Reliability and validity of self-reported sitting and breaks from sitting in the workplace

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Title. Reliability and validity of self-reported sitting and breaks from sitting in the workplace

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a. Abstract

Objectives: Prolonged sitting is a health risk factor which is ubiquitous to the workplace, and breaking up prolonged sitting is widely recommended. The present study evaluated the test-retest reliability and criterion validity of a self-report measure of duration of sitting and breaks from sitting in the workplace.

Design: Cross-sectional study.

Methods: Fifty-nine workers who reported spending most of their work time sitting wore an activPAL inclinometer and the ActiGraph accelerometer for eight consecutive days, and completed single-item measures of duration of sitting and frequency of breaks from sitting at work, twice, seven days apart.

Results: Participants reported sitting at work for a median of 420 mins/day (Interquartile Range = 360-450 mins/day) and taking one break (Interquartile Range = 1.0-2.0) from sitting per hour. For reported duration of workplace sitting, test-retest reliability was adequate (Intra-Class Correlations = 0.78), and criterion validity fair against the activPAL (Spearman’s Rho = 0.24) and the ActiGraph (Rho = 0.39). For reported frequency of breaks from sitting at work, test-retest reliability was adequate (Intra-Class Correlations = 0.65) and criterion validity fair against the activPAL (Spearman’s Rho = 0.39) and the ActiGraph (Spearman’s Rho = 0.30). Self-reported duration of sitting was biased toward over-reporting compared to the activPAL (median = 45.4 minutes) and under-reporting compared to the ActiGraph (median = 21.7 minutes).

Conclusions: The single-item measure of frequency of breaks from sitting was acceptable for use at a population level among sedentary workers, however the item measuring duration of sitting in the workplace, while reliable, requires further adaptation to improve accuracy.

b. Key Words. activPAL; ActiGraph; sedentary behaviour; sedentary occupation; psychometrics
Sedentary behaviour, which includes all waking behaviours performed in a sitting/lying posture and expending $\leq 1.5$ metabolic equivalent units of rest (METs), is an emerging chronic health risk factor independent of insufficient physical activity. Experimental and observational evidence also suggests that the manner in which sedentary time is accumulated has an impact on health, with unbroken bouts of sedentary time adversely associated with cardio-metabolic risk factors.

Sitting is ubiquitous, particularly in the workplace where up to 80% of the workday can be spent sitting, often with few breaks. Although there is some evidence of adverse health effects from workplace sitting, research is limited by the capacity to accurately and conveniently measure workplace sitting and breaks from sitting, particularly at the population level. While objective measures, such as accelerometers and inclinometers, are precise and unaffected by subjective biases, they are not always feasible or cost-effective in large-scale assessments of sedentary behaviour. Thus there is a need for psychometrically sound self-report measures of sitting duration and frequency of breaks from sitting in the workplace.

Although a number of self-report measures have been developed to assess sitting time in the workplace, few also capture frequency of breaks from sitting. Overall, these measures have demonstrated low- to adequate-criterion validity, but have been validated against hip-mounted ActiGraph (AG) accelerometers which define sedentary time as a lack of/limited movement ($<100$ counts per minute [cpm]). As the accelerometer is unable to distinguish between different postures (such as, sitting and standing), a more suitable criterion measure of ‘sitting’ is needed. In recent years, tools such as the actviPAL (aP) inclinometer have become available that capture postural changes, and have been shown to distinguish between sitting and standing.

To date, only one study has evaluated the validity of self-reported duration of workplace sitting and frequency of breaks from sitting using an inclinometer (aP). That study reported only adequate validity (Spearman’s Rho $[\text{Rho}]=0.63$) and reliability (Intra-Class Correlations $[\text{ICC}]=0.74$) for
reported duration of sitting, and poor validity (Rho=0.06) and reliability (ICC=0.12) for reported
frequency of breaks from sitting at work. As such, there is a need to further develop simple self-report
measures that can be used in population studies to accurately assess duration sitting and frequency of
breaks from sitting specific to the workplace. The aim of this study was therefore to evaluate the test-
retest reliability and criterion validity of two simple single-item self-report questions designed to
estimate duration of sitting time at work and the frequency of breaks from sitting at work.

ii. Methods

Convenience sampling in workplaces across Melbourne (i.e. display of posters, advertisements,
snowball techniques) was used to recruit participants who were ≥ 18 years and reported working in an
occupation where they spent most of their work time sitting. Overall, 59 participants were recruited
(54% females, mean age 32.1±9.9 years; Table 1). Ethical approval was received from Institutional
Human Ethics Advisory Group (XX).

