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Understanding Episodes of Physical Activity at Work Using Fitbit® Data

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Abstract. For office workers as much as much as 77% of time at work is spent in sedentary behaviour, increasing the risk of cardio vascular disease, cancer, weight gain, obesity and musculoskeletal pain. Given the amount of time spent at work, increasing opportunities for moderate to vigorous physical activity for office workers can not only reduce risk of disease but also actively contribute to better brain function and reduced anxiety at work. In this research we adopt an ecological approach to understanding opportunities for physical activity at work. Using 1373 Fitbit data points from two collocated office workers with identical job descriptions, we demonstrate that episodes of movement in the office are of very short or short duration. Results were less clear for sedentary behaviour because of the potential for spurious step counts and the fact that accelerometers cannot distinguish between sitting and standing. The paper shows the limitations and potential of data from Fitbit devices as a means of understanding the opportunities and constraints of the organisational and physical environment for physical activity at work for office workers.

Keywords. Physical activity, occupational sedentary behaviour, workplace, office

Introduction

It is now widely accepted that sedentary behaviour at work is a health issue [1, 2]. Sedentary behaviour, and in particular prolonged sedentary behaviour, has been linked to increased risk of cardio vascular disease, cancer, weight gain, obesity and musculoskeletal pain [3, 4]. Time spent in physical activity at work is dependent on occupation and status [5]. The rise of employment in the service sector in developed countries has led to population level decreases in levels of physical activity at work with corresponding decreases in overall daily levels of physical activity and increases in sedentary behaviour [5, 6]. Office workers in particular have high levels of sedentary behaviour, spending as much as 77% of time at work sedentary often for prolonged periods of time [7].

Before developing interventions to address sedentary behaviour at work, it is necessary to understand the opportunities for physical activity in office-based work. The ecological approach to understanding physical activity emphasizes the importance of context in the determination of opportunities and constraints for physical activity at work [8, 9]. The workplace is a micro system [10] characterised by specific activities in a specific location at specific times with specific people, in which each individual has a specific role to play. Organisational structures and policy largely determine the non-

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discretionary aspects of physical activity at work. This includes individual job descriptions as well as organisational culture including formal and informal expectations of work activities and working hours. These in turn are guided by workplace health and safety guidelines and relevant legislation.

Most office workers' time is spent sitting at a desk using a computer and/or a phone, occasionally leaving the personal work space for example attending work related meetings, going to the printer and taking breaks. The physical environment in which the work is curried out determines the opportunities for physical activities [8, 11, 12]. In a workplace, the office layout, location of meeting rooms, stairs, elevators largely delimit non-discretionary work-related opportunities for physical activity, however there is some opportunity for personal choice that can enhance physical activity at work, for example using stairs rather than lifts. Furthermore, there are also opportunities for discretionary behaviour during breaks which can be dependent on the immediate environs of the workplace, such as the proximity of parks, cafes, shops which offer opportunities for physical activity if only walking to the shops.

Physical activity at work is typically measured with accelerometers. Accelerometers identify movement generally expressed as step counts. They also identify periods of inactivity. Inactivity it not a measure of sedentary behaviour because standing, which would show as absence of movement, is not classified as sedentary behaviour [13]. Although consumer activity trackers do not have the same level of accuracy and reliability as research grade accelerometers, they are under constant development and their accuracy is such that they are comparable to research grade accelerometers [14-16]. Consumer activity trackers have several advantages for researchers. Designed for consumer purchase and everyday living, they are very affordable and particularly suited to large scale longitudinal research. Unlike research grade devices which need to be returned to the researcher for download every 7 days, consumer trackers automatically synchronize data via Bluetooth to the manufacture's apps. On the downside research grade devices can download data at 15-sec intervals compared to 1-min interval data from consumer activity trackers. However, one of the key reasons for using consumer activity trackers is that they can provide real time feedback for mobile phone behaviour change interventions.

In this pilot research we use consumer activity trackers to measure physical activity in an office context where sedentary behaviour at work is largely non-discretionary. Our approach follows the principles of ecological modelling of human behaviour [10, 17] emphasizing the importance of understanding behaviour in context and specifically, how the physical context impacts opportunities for physical activity at work. The aim of this work is to explore whether consumer activity trackers can be used to understand physical activity patterns at work. To do this we used an approach described in Orendurff, Schoen, Bernatz, & Segal [18] in which we focus on episodes of movement to understand the length and duration of bouts of walking activity in an office setting.

