## RESEARCH

# Physical Activity Behaviours in the Workplace and Home in a University College Population

N. S. Riddell[1], R. Baskerville[1,2] and L. M. Castell[1]

[1] Green Templeton College, University of Oxford, Oxford, UK

[2] Centre for Movement, Occupational and Rehabilitation Sciences, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK

Corresponding author: N. S. Riddell (nathansriddell@gmail.com)

**Background:** Regular physical activity (PA) and low sedentariness have significant long-term health benefits. Achieving and measuring adequate levels of PA are difficult in office environments. This study's primary aim was to evaluate PA levels and sedentariness within work and home settings. The accuracy of self-reported physical activity and accelerometer use acceptability were also determined.

**Methods:** 121 university staff, students and fellows (faculty) gave informed consent. Pre-study questionnaires on PA, sedentary time, mood and sleep were completed. Using a FitBit One accelerometer PA was monitored for 7 days. Steps were counted. PA intensity was categorized as light or moderate-to-vigorous (MVPA). Group differences were compared with Spearman's and Pearson's correlation tests.

**Results:** Average pre-study activity estimation was 1.18 hrs/day (SD: 0.622) (95%CI ± 0.049). Subsequently, each participant averaged 1.49 hrs/day (SD: 0.98) walking; (70.9 mins/day (SD: 45.0) moderate activity (3–5 Metabolic Equivalents (METs); 20.5mins/day (SD: 17.2) vigorous activity (>5METs). Average daily sedentary time was 654.6 min (±152.3), with average time at work standing or in very light activity as 6.47 hrs (SD: 4.3 hrs) (<1.5METs). Self-estimated pre-study walking activity and objectively measured PA ($R^2$ = –0.172) were not correlated. Participant acceptability rating for device use was 87%.

**Conclusion:** All participants achieved near recommended PA levels. Work and home environments contributed reciprocally to daily totals. Significant differences between self-reported and measured PA levels indicates that both should be recorded.

## Background

Regular physical activity reduces the risk of many chronic conditions including cardiovascular disease type 2 diabetes and cancer (Warburton & Nicol 2006). Benefits within the workplace include: improvements in perceptions of wellbeing, job satisfaction and productivity (Gilson et al. 2008). However, despite strategies at national and international levels, recent statistics show a continuing rise in mortality due to inactivity and obesity-related diseases.

There is a known influence of environmental factors on physical activity behaviour (Gorman et al. 2013) and, as the workplace forms a significant proportion of daytime activity, these environments are an important area of study (Parry & Straker 2013). However, in most research on workplace behaviour, participants have not been followed over time (Thorp et al. 2012; Miller & Brown 2004) and sedentary patterns are often omitted and overlooked (Chan et al. 2004; Purath et al. 2004). This is an important omission as sedentary behaviour is independently associated with increased risk of morbidity (Biswas et al. 2015). With an increase in task automisation and internet-based activity, desk-bound work is increasing across the workforce (Owen et al. 2010). At least two-thirds of office-based work is sedentary (Ryan et al. 2011) and can be associated with poor nutritional habits and sedentary leisure behaviour outside of work (Alkhatib 2015). There is considerable occupational research evidence about physical activity patterns and higher educational

achievement (Wallmann-Sperlich & Bucksch 2014) but there is a dearth of specific research on UK university staff and students. Of three studies identified one used accelerometry in the workplace only (Bird et al. 2015), one used self-reported activity (Alkhatib 2013), and one measured workers' perceptions of physical activity (George et al. 2014).

Research conducted on the general population indicates that self-reported measures of physical activity and sedentary behaviour are inaccurate when compared with objective measures (Dyrstad et al. 2014). In addition, much of the evidence on physical activity and sedentary behaviour is derived from extrapolations from self-reporting questionnaires in population studies, rather than detailed group studies (McCluskey et al. 2007). While many questionnaires such as Global and International Physical Activity Questionnaires (GPAQ) (Cleland et al. 2014) and IPAQ (van der Ploeg et al. 2010) are well researched and validated, discrepancies have been seen in comparison with objective methods (Sitthipornvorakul et al. 2014; Segura-Jimenez et al. 2013).