Participants simultaneously wore an aP on the left thigh and an AG on the right hip for eight
consecutive days. The two self-report items were completed on two occasions, seven days apart,
corresponding to the first and last day that the aP and AG were worn. A daily log book was also
maintained throughout the week in which participants recorded workdays and hours, and any periods
during which they did not wear the aP or AG. Participants were shown how to wear the monitors by
trained research assistants, and were instructed to remove the devices only if engaging in water-based
activities.

Participants reported the duration of sitting time at work in response to the single item: “During
the last 7 days, how much time did you usually spend sitting at work on a weekday”. Open ended
numerical responses in hours and/or minutes were provided. Frequency of breaks from sitting at work
was obtained by a single item modified from previously validated items, with an open ended response
scale.”. For duration of workplace sitting, self-report values were deemed admissible if: (i) sitting time
did not exceed work hours recorded in the log book; and (ii) if sitting time was at least half the amount of time participants recorded working in the log book. Only one participant was excluded based on these criteria. Frequency of breaks in sitting was truncated at six breaks/hour.16

The hip-mounted AG GT3X (www.theactigraph.com) accelerometer and the thigh-mounted aP activPAL3™ (PAL Technologies, Glasgow, UK) inclinometer were used as criterion measures and collected data in 15 second epochs. Both have demonstrated acceptable reliability and validity as instruments for assessing sedentary and sitting time respectively, in free-living studies.19 For the aP, the sitting posture (as determined based on the angle of the thigh relative to gravity) was used as the criterion for duration of workplace sitting, and transitions from a sitting posture to an upright posture was used as the criterion for frequency of breaks in workplace sitting. For the AG, sedentary time was defined as <100 cpm,8 and breaks in sedentary time were defined as the frequency of occasions that the accelerometer counts transitioned from sedentary (<100 cpm) to active (≥ 100 cpm).7 Consistent with previous research, ≥ 60 minutes of consecutive zeros was considered ‘non-wear’ time.21 Using information recorded in the log books, aP and AG data were extracted for each participant’s work hours. To be included, participants needed to have worn the monitors for 75% of reported work hours on at least three weekdays days for full-time workers and on two weekdays for part-time workers.22 Overall, 52 participants (88%) had valid aP data (8.63±0.82 hours/day, proportion of wear time (0.98±0.02), and 49 (83%) had valid AG data (8.68±0.70 hours/day, proportion of wear time=0.99±0.02). To compute frequency of breaks in workplace sitting per hour, the frequency of transitions from sitting to an upright position recorded by the aP that occurred during work hours was divided by the duration of sitting during work hours. For the AG data, the frequency of breaks in sedentary time per hour during work was divided by total sedentary time (<100 cpm) during work hours. For duration of sitting/sedentary time error variables (monitor data – self-report estimates) were used to screen for multivariate outliers, and one case was removed from the analytic sample as it approximated classification as a multivariate outlier.23

On the first day of monitoring, participants reported their height and weight, which was used to calculate body mass index (BMI: kg/m²) and classify participants as healthy weight (<25kg/m²) or overweight or obese (≥ 25kg/m²).24 The highest level of education reported was collapsed into four
categories: <12 years, >12 years, trade/diploma, and university. Work status was dichotomised into full-time or part-time. The Active Australia Survey [AAS] was used to assess time spent in moderate- and vigorous-intensity physical activity (MVPA); this survey has been found to have adequate reliability and validity properties. The data were scored using established methods described in the guide for implementation of the AAS and participants were dichotomised as sufficiently (≥ 150 mins/wk) or insufficiently (<150 mins/wk) active.

