Comparisons of Accelerometer and Pedometer Determined Steps in Free Living Samples

Timothy K. Behrens and Mary K. Dinger

Background: The purpose of this study was to compare steps∙d⁻¹ between an accelerometer and pedometer in 2 free-living samples. Methods: Data from 2 separate studies were used for this secondary analysis (Sample 1: N = 99, Male: n = 28, 20.9 ± 1.4 yrs, BMI = 27.2 ± 5.0 kg∙m⁻², Female: n = 71, 20.9 ± 1.7 yrs, BMI = 22.7 ± 3.0 kg∙m⁻²; Sample 2: N = 74, Male: n = 27, 38.0 ± 9.5 yrs, BMI = 25.7 ± 4.5 kg∙m⁻², Female: n = 47, 38.7 ± 10.1 yrs, BMI = 24.6 ± 4.0 kg∙m⁻²). Both studies used identical procedures and analytical strategies. Results: The mean difference in steps∙d⁻¹ for the week was 1643.4 steps∙d⁻¹ in Study 1 and 2199.4 steps∙d⁻¹ in Study 2. There were strong correlations between accelerometer- and pedometer-determined steps∙d⁻¹ in Study 1 (r = 0.85, P < .01) and Study 2 (r = 0.87, P < .01). Bland-Altman plots indicated agreement without bias between steps recorded from the devices in Study 1 (r = –0.14, P < .17) and Study 2 (r = –0.09, P < .40). Correlations examining the difference between accelerometer–pedometer steps∙d⁻¹ and MVPA resulted in small, inverse correlations (range: r = –0.03 to –0.28). Conclusions: These results indicate agreement between accelerometer- and pedometer-determined steps∙d⁻¹; however, measurement bias may still exist because of known sensitivity thresholds between devices.

Keywords: steps per day, motion sensor, step counters, physical activity

Recent technological advances in objective physical activity (PA) assessment, particularly with motion sensors, have given researchers the ability to reduce the potential errors associated with many types of PA measurement techniques. This newfound clarity provides researchers a more accurate representation of PA patterns and levels of PA among individuals and groups. Motion sensors provide an objective measure of PA, assessing actual bodily movement and providing estimates of energy expenditure. Pedometers and accelerometers are 2 motion sensors that are commonly used to assess PA. Pedometers are relatively inexpensive motion sensors that record the number of steps taken over a user-defined time period (ie, steps per day, week, etc), or since the last manual reset. They allow for objective and reliable measurement of ambulatory physical activity¹ and have been employed in large-scale epidemiological studies.¹,² Pedometers are relatively low-tech, user-friendly, and are increasingly being marketed and employed in interventions as a motivational instrument to increase an individual’s physical activity.³,⁴ While some pedometers provide outputs such as distance traveled and energy expenditure, research has indicated⁵ that pedometers are most accurate for assessing steps.

Accelerometers are motion sensors that assess ambulatory PA (frequency, intensity, and duration of activity) and provide an estimate of energy expenditure.¹,⁶,¹⁰ Accelerometers have been used to monitor and provide a description of PA in laboratory and free-living populations.¹⁰–¹² In addition to the frequency, intensity, and duration of activity, some accelerometers have the capability to assess steps. The ActiGraph is a commonly used accelerometer that also outputs steps.⁵,⁷,¹³ LeMasurier and colleagues suggested that the ActiGraph be used as the criterion measure when assessing steps.¹⁴ However, known problems arise when comparing steps between 2 different devices because of movement detection threshold differences among devices. The detection threshold of the ActiGraph is 0.3 g, while the reported detection threshold of the Yamax Model 200 pedometer is 0.35 g.¹⁵ One of the first studies to report this inconsistency in a free-living sample was an investigation by Tudor-Locke and colleagues.¹⁶ In their study, the researchers examined the differences in steps∙d⁻¹ from the ActiGraph and Yamax pedometer among a convenience sample recruited to examine the validity of the International Physical Activity Questionnaire in South Carolina. They found a mean difference of ± 1,845 steps∙d⁻¹. To our knowledge, no other studies have attempted to specifically examine the relationships and agreement between steps per day from the ActiGraph and pedometers in free-living settings.

