, 0.47)	0.702
Triglycerides (mmol/L)	1.02 (0.37)	1.19 (0.44)	1.18 (0.61)	1.18 (0.81)	0.19 (-0.02, 0.41)[b]	0.075
HDL-Cholesterol (mmol/L)	1.58 (0.43)	1.54 (0.38)	1.48 (0.43)	1.40 (0.4)	0.04 (-0.08, 0.17)	0.464
LDL-Cholesterol (mmol/L)	2.76 (0.92)	2.73 (0.84)	3.12 (0.73)	3.00 (0.59)	-0.01 (-0.31, 0.28)	0.918
Glucose (mmol/L)	4.94 (0.98)	4.51 (1.06)*	4.58 (0.70)	4.48 (0.99)	-0.30 (-0.78, 0.18)	0.217
Insulin (pmol/L)[c]	62.9 (36.3)	56.4 (35.7)	42.5 (18.8)	48.7 (38.3)	-15.7 (-34.30, 2.90)	0.096
Systolic BP (mmHg)	131.6 (13.8)	133.5 (14.8)	130.6 (15.1)	129.4 (11.3)	3.55 (-3.77, 10.87)	0.331
Diastolic BP (nmHg)	76.8 (8.2)	79.2 (9.3)	79.4 (8.4)	76.7 (9.6)	4.02 (-1.64, 9.68)	0.158
Self-reported (n=18 intervention, 19 control)						
Eye strain (1-7)	3.2 (1.6)	2.9 (1.8)	2.8 (1.5)	2.9 (1.6)	-0.18 (-1.23, 0.87)	0.734

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Fatigue (1-5)	2.9 (0.6)	2.8 (0.9)	2.6 (0.5)	2.8 (0.7)	-0.19 (-0.69, 0.31)	0.450
Work performance (1-10)	7.6 (0.9)	7.9 (0.9)	7.9 (0.9)	7.8 (0.9)	0.21 (-0.36, 0.77)	0.465

* $p<0.05$ for change from baseline (paired t-test)
[a] mean difference at follow-up between intervention and control participants, adjusted for baseline values (i.e. also mean difference in change, adjusted for baseline values). SD, standard deviation; CI, confidence interval; HDL, high density lipoprotein; LDL, low density lipoprotein
[b] Log transformed values used in the model and shown here.
[c] converted from mU/L by multiplying by a factor of 6.
Eye strain: 3-item scale. Higher scores indicate a more severe condition (May et al., 2004). Defined as present if observed at all in the last week.
Fatigue: 7-item scale (Lawler, 1999). Higher scores indicate a more severe condition.
Work performance: 9-item scale (Sundstrom et al., 1994). Higher scores indicates better performance.
Note: Participants were employees of Comcare (Melbourne, Australia). The intervention was undertaken July-September 2011.

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Supplementary Table 3 – Sample sizes required for adequately powered trials to detect intervention effects observed in the present study with 5% significance (two-tailed)

Measure	Standard Deviation (post)		Correlation (Pre-post)	Difference	N/group required [a]	
	Control	Intervention			80% power	90% power
Anthropometric (n=19 per group)						
Weight, kg	17.3	15.8	0.991	0.47	350	468
Waist circumference, cm	14.6	11.7	0.972	0.39	998	1336
Hip circumference, cm	7.3	12.8	0.964	1.03	114	153
Fat free mass, kg	12.6	10.0	0.993	-0.09	3499	4683
Fat mass, kg	9.2	12.4	0.986	0.85	73	97
Clinical (n=18 per group)						
Cholesterol-total (mmol/L)	0.70	0.92	0.728	0.07	1007	1347
Log triglycerides (mmol/L)	0.51	0.32	0.825	0.19	25	33
HDL-cholesterol (mmol/L)	0.40	0.38	0.895	0.04	298	398
LDL-cholesterol (mmol/L)	0.59	0.84	0.828	-0.01	26004	34812
Glucose (mmol/L)	0.99	1.06	0.732	-0.3	86	115
Insulin (pmol)[b]	38.3	35.7	0.720	-15.7	43	57
Systolic BP (mmHg)	11.3	14.8	0.563	3.55	148	198
Diastolic BP (nmHg)	9.6	9.3	0.481	4.02	67	90
Self-reported (n=18 Intervention, 19 control)						
Eye strain (1-7)	1.6	1.8	0.449	-0.18	1112	1502
Fatigue (1-5)	0.7	0.9	0.525	-0.19	205	275

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Work performance (1-10)	0.9	0.9	0.565	0.21	197	263

[a] Number of independent observations per group required for 80% or 90% power to detect differences observed in this study, with 5% significance, assuming the ANCOVA method is used; does not account for attrition or clustering (if randomizing multiple workplaces)
[b] converted from mU/L by multiplying by a factor of 6.
Note: Participants were employees of Comcare (Melbourne, Australia). The intervention was undertaken July-September 2011.

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Supplementary Table 3 – Self-reported musculoskeletal symptoms, general health symptoms, and work-related outcomes in each group at baseline and follow-up

	Intervention			Control		
	Baseline (*n*=19)	**Follow-up (*n*=18)**	**p**	**Baseline (*n*=19)**	**Follow-up (*n*=19)**	**p**
Musculoskeletal symptoms[a]						
Neck	58% (11)	50% (9)	0.999	79% (15)	47% (9)	0.070
Shoulders	42% (8)	39% (7)	0.999	37% (7)	42% (8)	0.999
Elbows	11% (2)	17% (3)	0.999	11% (2)	21% (4)	0.500
Wrist/hands	42% (8)	28% (5)	0.375	32% (6)	16% (3)	0.250
Upper back	32% (6)	28% (5)	0.999	47% (9)	16% (3)	0.070
Lower back	53% (10)	44% (8)	0.625	63% (12)	37% (7)	0.125
Hips/thighs/buttocks	32% (6)	39% (7)	0.999	21% (4)	37% (7)	0.375
Knees	26% (5)	11% (2)	0.625	37% (7)	26% (5)	0.500
Ankles/feet	16% (3)	22% (4)	0.500	32% (6)	16% (3)	0.200
Other health symptoms[a]						
Migraine headache	21% (4)	17% (3)	0.999	21% (4)	26% (5)	0.999
Headache other than migraine	79% (15)	78% (14)	0.999	63% (12)	58% (11)	0.999
Digestion problems	58% (11)	61% (11)	0.999	26% (5)	42% (8)	0.375
Trouble waking	47% (9)	72% (13)	0.125	21% (4)	42% (8)	0.375
Trouble sleeping	58% (11)	67% (12)	0.999	42% (8)	42% (8)	0.999
Work-related outcomes						
≥1 Sick day (last month)	47% (9)	33% (6)	0.549	53% (10)	58% (11)	0.999
≥1 days worked while suffering health problems (last month)	53% (10)	39% (7)	0.549	58% (11)	42% (8)	0.453

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Table presents % (*n*). Within group changes were assessed by McNemar test (exact).
[a] symptom defined as present if observed at all in the last month (Dickinson et al., 1992; Lawler, 1999).
Note: Participants were employees of Comcare (Melbourne, Australia). The intervention was undertaken July-September 2011.

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