Data were processed and analysed using the Statistical Package for the Social Sciences (SPSS; version 22; IBM Corp, 2012) and STATA (version 13; StataCorp LP, 2012). Statistical significance was set at p<0.05. Chi-square analyses were conducted to examine if socio-demographic characteristics differed between participants with and without valid monitor data (Table 1). To quantify duration of sitting and frequency of breaks from sitting per work hour, medians and Interquartile Ranges (IQR) were calculated for self-report and monitor data. Test-rest reliability of the self-reported duration of sitting and frequency of breaks in sitting was examined using ICCs. ICCs were calculated using a two-way mixed model based on absolute agreement, with ICC<0.40 indicating poor agreement, 0.40-0.74 indicating fair to good agreement, and ≥ 0.75 excellent agreement. Criterion validity between self-reported duration of sitting and frequency of breaks in sitting, and each of the monitors was established using Spearman’s Rho. Rho estimates were interpreted as: 0.00 indicating poor; 0.00-0.20 slight; 0.21 - 0.40 fair; 0.41 - 0.60 moderate; 0.61 - 0.80 substantial; and 0.81-1.0 almost perfect. To further examine differences between reported duration of sitting and monitor data box-and-whisker plots were used to illustrate the error range (Figure 1).

iii. Results

As shown in Table 1, just over half the sample were women and the majority were aged between 18-39 years and worked full-time. Most participants reported meeting physical activity (PA) recommendations and were in the healthy weight range. The socio-demographic characteristics of participants generally did not differ between those with or without valid data for either monitor. Participants reported sitting for most of the work day (76%), with a median sitting time of 420mins/day (IQR=360-450 mins/day). Median self-reported frequency of breaks in sitting was one break/hour (IQR = 1-2).
There was excellent repeatability of self-reported duration of sitting (ICC = 0.78; 95% CI = 0.65, 0.86) and good repeatability for frequency of breaks in sitting (ICC = 0.65; 95% CI = 0.48, 0.78; Table 2). Agreement between self-reported duration of workplace sitting and duration of workplace sitting measured by the aP was fair (Rho = 0.24, 95% CI = -1.0, 0.47), as were comparisons to the AG (Rho = 0.39, 95% CI = 0.15, 0.68). Agreement between self-reported frequency of breaks from sitting and data from the aP was fair (Rho=0.39; 95% CI = 0.25, 0.74), as were comparisons with the AG (Rho=0.30; 95% CI = 0.15, 0.69; Table 2). Compared to the aP-measured duration of sitting during work hours, self-reported sitting time was biased towards over-reporting (median = 45.4 minutes), with a large level of variance (IQR = -108.1, 19.6 minutes) at the extremes (Figure 1). Compared to the AG, self-reported sitting was slightly under-reported (median = 21.7 minutes).

iv. Discussion

This study found adequate reliability and fair validity for self-reported duration of sitting and frequency of breaks from sitting at work. The test-retest reliability estimates for the item assessing duration of sitting at work were consistent with past research, suggesting that workplace sitting can be consistently captured, while reliability of the item assessing frequency of breaks from sitting was higher than a previous study and similar to the original survey on which the current instrument was adapted.

The validity estimates were reasonably consistent with past research that tested similar self-report items against the AG. However, validity estimates against the aP were poorer for items assessing duration of workplace sitting (Rho=0.63 versus 0.24) but more favourable for items assessing frequency of breaks in sitting (Rho= 0.06 versus 0.39) compared to the only other study to have used the aP as a criterion. These differences could be explained by sample characteristics, the current study included workers who spent most of their work time sitting, while Wijndaele et al. included unemployed adults and adults who reported no workplace sitting. Using the AG, Clark et al. found stronger validity for self-reported duration of sitting among office-based workers than among customer service workers, and in frequency of breaks among office-based and call centre workers compared to
customer service workers. Differences in workplace roles among in the current sample, compared to that of Wijndaele et al.\textsuperscript{17} may partly explain the different reliability and validity estimates obtained. Future research with larger heterogeneous samples should explore the influence of work roles on recall accuracy to ensure that those most at risk of prolonged workplace sitting can be identified. There were also important differences in question structure between the two instruments. Wijndaele et al.\textsuperscript{17} asked participants to report the average number of times per day sitting was interrupted. The current study requested the number of breaks from sitting per work hour. Our findings suggest that reporting frequency of breaks from sitting, particularly subtle types of breaks involving a postural change from sitting to standing without necessarily moving around, may be less cognitively demanding and more accurate when respondents are asked to reflect over a shorter period.