The advent of miniaturised technology has made unobtrusive, objective monitoring in the workplace possible. Pedometers, as simple, monofunction step-counters, were the first monitoring devices. In contrast, time-based movement sensors (accelerometers) can define the characteristics of activity and detect sedentary periods (Tudor-Locke et al. 2008). Small studies of office workers have detected higher periods of activity by self-reporting rather than measuring by accelerometry (Miller & Brown 2004). However, this may not also apply to university staff and students as these groups are of above average education which tends to be associated with better awareness and practice of healthy lifestyle behaviours (Ose et al. 2014). Nevertheless, academic study does involve prolonged periods of inactivity which risks counteracting such benefits.

In the light of all this the present study was set up to determine the activity and sedentary levels in university staff and students, at work and home, over seven days. An additional aim was to determine the accuracy of self-reporting of physical activity in this group against objective accelerometry measures and to obtain participant feedback on the acceptability of accelerometer use.

## Methods
### Participants
Staff, students and fellows (faculty) of a university college, aged between 18–80 years, were invited to take part in the study (n = 121) via circulated information. There was no stratified recruitment but, fortuitously, volunteers were largely representative in age, gender and work status, of the proportions in the college as a whole.

Ethical permission was obtained from CUREC (MSD-IDREC-C1-2014-017), and all participants gave signed, informed consent for their participation in the study.

### Procedures
Recruitment was conducted over a 3-month period. Responders were invited to a preliminary interview, and screened for study suitability. On day one, consent was obtained and general demographic information (age, height, gender) was recorded. Pre-study questionnaires were completed on: the participant's usual physical activity levels (modified GPAQ), profile of mood states (POMS), sleep (Pittsburgh Scale) and anthropometric data. Height and weight were measured wearing light clothing and without shoes. Body mass index (BMI) was calculated as weight (kg)/height($m^2$) and categorised to reflect weight status (normal or underweight <25 kg/$m^2$; overweight 25–29.9 kg/$m^2$; obese ≥30 kg/$m^2$). Participants were issued with a triaxial accelerometer (*Fitbit One; Fitbit Corp, California, USA*), with the display concealed. They were asked to wear the accelerometer during all waking hours, and at nights, for 7 days. They were instructed to engage in usual activities at work and home, for the whole period of wearing the Fitbit One. The device required neither charging nor synchronization during this time, was removed for activities in water and was collected after seven days of continuous recording.

On Day Two, after the subjects returned the device, they completed post-study questionnaires on mood, sleep and perceived activity during the seven day period. Fitbit One accelerometers have been shown to provide a valid assessment of sedentary time (Ferguson et al. 2015) and physical activity (Diaz et al. 2015) in free-living adults.

### Data Collection and Analysis
Accelerometer data were collected in five minute epochs. To quantify work-days more accurately, participants recalled whether the study period represented a typical working week. Data were excluded from relevant analyses if the period was not representative by more than two days or more, of a usual week for that person.

Accelerometer data was downloaded using the proprietary Fitbit software, extracted with a Java applet and categorised into bands of varying intensity, using Excel version 12. Non-wearing periods were not included in the analyses: these were periods with at least 60 minutes of zero counts per minute (cpm). For up to 2 days of missing data, averages were inputted from the available recording.

Activity counts were categorised as sedentary (<100 cpm; predominantly sitting), light intensity activity (100–1951 cpm; typically, gentle walking), or moderate to vigorous physical activity (MVPA) (≥1952 cpm; typically at least brisk walking). Daily summaries of time spent in sedentary, light and moderate-to-vigorous activity, were calculated and overall step counts estimated (Adam Noah et al. 2013).

Activity intensity was estimated by calculation of Metabolic Equivalents (METS) by the Fitbit software relative to 1 MET being the energy expenditure of sitting quietly at rest (Kozey et al. 2010).

## Statistics

Potential associations between the observed activity and relevant factors across genders were explored using Pearson's correlation coefficient, Spearman's correlation and the $Chi^2$ test. The study design and subsequent small numbers excluded the use of regression models and investigation of the relative contribution of factors to activity levels. All data were analysed with SPSS version 22, and significance levels were set at $p < 0.05$. Data are expressed as means with standard deviation (SD) unless otherwise stated.