1. Method

In this paper we use pilot data 1373 data points from a pilot project on physical activity at work consisting of step count data from a Fitbit Charge HR. Data were collected from two co-located female office-based workers with identical job descriptions, thereby eliminating differences between work related activity attributable to different job

descriptions. Participant A was aged 58, weighed 76 kg and was 164 cm tall. Participant B was aged 40, weighed 48 kg and was 155 cm tall.

Fitbit Charge HR was selected to collect data in a free-living context, because of ease of access to data and because of the low error rate on step count [14, 19, 20]. Data were synced using the Fitbit phone app and downloaded using the Fitbit API in 1-min epochs, the highest resolution of data available for Fitbit step count data.

Data were cleaned to eliminate missing data attributable to flat battery, charging the device, forgetting to put it on after showering or charging and forgetting to synch the device with the mobile app. Known absences from the workplace were also excluded including weekends, public holidays, leave (annual/sick) and travel abroad. Both participants worked a 40-hour week with regular hours of attendance. Normal arrival and departure times were trimmed back by 15 minutes to allow for late arrival or early departure. Both participants wore Fitbits 24/7 for a period of three months. To closely match participant data 10 working days were selected where both participants had no more than 1 hours' missing data. The ten days data included 9,896 instances of 1-min epoch data resulting in 1,341 episodes of movement and sedentary behaviour. To ensure the integrity of episode start and end times, the first and last episode of data each day were deleted. In the event of missing data, the episode preceding and following the start of the break were also deleted.

In this research step counts of zero steps/minute was defined as sedentary behaviour and step counts greater than zero were counted as movement implying physical activity. Data were ordered by date and time and split into episodes of movement and rest [18]. Movements episodes were series of consecutive step counts and sedentary episodes were series of consecutive periods of zero step count [18]. The 1-min epoch data from Fitbit means that duration of movement and rest are rounded up to the nearest minute. Summary statistics (total step count, duration) described each episode of movement. For episodes of sedentary behaviour only duration was calculated. Frequency plots and descriptive statistics were used to explore the data.

2. Results

2.1. Movement Episodes

Distribution of duration of episodes and steps per episode are summarised in Table 1. Distribution of duration were skewed toward low duration of movement and low step counts as shown in Figure 1. Overall results show that 70% of participant movement episodes have a duration of 3 minutes or less. In the 11 days studied, there were only 16 episodes of movements $\geq$10 and <20 minutes and only 18 episodes $\geq$20 minutes or more. The longest episode of sedentary behaviour was 67 minutes. Fifty percent of the episodes of movement were short distances of $\leq$ 20 steps, 75% were $\leq$ 111 steps. The longest episode of movement was 40 minutes and the highest step count was 1566 steps. Health guidelines recommend spending at least 20 minutes a day in moderate to vigorous physical activity (MVPA) [21, 22]. A recent US review of Physical Activity Guidelines found that unlike the previously suggested requiring a minimum duration of 10 minutes of physical activity contribute to MVPA targets, the Physical Activity Guidelines Advisory Committee found that any time spent in MVPA contributes towards the recommended weekly totals [23].

Comparing the histograms showing duration and number of steps per episode there was little difference in the distribution of duration of step count and in step count between the participants. The mean duration of step count episodes for Participant A was 2.98 minutes (SD=3.35) compared to 2.75 (SD=2.37) for Participant B, with a median of 2 for both participants. There was somewhat more variability in the step counts per episode: Participant A had a mean of 91.22 steps (SD=165.33) compared to a mean of 79.02 steps (SD=137.32) for Participant B.

Table 1. Summary statistics.

ID		N	Range	Median	Mean	SD
A	Movement Episode Duration in Min	329	1 -40	2	2.98	3.35
	Total Steps per episode	329	3 -1566	25	91.22	165.33
	Rest Episode Duration in Min	313	1 - 67	5	11.66	14.71
B	Movement Episode Duration in Min	374	1 - 17	2	2.75	2.37
	Total Steps per Episode	374	1 - 1384	19	79.02	137.32
	Rest Episode Duration in Min	357	1 - 67	5	11.62	14.63

2.2. Sedentary Episodes

As with step count, the distribution of duration of episodes of sedentary behaviour was skewed toward low duration (see Figure 1). Overall results showed that 50% of sedentary duration was ≥ 4 minutes and 70% < 10 minutes.