There were differences in validity estimates depending on the criterion measure used. Validity of self-reported frequency of breaks from sitting were higher against the aP than the AG. This is consistent with the aP’s ability to detect changes in posture (i.e. transitions from sitting to standing) rather than shifts in accelerations of the body beyond a particular threshold. Posture-based monitors should be used as a criterion for frequency of breaks in sitting.\textsuperscript{20} Conversely, validity estimates for self-reported duration of sitting were stronger, with less bias, against the AG rather than the aP. It may be that people associate sitting with a lack of/limited movement, rather than being in a sitting posture. Further research should explore adults’ understanding of the terms ‘sitting’ and ‘breaks in sitting’ and the cognitive processes used to generate answers to questions such as the brief single-item measures used in this study.

The main strength of this study was the use of two criterion measures (aP and AG). Previous research validating self-reported measures of sitting have primarily used accelerometers, which provide imprecise estimates of duration of sitting and frequency of breaks from sitting.\textsuperscript{19, 20} Limitations of the study include the unknown job roles of participants, the relatively small sample, and the convenience sampling used to recruit participants, which may limit the generalisability of results. Further, while the item assessing frequency of breaks from sitting asked participants to exclude structured work breaks (i.e. lunch, or tea breaks), it was not possible to exclude these breaks from estimates derived from the
aP or AG as the monitor log did not collect information about these types of breaks. Thus frequency of
breaks from sitting extracted from these devices could be overestimated.

v. Conclusion

With emerging evidence suggesting that the volume and manner in which sitting time is accumulated
may be important for health, easily administered, accurate and reliable self-report measures of duration
of sitting and frequency of breaks from sitting while at work are needed.\(^\text{12}\) This study showed acceptable
criterion validity and test-retest reliability for a single-item designed to assess frequency of self-reported
breaks from sitting. However, while reliability was acceptable, validity of the item assessing duration
of sitting at work was not acceptable, precluding its wider application. There was also variability in
validity estimates between the criterions; further validation using inclinometers is needed. Future
research should identify the optimal reference period (i.e. day, hour) that most accurately captures self-reported
duration in workplace sitting. Involving larger samples with diverse job roles, and examining
responsiveness to change are further next steps.

vi. Practical Implications.

- A single-item self-report measure can provide an adequate estimate of frequency of
  breaks from workplace sitting.
- For capturing breaks in sitting, shorter reference periods, such as breaks per hour of
  work sitting, may benefit recall accuracy.
- Total duration of workplace sitting was not accurately recalled.

vii. Acknowledgements.

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support from the NHMRC Centre of Research Excellence [XX], which is used to support XX.