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Overall, the use of steps as a method of assessing physical activity is a growing trend. A review of PubMed articles dated before 2000 indicated 82 papers regarding pedometers. From January 2001 to February 2008, there were 318 articles indexed. While this increase indicates a growing number of studies using pedometers, it is possible that steps alone may not give researchers all the information that is required. Researchers may also need information about the frequency, intensity, and duration of activity; types of information not typically obtained with many pedometers. Therefore, accelerometers such as the ActiGraph, represent a valuable measurement device in that they can capture both steps and different aspects of PA (ie, frequency, intensity, and duration). Because this represents an important measurement issue in PA assessment, and since many studies use steps as outcome measures,17–20 the purpose of this study was to compare steps∙d⁻¹ from an accelerometer and pedometer in 2 separate samples in an effort to examine agreement between devices with varying populations.

Methods

Participant Recruitment and Study Design

Sample 1. The sample in the first study was drawn from a previous investigation conducted to examine reactivity to objective motion sensors in physically active young adults.21 Eligible participants were between 18 to 30 years of age and full-time undergraduate students. Data were collected in 3 different cohorts, ranging in size from 47 to 52 participants, between January 2004 and March 2004.

Sample 2. The sample in the second study were participants in a previous investigation completed to examine the accuracy of step recording among free-living adults.22 Participants between 25 and 60 years of age were recruited from a large metropolitan area in the south central United States. Data were collected in 3 different cohorts ranging from 22 to 39 participants between September and November 2004.

Instruments

The ActiGraph Monitor Model 7164 [ActiGraph (formerly CSA); Pensacola, FL] was used in both of studies. The ActiGraph is a single axis accelerometer that measures and records vertical accelerations ranging in magnitude from 0.05 to 2 g.23 The ActiGraph measures 5.08 × 4.06 × 1.54 cm and weighs 45.52 g. The ActiGraph is initialized and downloaded using a reader interface that is connected to a serial port of a computer. When cycle mode is initialized, the ActiGraph accesses each sample of the accelerometer signal using the summed magnitude mode and cycle counts to determine the number of steps.23 Research has indicated a high correlation between pedometer steps·d⁻¹ and ActiGraph steps·d⁻¹ and it has recently been suggested that ActiGraph-determined steps be used as a criterion measure when counting steps.24 The Accusplit Eagle 120 (San Jose, CA) was the pedometer used in both of these studies. Distributed by Accusplit, this pedometer is identical to the Yamax Model 200,15 which is among the most accurate pedometers available to assess steps.1 When ambulatory movement results in a force ≥ 0.35 g,15 the pedometer counts the number of steps an individual takes by vertically displacing the lever arm inside the unit.156 Accumulated steps appear on a digital screen. The calibration of each pedometer was checked by the researchers at the beginning of these individual studies using the methods recommended by Tudor Locke and Myers.25

Procedures

The procedures for these 2 samples were identical. Following approval from the institutional review board, participants visited the research laboratory twice. During the first visit participants completed the written informed consent, the Physical Activity Readiness Questionnaire,26 a short demographic questionnaire, and had their height and weight assessed using a portable stadiometer (Seca Model 214, Hanover, MD) and a physician’s balance-beam scale (Detecto Model 439, Webb City, MO). Participants received an accelerometer and pedometer to wear simultaneously for the next 7 consecutive days during all waking hours, except when showering, bathing, or swimming. Each participant was fitted with an elastic belt that fit snugly around his/her waist. The belt was used to attach the accelerometer to the body, so it could be worn under clothing and fit closely against the skin. Participants were instructed to wear the accelerometer over their right iliac crest. They also were told to wear the pedometer over the midline of their right leg on the waistband of their clothing and to reset the pedometer each morning before wearing the device. Participants were given log sheets to record their daily steps from the pedometer and when they put on and removed the devices each day. At the second visit, participants returned the accelerometer, pedometer, and both logs. All participants who completed the study received an individual physical activity report.

Data Reduction and Analysis

Analytic methods used in each of the 2 samples were identical. A valid “day” of wear was indicated by participants’ wearing the accelerometer for a minimum of 10 hours per day. Raw data files were reviewed for outliers and unreasonable values and analyzed using the NHANES data reduction algorithm (http://riskfactor.cancer.gov/tools/nhanes_pam), which utilizes a computer program to examine the “start time” for wear and “stop time” for daily wear (ie, 60 consecutive minutes.
of wear or nonwear). Individual days with less than 10 hours of wear for any single day during the monitoring timeframe were not included in analyses, which included participants with at least 5 valid days.