## Results

From an initial sample of 121 participants, 14% had missing or atypical data on 3 or more days. This data was removed prior to analysis. Six participants whose data was missing or atypical repeated the 7-day period with a new device and data was collected successfully. Of a final sample of 106 participants there were 52 males and 54 females (age range; 20–77 years). The average BMI was 24.2 (SD: 5.2). Within the study, each participant averaged 1.33 hours/24 hours (SD: 0.98) of walking activity. Banded averages were 60.44 min/day (SD: 46.9) for light activity (100–1951 cpm) and 19.53 min/day (SD: 19.8) for vigorous activity (>1951 cpm).

The average time spent sedentary or standing, during working hours, was 5.87 hours (SD: 0.51) per day. The average number of 1 hour periods of complete inactivity in working hours was 1.84 (SD: 1.47). The average workplace stepcount was 4682.6 (SD: 3383.4) and outside work was 4194.5 (SD: 3523.4). Higher stepcounts achieved within one environment tended to correspond with lower counts in the other. Workplace step counts were similar between students (3726, SD: 2847 steps) and staff (4182 SD: 3189 steps) (P = 0.472), and between males (4977, SD: 3130 steps) and females (4138 SD: 3821 steps) (P = 0.2312).

There was no overall correlation of physical activity level with age ($R^2 = 0.063$), although there were higher volumes of vigorous activity in participants under 30 years. There were non-significant peaks of total activity in the 20–30 and 50–60 year age groups (**Figure 1**).

A secondary aim was to investigate the accuracy of participants' self-estimation of activity levels within the study. There was no overall correlation between individual estimation and usual level of PA with that observed within the study ($R^2 = -0.172$). However, males' estimation of their usual activity levels (*i.e.* outside the study) and study activity levels correlated more strongly than in females (Pearson's rank correlation in males = 0.452 P = 0.001; females = 0.071 P = 0.336) (**Figure 2**).

For self-reporting accuracy of the trial period the recorded PA correlated poorly with the retrospectively estimated value for the same period ($R^2 = 0.464$). Female participants recorded more accurate retrospective step counts for the week ($R^2 = 0.489$ and $R^2 = 0.112$ respectively) despite similar activity levels (**Figure 3**).

More active participants were less accurate at estimating the weekly total than less active ($R^2 = -0.599$ P = 0.001) (**Figure 4**). There were no significant associations between sleep, mood and BMI with levels of physical activity or accuracy of self-reporting.

There were 30 post-study questionnaire responses. 87% of the respondees reported that study participation and device use was a positive experience and said they would participate in future studies.

