Sitting time and step counts in office workers

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Introduction

Evidence suggests that sedentary behaviour, defined as ‘any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents [METs] while in a sitting or reclining posture’ [1], is an independent risk factor for a number of adverse health outcomes. For example, greater sitting time has been associated with increased risk of obesity [2,3], some cancers [4], type 2 diabetes and the metabolic syndrome [2,5], and of mortality from all causes and cardiovascular disease [6,7].

Adults typically spend time sitting in three settings: at work, during leisure and when travelling [8]. Economic advances and industrial innovation have resulted in many people being employed in sedentary occupations. Australian workers have been shown to spend half of their total daily sitting time at work [9,10]. Similar findings have been reported in UK workers [11]. Furthermore, recent evidence suggests that individuals who sit for long periods of their working day do not compensate by increasing their physical activity levels and/or reducing their sitting time during leisure time [10,12–14].

Our limited understanding of sitting time in UK adults is largely restricted to studies of leisure-time screen-based sedentary behaviours such as computer use and television viewing [15], or of specific occupational groups [13]. To increase our understanding of patterns and determinants of sedentary behaviour in adults, and to inform behaviour change interventions, it is important to measure all types of sedentary behaviour, in a range of settings, particularly the workplace [11]. The aim of this study was to examine sedentary behaviour and physical activity during and outside working hours in a sample of full-time office workers from England. A secondary aim...
was to develop our understanding of the links between occupational sitting and leisure sitting, by investigating whether those who sit for long periods at work compensate by decreasing their sitting, or increasing their physical activity, when not at work. This increased understanding could inform workplace interventions targeting physical activity and sedentary behaviour.

**Methods**

We recruited volunteers through advertisements posted on staff notice boards at work, and via word of mouth, from two workplaces (an insurance company and a college of further education) in the East Midlands region of England. The study was approved by the Loughborough University Ethical Advisory Committee, and participants provided written informed consent.

We measured participants’ body mass (kg) and height (cm) without shoes, using electronic scales (Tanita UK Ltd) and a wall-mounted stadiometer (Seca UK) before the monitoring period. Body mass index (BMI) was calculated as kg/m². All participants completed an initial health screening questionnaire. We measured physical activity using Yamax Digi-Walker SW-200 pedometers, worn throughout waking hours for 1 week. We chose pedometers given their popularity in workplace activity promotion campaigns [16]. The SW-200 pedometer has been shown to accurately detect steps taken in both free-living conditions [17,18] and in controlled laboratory conditions in normal weight and overweight [19–21] individuals. We showed participants the appropriate position to wear the pedometer, on the waistband in-line with the midline of the anterior aspect of the thigh, at the outset. We confirmed pedometer accuracy for each participant on issue with a 20-step test (acceptance criteria: 20 ± 2 steps recorded) [22]. Throughout the monitoring period, we asked participants to continue their normal daily routine and to record daily step counts and sitting time in a diary. On work days, participants recorded their step count on arriving at work, at the start and end of their lunch break and at the end of the afternoon and their total daily step count at bedtime. They also recorded their work start and finish time, morning and afternoon sitting time, time spent sitting after work and their mode (and duration) of transport to and from work. A sample page from the diary is included in Appendix 1 (available as Supplementary data at Occupational Medicine Online).

On non-work days, participants recorded their step counts and sitting times at the end of the day only. We only included participants with full diary entries (completed step counts and sitting times throughout each timepoint of the day) on at least three work days and one non-work day in our analysis.

Statistical analyses were conducted using the IBM Statistical Package for the Social Sciences (SPSS) for Windows version 21. We calculated mean step counts and sitting times recorded at each timepoint throughout the working day, total step counts, sitting times and minutes spent at work. We calculated total daily sitting times on work days by summing the sitting times reported in each domain (sitting at work in the morning and afternoon, sitting during transport to and from work and sitting after work) and compared this with total daily sitting times reported on non-work days using a paired sample t-test. We calculated the proportion of time spent sitting at work ((sitting at work in the morning and afternoon/time spent at work) × 100) and the proportion of total daily sitting time that occurs at work ((sitting at work in the morning and afternoon/total daily sitting time) × 100). We grouped participants into tertiles based on the proportion of time (low, medium and high) spent sitting at work. We compared time reported sitting after work and sitting during travel on workdays, and total daily sitting time on non-workdays between the three groups. We also compared reported time spent at work, step counts reported during and out of working hours on work days and total step counts reported on non-work days between the groups. For all between-group comparisons, we used one-way analysis of variance (ANOVA) with Bonferroni-corrected post hoc comparisons. For those participants who provided seven full days of pedometer data, we compared total step counts reported on each day of the week using repeated measures ANOVA, with Bonferroni-corrected post hoc comparisons. Statistical significance was set at $P < 0.05$ for all analyses unless otherwise stated.

