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Original research

The validity of the GENEActiv wrist-worn accelerometer for measuring adult sedentary time in free living

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ABSTRACT

Objectives: Based on self-reported measures, sedentary time has been associated with chronic disease and mortality. This study examined the validity of the wrist-worn GENEactiv accelerometer for measuring sedentary time (i.e. sitting and lying) by posture classification, during waking hours in free living adults.
Design: Fifty-seven participants (age = 18–55 years 52% male) were recruited using convenience sampling from a large metropolitan Australian university.
Methods: Participants wore a GENEActiv accelerometer on their non-dominant wrist and an activPAL device attached to their right thigh for 24-h (00:00 to 23:59:59). Pearson's Correlation Coefficient was used to examine the convergent validity of the GENEActiv and the activPAL for estimating total sedentary time during waking hours. Agreement was illustrated using Bland and Altman plots, and intra-individual agreement for posture was assessed with the Kappa statistic.
Results: Estimates of average total sedentary time over 24-h were 623 (SD 103) min/day from the GENEActiv, and 626 (SD 123) min/day from the activPAL, with an Intraclass Correlation Coefficient of 0.80 (95% confidence intervals 0.68–0.88). Bland and Altman plots showed slight underestimation of mean total sedentary time for GENEActiv relative to activPAL (mean difference: −3.44 min/day), with moderate limits of agreement (−144 to 137 min/day). Mean Kappa for posture was 0.53 (SD 0.12), indicating moderate agreement for this sample at the individual level.
Conclusions: The estimation of sedentary time by posture classification of the wrist-worn GENEActiv accelerometer was comparable to the activPAL. The GENEActiv may provide an alternative, easy to wear device based measure for descriptive estimates of sedentary time in population samples.

1. Introduction

Watching television and sitting while at work, using a computer, or in transport are common examples of sedentary behaviours, which are defined as waking behaviours with an energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting or reclining posture.[1,2]

There is increasing evidence that prolonged sedentary time (ST) is associated with increased risk of chronic illnesses (including, cardiovascular disease, cancer, diabetes, and obesity) and mortality in mid-age and older adults.[3–5] A recent meta-analysis has shown that sitting for more than 7 h per day is associated with increased risk of all-cause mortality.[6]

There are several subjective and objective methods for assessing ST in free living conditions. Questionnaires are low cost, easy to administer and can provide information on the type and context of different sedentary behaviours. Although several validated questionnaires are available, the inherent problems of self-report remain, such as recall bias and social desirability, which results in lower accuracy than objective measures.[7–9] Waist-worn accelerometers (e.g. Actigraph) are not open to recall bias, provide valid approximations of physical activity, and can *estimate* sedentary behaviour. There can however, be problems with non-wear time if people take the monitors off and forget to put them back again.[10] Inclinometers (e.g. activPAL) can measure sitting and lying time very accurately but they are expensive, and the practical application (with adhesive to the thigh) may be bothersome for some, particularly where repeated application is needed over several days.[11] Further, for those with sensitive skin, skin irritation occurring from the adhesive may lead to reduced adherence to wear time protocols.[12,13]

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Inexpensive water-proof, wrist-worn monitors offer the likelihood of better compliance with wear time requirements, as they can be worn continuously, without the need to remove them when changing clothes, showering or sleeping. Recently, Rowlands and colleagues assessed the utility of classifying time in sedentary postures using the wrist-worn GENEActiv accelerometer.[14] In free living conditions, the correlation between the GENEActiv and activPAL estimated ST was $rho = 0.79$ ($p < 0.01$). However, despite the moderate to strong correlation, there was still some disagreement in categorisation of posture as sitting or standing. Taken together with a small sample size ($n = 13$) and the inclusion of sleeping time, the utility of estimating sedentary time using the GENEActiv warrants further investigation.

Therefore, the aim of this study was to assess the validity of the GENEActiv as an objective measure of ST in adults in free living conditions, during waking hours only.

2. Methods

Participants were recruited from the University of Queensland by convenience sampling, including word of mouth and an online university newsletter. Those who showed interest received an information sheet explaining the study and the eligibility criteria; and an invitation to join the study via email. To be eligible, participants had to be over the age of 18 years, healthy and ambulatory. Eligible participants provided written informed consent prior to enrolling in the study and in return for their participation received a $20 cash gratuity. Ethical clearance was obtained from the Medical Research Ethics Committee of the University of Queensland (#2013000870).

The protocol took place over three days. On Day 1, participants completed a questionnaire to provide demographic information including age, gender, and education. Standing height and weight measures were taken using a stadiometer (SECA 217-172-1009, Hamburg, Germany) and electronic scale (Charder MS 3200, Hamburg, Germany). Each measure was taken twice and the average measure obtained. If the first and second measures varied by more than 1%, a third measurement was taken and the median of the three values recorded. Body mass index was calculated as weight (kg)/height^2 (m^2).