## Discussion

This study aimed to investigate levels of physical activity and time spent sedentary in a university population and to explore the relationship between self-assessed and measured physical activity levels. A heterogenous mix of activity profiles was identified and was irrespective of gender. The majority exceeded 8000 steps per day between work and home, which comes close to achieving recommended levels (Tudor-Locke et al. 2008). This is a somewhat surprising result for a largely desk-based population but is explained by activity occurring outside the workplace and shows the importance, in contrast to other studies, of measuring both
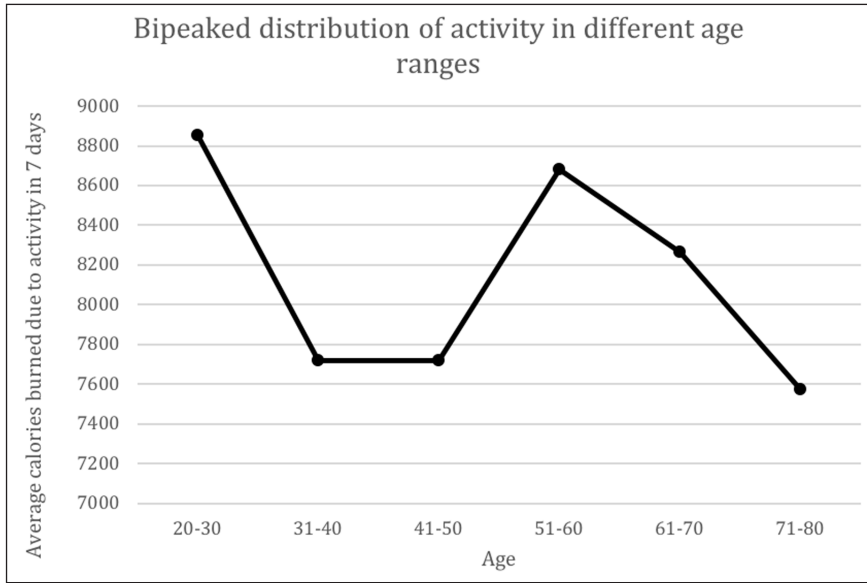
**Figure 1:** Comparison of activity with age. Bipeaked pattern of activity highest at 20–30 and 51–60.
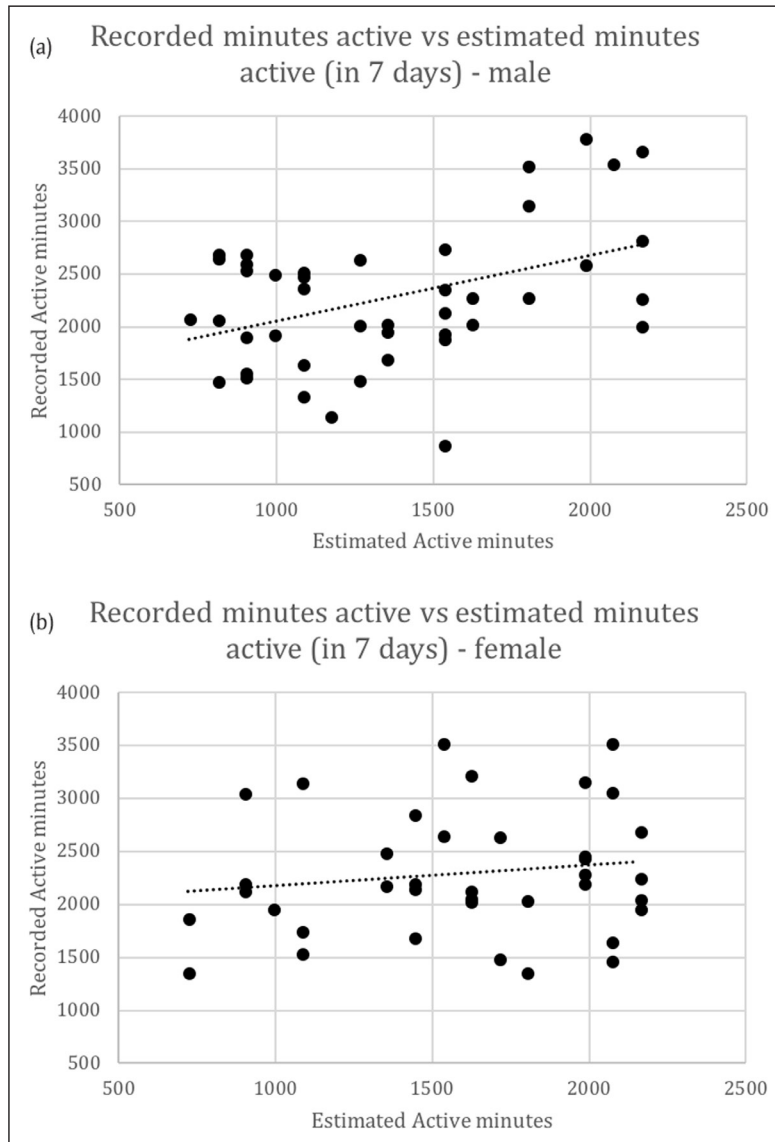