References


### Table 1 Descriptive and socio-demographic characteristics of the sample

<table>
<thead>
<tr>
<th>Socio-demographic characteristics</th>
<th>Total sample</th>
<th>Valid aP data</th>
<th>Valid AG data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (n=59)</td>
<td>% (n)</td>
<td>p-value&lt;sup&gt;a&lt;/sup&gt; % (n)</td>
</tr>
<tr>
<td><strong>Total sample</strong></td>
<td>88.3 (52)</td>
<td>83.1 (49)</td>
<td>0.30</td>
</tr>
<tr>
<td>Women</td>
<td>54.2 (32)</td>
<td>42.3 (22)</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-39 years</td>
<td>78.0 (46)</td>
<td>76.9 (40)</td>
<td>0.30</td>
</tr>
<tr>
<td>40-54 years</td>
<td>15.3 (9)</td>
<td>17.3 (9)</td>
<td>0.38</td>
</tr>
<tr>
<td>55+ years</td>
<td>6.8 (4)</td>
<td>5.8 (3)</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;12 years</td>
<td>1.7 (1)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12 years</td>
<td>18.6 (11)</td>
<td>19.2 (10)</td>
<td>0.30</td>
</tr>
<tr>
<td>Trade/diploma</td>
<td>13.6 (8)</td>
<td>15.4 (8)</td>
<td>0.06</td>
</tr>
<tr>
<td>University</td>
<td>66.1 (39)</td>
<td>65.4 (34)</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Work Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>91.5 (54)</td>
<td>92.3 (48)</td>
<td>91.8 (45)</td>
</tr>
<tr>
<td>Part-time</td>
<td>8.5 (5)</td>
<td>7.7 (4)</td>
<td>1.0</td>
</tr>
<tr>
<td><strong>PA Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Level</td>
<td>Percentage</td>
<td>Sample Size</td>
<td>BMI</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>------------</td>
<td>-------------</td>
<td>-----</td>
</tr>
<tr>
<td>Insufficiently active (&lt; 150 mins/week)</td>
<td>16.9 (10)</td>
<td>15.4 (8)</td>
<td>16.3 (8)</td>
</tr>
<tr>
<td>Sufficiently active (≥ 150 mins/week)</td>
<td>83.1 (49)</td>
<td>84.6 (44)</td>
<td>0.73</td>
</tr>
</tbody>
</table>

**Body Mass Index (BMI)**

<table>
<thead>
<tr>
<th>BMI Status</th>
<th>Percentage</th>
<th>Sample Size</th>
<th>BMI</th>
<th>Percentage</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy (&lt;25kg/m2)</td>
<td>61.0 (36)</td>
<td>57.7 (30)</td>
<td>57.1 (28)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight or obese (≥ 25kg/m2)</td>
<td>37.3 (22)</td>
<td>40.4 (21)</td>
<td>0.34</td>
<td>40.8 (20)</td>
<td>0.36</td>
</tr>
</tbody>
</table>

\[a\] Chi-square tests comparing characteristics of those with valid aP data to the total sample.

\[b\] Chi-square tests comparing characteristics of those with valid AG data to the total sample.
<table>
<thead>
<tr>
<th>Workplace</th>
<th>Self-report measure (mins/day) (n=59)</th>
<th>Test-retest reliability</th>
<th>Criterion validity aP sample (n=52)</th>
<th>AG sample (n=49)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=59)</td>
<td>(Median, IQR)</td>
<td>Monitor data (Median, IQR)</td>
<td>Monitor data (Median, IQR)</td>
</tr>
<tr>
<td></td>
<td>Test (Median, IQR)</td>
<td>Retest (Median, IQR)</td>
<td>Rho (95% CI)</td>
<td>Rho (95% CI)</td>
</tr>
<tr>
<td>Sitting</td>
<td>420.0 (360.0, 450.0)</td>
<td>420.0 (360.0, 450.0)</td>
<td>0.78** (0.65, 0.86)</td>
<td>346.81 (281.46, 414.31) 0.24 (-1.0, 0.47)</td>
</tr>
<tr>
<td></td>
<td>(duration)</td>
<td></td>
<td></td>
<td>430.94 (395.11, 451.38) 0.39** (0.15, 0.68)</td>
</tr>
<tr>
<td>Breaks in</td>
<td>1.0 (1.0, 2.0)</td>
<td>1.0 (1.0, 2.0)</td>
<td>0.65**(0.48, 0.78)</td>
<td>0.08 (0.05, 0.10)    0.39**(0.25, 0.74) 0.03 (0.03, 0.05)</td>
</tr>
<tr>
<td>sitting</td>
<td>(freq)</td>
<td></td>
<td></td>
<td>0.30*(0.15, 0.69)</td>
</tr>
</tbody>
</table>

* P<0.05; **P<0.01
Figure Legend

Figure 1 Box-and-Whisker plots displaying the error range for self-report workplace compared to the aP and AG derived workplace sitting/sedentary time (circles are outliers).