**Results**

A one-sample Kolmogorov–Smirnov test confirmed that all data were normally distributed; descriptive data are therefore reported as the mean ± the standard deviation throughout. Preliminary analyses revealed no significant differences in step counts, sitting times or time spent at work ($P > 0.05$, data not shown) between the work sites or sexes. The analyses were therefore conducted on the sample as a whole.

Of the 75 participants who commenced the study, 72 (60% female, age 37 ± 13, BMI 24.0 ± 3.5 kg/m²) provided complete diaries for the 7-day monitoring period of step counts and sitting time on work days and non-work days. Of these 72, 63% (45) provided complete diary entries on all 7 days, 25% (18) did so on 6 days, 8% (6) on 5 days and 4% (3) on 4 days; 92% (66) provided complete diary entries on both weekend days. All participants reported predominantly sedentary occupations, in full-time administrative roles and telephone-based customer services. The initial health screening questionnaire confirmed that all participants were in good general health and none had any physical illnesses or disabilities that might affect their normal daily routine.
Participants reported sitting (including sitting at work, sitting out of work and sitting in motorized transport) for a total of $517 \pm 144$ min (8 h, 37 min) per day on work days and $339 \pm 137$ min (5 h, 39 min) per day on non-work days ($P < 0.001$). The mean reported daily time at work was $8 \text{ h} 26 \pm 66$ min, of which $327 \pm 114$ min (65% of time at work) were reportedly spent sitting. On work days, sitting at work accounted for 63% of total daily sitting time.

A total of 83% (60) of participants reported that motorized transport was their method of commuting. The mean daily reported time spent in motorized transport was $38 \pm 41$ min; 17% (12) reported walking or cycling to and from work.

Figure 1 shows total daily and mean step counts recorded before work, during the morning, over lunch, during the afternoon and after work on work days, and total step counts recorded on non-work days. Mean step counts were $1345 \pm 1133$ before work, $1536 \pm 1278$ during the morning, $707 \pm 644$ over lunch, $2134 \pm 1486$ in the afternoon and $3056 \pm 1522$ after work on work days. In the 63% (45) of participants who provided step count data on all 7 days, total daily step counts varied significantly across the week ($F = 2.7, P < 0.05$). Saturday step counts were significantly higher than those reported on Wednesday, Thursday, Friday and Sunday ($P < 0.01$).

Participants in tertile 1 (low work-time sitters) spent <58% of their working hours sedentary ($n = 24$). Participants in tertile 2 (medium work-time sitters) spent 59–80% of their working hours sedentary ($n = 24$), and participants in tertile 3 (high work-time sitters) reported sitting for over 80% of their working hours ($n = 24$). Table 1 shows that when grouped into tertiles according to the proportion of time spent sitting at work (low, medium and high work-time sitters), there were significant differences in reported sitting times outside working hours between groups. High work-time sitters reported spending significantly longer sitting in motorized transport to and from work than medium and low work-time sitters (differences = 37 and 43 min/day, respectively, $P < 0.01$). High work sitters also reported sitting for significantly longer after work (on workdays) than low work sitters (difference = 28 min/day, $P < 0.05$) and significantly greater total daily sitting times on non-workdays than low work sitters (difference = 94 min/day, $P < 0.05$). The three groups did not differ significantly in terms of their reported work duration ($P > 0.05$).

The low work-time sitting group accumulated significantly more step counts during working hours compared with the medium and high work-time sitting groups (differences = 2355 and 2973 steps, respectively, $P < 0.01$). However, there were no significant differences in step counts accumulated before work, during the lunch break, after work, and in total steps accumulated on non-work days between the groups (all $P > 0.05$).

Discussion

In this sample of full-time office workers in central England, significantly higher levels of sedentary behaviour were reported on work days ($517 \pm 144$ min/day) compared with non-work days ($339 \pm 137$ min/day). Overall, 65% of time at work was sedentary, and sitting at work accounted for 63% of total daily sitting time. We found that those who were most sedentary at work did not compensate by reducing their sedentary behaviour outside work.