Instructions on how to use the GENEActiv and activPAL were provided before the devices were attached. Participants were instructed to wear the GENEActiv (wrist) and activPAL (thigh) monitors continuously until the next visit on Day 3, allowing complete 24 h wear on Day 2. Participants were also provided with an sleep time diary to record their waking and sleeping times for Day 2 and any periods the GENEActiv and activPAL devices were removed. Recorded wake and sleep times were used to extract GENEActiv and activPAL data for the times participants were awake on Day 2.

The second visit took place on Day 3. The GENEActiv, activPAL and the completed sleep time diary were collected from participants, and they completed an interviewer assisted time use recall tool (the Multimedia Activity Recall for Children and Adults). As Day 3 was scheduled for either Wednesday or Friday, the previous measurement day was always a week day.

The GENEActiv (Activinsights Ltd., Cambridgeshire, UK) is a tri-axial, ±6 g seismic acceleration sensor, which is small (36 cm × 30 cm × 12 cm), lightweight (16 g), waterproof, and offers a near body temperature sensor to help improve the confirmation of wear and non-wear time. GENEActiv validity studies have demonstrated strong correlations for criterion validity (Pearson's $r = 0.79–0.98$) against indirect calorimetry for both physical activity and sedentary behaviour.[15,16] GENEActivs were configured with a sampling frequency of 30 Hz. Downloaded .bin files were converted to 15 s epoch .csv files using PC software version 2.1 (GENEActiv). These files were imported into a custom built spreadsheet (Excel) that calculated the most likely posture (available from authors Rowlands and colleagues[14]). Briefly, estimation of posture is based on collected data, where recorded elevations greater than 15° below the horizontal indicate the wrist is elevated, and if activity intensity level is low and the wrist is elevated, this indicates a sitting or reclining posture. When the GENEActiv is less than 15° below the horizontal, this indicates that the arm is hanging more vertically, indicating a standing position. Where activity level is moderate or vigorous, posture is classified as standing irrespective of wrist elevation (see[14] for further details and diagram depicting monitor elevation).

The activPAL device (Version 3, Pal Technologies Ltd., Glasgow, UK) is a thigh-worn inclinometer accelerometer, which continuously records posture and movement (time spent sitting/lying, standing or stepping). The device was sealed with a nitrile finger cot and a layer of opsite and attached to the skin with a transparent film (Tegaderm™ Roll, 3M™) in order to provide a waterproof barrier. The attachment was made to the right thigh (midline on the anterior aspect). The activPALs were initialised (default settings used) and data were downloaded using activPAL™ Professional Software, v6.1.2 Research Edition (Pal Technologies Ltd., 2010). Estimates of time spent sitting/lying were derived from the event file, which includes time intervals per day in seconds. The activPAL has been shown to have high accuracy as a measure of posture (sit/lie as opposed to upright) and ST.[11,17] Participants' activPAL and GENEActiv data were considered valid if they reported wearing the device for all waking hours, with less than 30 min removal.

To match posture classification between the GENEActiv and activPAL, the same protocol as was used by Rowlands and colleagues was followed, with 15 s epochs for the activPAL based on the posture that occurred for the majority of the epoch.[14]

The adult version of The Multimedia Activity Recall for Children and Adults (MARCA,[18]) was used to identify specific activities, if there was substantial disagreement in estimates of ST between monitors at the individual level. The MARCA was administered via computer assisted personal interview (CAPI) on Day 3. Participants were asked to report their activities for the previous 24-h (Day 2) in time slices as small as 5-min. Activities were recorded by the interviewer by choosing from a list of over 250 activities organised under a number of categories such as "Inactivity", "Sport/Recreation", "Occupation", "Self-care", "Home activities" and "Other". Each activity in the compendium is assigned a unique 5-digit code to classify the activities category, body position and intensity. The second digit of this 5-digit code refers to body position, where; 0 = sleeping, 1 = lying down, 2 = sitting, 3 = standing and 4 = locomotion.

Descriptive statistics (mean and standard deviation [SD]) were used to describe the characteristics of the sample. Statistical difference between ST estimated from the GENEActiv and the activPAL were examined using paired *t*-tests. As data were normally distributed, Intraclass Correlation Coefficients (ICC) with 95% confidence intervals (CI) were used to determine the association between activPAL estimated ST and GENEActiv estimated ST. Pearson's correlation coefficients (r) are also reported for comparison with previous studies. Bland–Altman plots[19] were used to examine differences between GENEActiv and activPAL ST and the average of the two measures, with mean difference (MD) and 95% limits of agreement (LoA; ±1.96 SD) reported. Intra-individual agreement for posture classification using the 15-s epochs of the GENEActiv and activPAL were assessed with the Kappa statistic.

For individual participants where there was substantial disagreement identified (i.e. where ST estimates fell outside the Bland–Altman LoA), MARCA files were examined to determine whether specific activities had contributed to misclassification of posture and disagreement between monitors. The corresponding