**Figure 2:** Male participants recorded more accurate estimates of the amount of time spent active in the 7 days **(a)** than their female counterparts **(b)**.
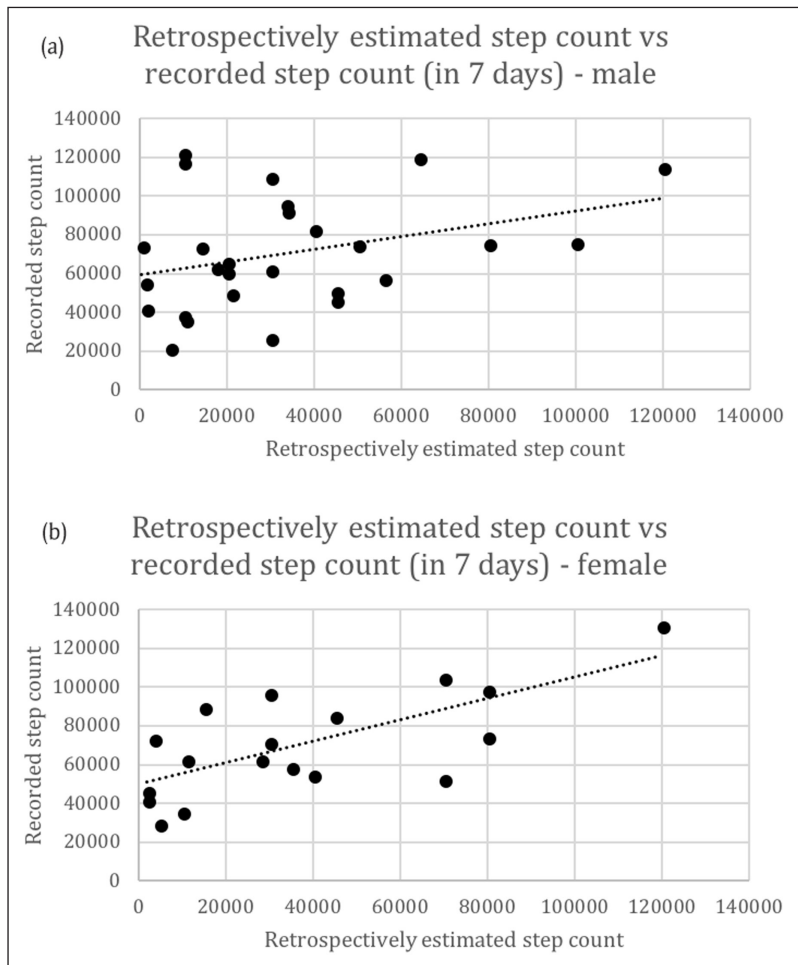
**Figure 3:** Females recorded a slightly more accurate retrospectively estimated number of steps completed in 7 days **(b)** than their male counterparts **(a)**.
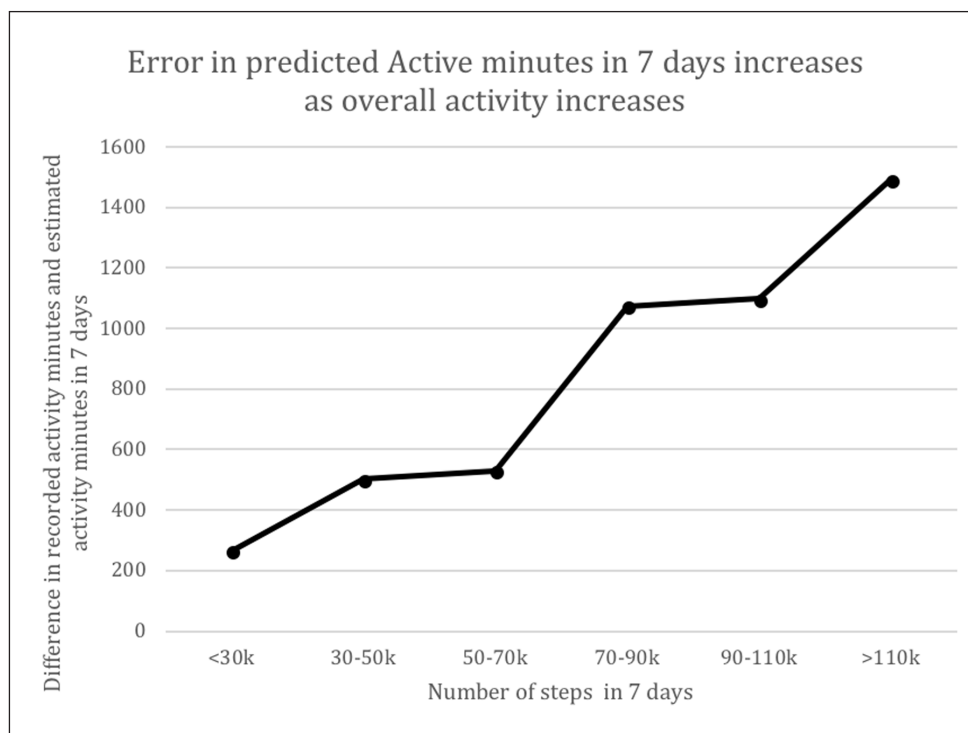