A strength of the study was our ability to measure sitting time and physical activity at discrete periods of the working day to understand how sedentary behaviour...
Table 1. Sitting times reported across different domains on workdays (at work, during transport, after work), along with total sitting times and step counts reported on a workday and non-workday for the sample (72 full-time office workers) grouped into tertiles based on the proportion of time spent sitting at work

<table>
<thead>
<tr>
<th></th>
<th>Low work sitters (n = 24)</th>
<th>Medium work sitters (n = 24)</th>
<th>High work sitters (n = 24)</th>
<th>Between-group differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting at work (min/day)</td>
<td>205 ± 76</td>
<td>333 ± 52</td>
<td>443 ± 46</td>
<td>96.3</td>
</tr>
<tr>
<td>Sitting in transport (min/day)*</td>
<td>21 ± 16</td>
<td>27 ± 18</td>
<td>64 ± 59</td>
<td>8.1</td>
</tr>
<tr>
<td>Sitting after work (min/day)</td>
<td>126 ± 51</td>
<td>144 ± 46</td>
<td>154 ± 30</td>
<td>3.2</td>
</tr>
<tr>
<td>Total sitting time on workdays (min/day)</td>
<td>352 ± 107</td>
<td>504 ± 69</td>
<td>661 ± 98</td>
<td>64.0</td>
</tr>
<tr>
<td>Total sitting time on non-workdays (min/day)</td>
<td>288 ± 124</td>
<td>341 ± 142</td>
<td>382 ± 133</td>
<td>3.5</td>
</tr>
<tr>
<td>Steps accumulated at work</td>
<td>5446 ± 3381</td>
<td>3091 ± 1297</td>
<td>2473 ± 1125</td>
<td>12.3</td>
</tr>
<tr>
<td>Steps accumulated out of work (on workdays)</td>
<td>4257 ± 1640</td>
<td>5773 ± 2963</td>
<td>5295 ± 2393</td>
<td>2.5</td>
</tr>
<tr>
<td>Total step count on workdays</td>
<td>9703 ± 3359</td>
<td>8864 ± 3364</td>
<td>7768 ± 2828</td>
<td>4.7</td>
</tr>
<tr>
<td>Total step count on non-workdays</td>
<td>10329 ± 5825</td>
<td>9973 ± 5225</td>
<td>8284 ± 3475</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*Comparison based on 60 participants (19 low, 20 medium and 21 high work sitters) who reported travelling to and from work in motorized transport. Significance level: *P < 0.05, **P < 0.001. NS, not significant.

is accumulated during and outside working hours. However, while diaries provided valuable contextual information about how sitting is accumulated throughout the day, self-reporting may be a source of bias. The requirement for participants to record their step counts from their pedometers may have influenced their activity [23]. Inclinometers may provide a more objective measure of sedentary behaviour and physical activity [13]. A further limitation of pedometers is their inability to measure activities such as swimming and cycling. While these activities were recorded by a few participants in the diary, the pedometer data was the primary measure of physical activity in this study. As with similar studies [14,24,25], the volunteer sample in this study may not have been representative of the entire workforce. Higher levels of sedentary behaviour on work days accords with findings in Australian workers [14,24]. However, we found a higher proportion of total daily sitting time attributable to sitting at work than a study of Australian adults using similar measures, where 52% of total daily sitting time occurred at work [9,10].

Step counts recorded outside working hours did not vary significantly between the three workplace sitting groups, suggesting that individuals who reported greater sitting times at work did not compensate by increasing their activity levels outside working hours. In fact, those who reported sitting for longest at work reported sitting for longer outside work, similar to findings of Jans et al. [12] and Parry and Straker [14]. However, Chau et al. [10] found that Australian workers with jobs that involve mostly sitting were more likely to report being physically active during their leisure time than individuals in more active jobs.

In our study, the ‘high work-time sitting’ group also reported sitting for longer when using motorized transport, perhaps because they had longer daily commutes. These people could benefit from occupational health interventions to reduce workplace sitting. We also found that participants took relatively few steps during their lunch break (700 steps). Lunchtime could be targeted for workplace interventions to increase physical activity. Total work day sitting times of 11 h in the ‘high work-time sitting’ group increases their risk of chronic conditions associated with sedentary behaviour [7]. As work represents a large proportion (>50%) of office workers’ total daily sitting time, it is an ideal environment for occupational behaviour change interventions to reduce sedentary behaviour. Indeed, recent studies have investigated the effectiveness of sit-to-stand workstations for reducing sedentary time at work [26,27]. However, our findings, and those of Jans et al. [12] and Parry and Straker [14], suggest that occupational health interventions should also address sitting outside working hours.

We studied full-time office workers with similar job roles and ranks. Further research could explore sedentary behaviour during and outside working hours in different employment sectors and grades (such as professionals, managers and technicians). This study’s cross-sectional design prevents inference about causality. We cannot determine whether being sedentary at work leads to being more sedentary outside working hours. Longitudinal research could explore the long-term
relationships between sedentary behaviour during and outside working hours.

**Key points**
- In this sample, office workers were sedentary for 65% of their working day.
- Those who reported sitting most at work also reported sitting for longer outside working hours, and did not compensate for their sedentary behaviour at work by being more active in their leisure time.
- Occupational health interventions should aim to reduce workplace and leisure-time sitting in sedentary office workers.

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**Conflicts of interest**
The authors declare that there are no conflicts of interest.

**References**