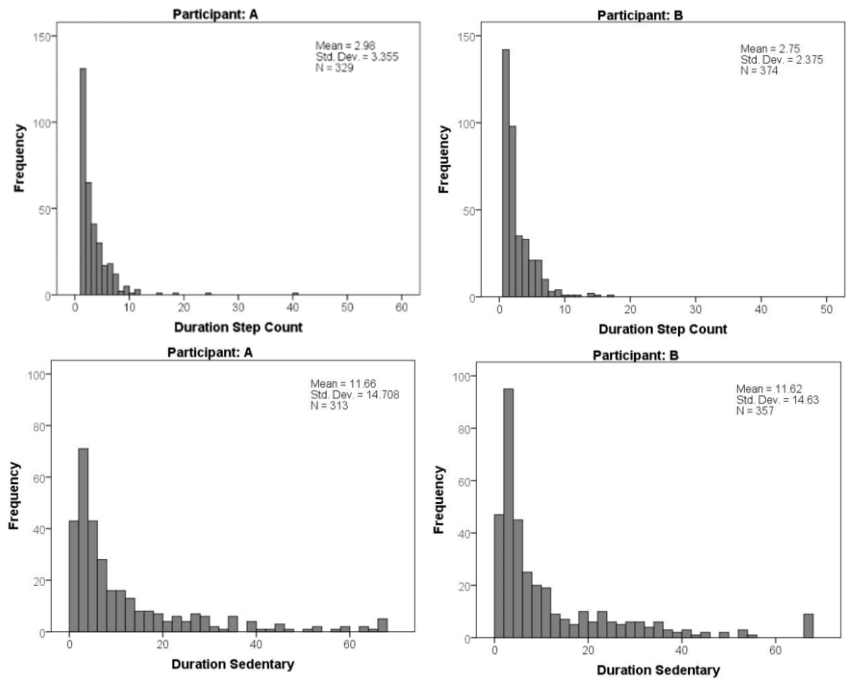

Figure 1. Histograms and summary statistics

Health guidelines advise that the maximum recommended duration of sitting is 30 minutes [24]. Results for both participants combined show that only 11% of time (69 episodes in total) were spent in prolonged sitting episodes (≥30 minutes). However, this finding may be misleading because it is possible to accumulate spurious step counts while still seated [25]. Sedentary episodes for the purposes of this research are episodes where there is a step count of zero, however, it is possible that some of low steps/min step counts were erroneously recorded as steps, when in fact they might be the result of gesticulation and might therefore be part of an episode of sedentary behaviour. However, it is also possible that these might be a result of standing up and or stepping to an adjacent location (e.g. filing cabinet).

The definition of sedentary behaviour does not include standing [26]. It is possible that some episodes of inactivity (zero step count) are in fact a result of standing rather than sitting, and therefore not episodes of sedentary behaviour. For example, it is likely that the very short episodes of sedentary behaviour (1- 2 minutes) in between episodes of movement are time spent standing rather than sitting. Visual inspection of patterns in the data reflected that this may be the case because there were episodes of movement separated by a one-minute episode of no movements, as would be the case if one went to the kitchen to make coffee (walking), made coffee, had a chat (no movement) and returned to your desk (movement).

3. Discussion

Results from this pilot physical activity data show that it is plausible that the physical context in which workplace behaviour takes place in conjunction with the constraint of job descriptions largely determine the amount of non-discretionary physical activity at work. Both participants had the same job description, occupied similar workplace physical settings, and had very similar distribution of both movement and rest episodes, despite inter-individual differences.

As expected, results reflected the lack of physical activity in office-based work. Although it seemed that only 11% of participants' sedentary time was for periods greater than the recommended length of sitting episodes, this may not be the case. Distinguishing between sedentary behaviour and low movement accelerometer data, as well as distinguishing between standing and sitting, both resulting in zero step count, mean that it is important to find additional ways to measure sitting behaviour to supplement/verify accelerometer data.

Health guidelines recommend spending at least 2.5-5 hours in MVPA a week or 20 minutes a day [21, 23, 27]. Recent recommendations by the US Physical Activity Guidelines Advisory Committee Scientific Report state that any time spent in MVPA, irrespective of duration, counts towards meeting the weekly target of 2.5 hours [23]. Office workers spent around 50% of waking time during the working week at work. Time spent at work, detracts from opportunities to achieve weekly targets. Spreading the physical activity load across the day over the whole week makes achieving targets easier, especially if opportunities for MVPA can be encouraged at work. In addition to lowering the risk of the disease associated with sedentary lifestyles resulting from achieving the recommended targets of MVPA, there are also short term benefits of regular doses of MVPA for both employers and employees, including improved brain functioning and reduced anxiety, all beneficial to better work outcomes and healthier workplaces [23].

The findings of this research are exploratory given the small sample size. Further research into the impact of office layout and job description on physical activity might be useful in informing the design of interventions to increase opportunities for physical activity at work.

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