**Figure 4:** Error in activity prediction versus activity level stratified by activity. Those more active individuals were, on average, less able to predict their overall activity levels.

environments. By recording the whole wakeful period outside sleep, the study also challenges previous notions that high levels of inactivity and activity are mutually exclusive in the same person.

Both students and staff exhibited similar levels of active and sedentary behaviours, although students and staff aged under 30 attained higher proportions of these during vigorous activity. However, in terms of clinical benefit, lower intensity exercise is still beneficial, relative to the age and low baseline levels of older participants (Casas Herrero et al. 2015). The peak observed in middle age may be due to (a) increased awareness of aches/pains/fitness/health; (b) more time available (children have left home, more flexible working hours).

There was poor correlation between actual and perceived levels of physical activity. This observation has been well reported, but not in an academic institution in terms of health literacy (Dyrstad et al. 2014). Controlling for other factors, the discrepancy was larger in men than women, which has not been previously documented. There was a trend for increased activity levels to be associated with poorer estimation accuracy: this accords with findings elsewhere, although the result was not statistically significant (Tomaz et al. 2016).

With the increasing miniaturisation of technology, PA tracking products are now unobtrusive and widely available. Our results showed that 87% of feedback received indicated the *FitBit One* use was agreeable. Further to this, 75% were more aware of their sedentary and activity behaviour as a result of study participation. 21% expressed an interest in engaging in more exercise in future. At least four people subsequently purchased their own devices, unprompted, and have continued to self-monitor.

Additional questionnaires were levied on those who represented College or University at sport. The scales included "Very negative, Negative, Neutral, Positive, Very positive". Seventeen questionnaires were completed: none of the participants reported a lower effect of exercise than "Neutral", on either category involving academic ability. The lowest reported effect of exercise on mood in this group was "Positive".

For overall academic performance, six reported a Positive effect of exercise and six reported a Very positive effect. For efficacy and productivity during academic assignments, one reported no effect (Neutral); twelve reported a Positive effect, and three reported a Very positive effect. The effect of exercise on mood in this group was rated overall as Very positive.

As this was primarily a study of physical activity behaviour, the estimation accuracy for sedentary time was not examined and is the subject of future research. Equally, daily diaries for participants were not used, as the study focused mainly on the acceptability and intrusiveness of accelerometer use in the workplace. Future research into reducing prolonged sitting periods and increasing total activity in the university workplace will be compromised unless accompanied by such objective monitoring techniques.

It is worth noting that, whilst the complexity of workplace interventions increase, such as standing desks, so does the sophistication required of the monitoring technology. Simple standard accelerometry did not discern standing from sitting and was unable to measure many non-pedantry activities such as weightlifting, cycling or static exercises. Modern devices are overcoming many of these problems. However, within the limitations discussed, accelerometry appears to be accurate, low cost and acceptable to participants in university workplace settings. PA was often accumulated in blocks, creating significant amounts of time being sedentary with potential adverse future health implications.

## Conclusion
All participant groups achieved near recommended levels of PA, with work and outside work environments tending to reciprocate in contribution to daily totals. Significant differences were identified between self-reported and measured PA levels in this study indicating that both should be recorded. To this end accelerometry appears accurate and acceptable to participants, particularly as the technology evolves. It is important that future research into workplace physical activity should include activity outside of work, as the two appear to be related.

## Acknowledgements

## Competing Interests
The authors have no competing interests to declare.

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