ActiGraph data were analyzed using standard cutpoints found in the latest NHANES analytic algorithm for adults. In addition, because physical activity recommendations indicate that physical activity should be accumulated in bouts of at least 10 minutes, the data were also examined to determine the number of minutes per day spent in moderate- or vigorous-intensity physical activity that occurred in bouts of at least 10 minutes. Of the 154 participants who were initially recruited to Sample 1, 3 decided not to complete the study and returned their equipment before the end of the week, 4 participants experienced battery failure or equipment malfunction, and 48 did not meet the a priori accelerometer compliance requirements and were excluded. Therefore, this analysis is based on data from the remaining 99 participants (representing approximately 64% of those recruited). Participant characteristics are located in Table 1.

There were 114 individuals who initially agreed to participate in Sample 2. Five individuals did not complete the study and returned their equipment before the end of the data collection period. Of the remaining 109 participants, 35 individuals did not record their steps for 7 days and were consequently excluded from statistical analyses. This resulted in a final sample of 74 participants (approximately 65% of recruited participants). Participant characteristics are located in Table 1.

Analysis of variance (ANOVA) was used to examine differences in steps-d⁻¹ from the accelerometer and pedometer among the different cohorts in each of the respective samples. Steps-d⁻¹ among cohorts in each study did not differ for pedometer-determined steps-d⁻¹ (Sample 1: \( P = .42 \); Sample 2: \( P = .83 \)) or ActiGraph-determined steps-d⁻¹ (Sample 1: \( P = .07 \); Sample 2: \( P = .47 \)). Therefore, data from the different cohorts in each sample were combined, by sample, for analyses.

Mean steps-d⁻¹ for the individual days of the week (ie, Monday–Sunday), mean steps-d⁻¹ for the entire week, and mean differences between ActiGraph- and pedometer-determined steps in each sample were calculated. Paired t tests were used to examine significant differences in steps-d⁻¹ from the different devices. In addition, after determining normal distribution among ActiGraph and pedometer steps-d⁻¹ in each sample, relationships were examined by calculating Pearson correlation coefficients. However, a simple significant, strong correlation does not always imply that similar devices are measuring the same outcome identically. Bland and Altman suggested that using correlation coefficients to determine agreement is fundamentally flawed because 2 methods of measuring the same outcome (eg, steps) should be related, thus, have a high correlation. For that reason, Bland and Altman suggested plotting true values against the mean difference of the 2 measures with 95% confidence intervals. This allows for a visual representation of the agreement between 2 different measures of a similar outcome. Thus, Bland–Altman plots were used to determine agreement between steps from the ActiGraph and pedometer in both samples. Finally, because of known sensitivity differences between the ActiGraph and pedometers, Pearson correlation coefficients were calculated between a difference variable (ActiGraph-determined steps-d⁻¹ minus pedometer-determined steps-d⁻¹) and time in moderate to vigorous PA for both total PA (accumulated in ≥ 1-min bouts) and PA accumulated in bouts ≥ 10 min. All data reduction and statistical analyses were conducted using SAS 9.2 (Cary, NC) with \( \alpha = .05 \) level of significance.

Results

Sample 1

There was a significant difference between ActiGraph and pedometer steps-d⁻¹ for each day during the week, and for the weekly steps-d⁻¹ average (Table 2), with the ActiGraph consistently registering more steps that the pedometer. Pearson correlation coefficients indicated strong, positive associations between accelerometer-determined and pedometer-determined steps-d⁻¹ (Table 2). The Bland–Altman plot indicated a mean difference of 2199.4 ± 1570.2 steps-d⁻¹ between the accelerometer and pedometer. Limits of agreement between measures ranged from −1157.6 to 4757.6 steps-d⁻¹. There were 3 individuals in whom the ActiGraph recorded more steps than the pedometer and 2 individuals who recorded more steps from the pedometer than were captured by the ActiGraph (ie, outside the limits of agreement). However, these discrepancies did not result in measurement bias between the 2 instruments (\( r = −0.09, P = .34 \); Figure 1).

When examining the relationships between the residual steps-d⁻¹ values (ActiGraph—pedometer) and

### Table 1 Participant Demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td></td>
<td>(n = 28)</td>
<td>(n = 71)</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>20.9 ± 1.4</td>
<td>20.9 ± 1.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>177.1 ± 7.6</td>
<td>165.3 ± 7.1</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>85.17 ± 14.7</td>
<td>62.2 ± 9.8</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>27.2 ± 5.0</td>
<td>22.7 ± 3.0</td>
</tr>
</tbody>
</table>
Table 2  Steps and Correlations for Sample 1 (n = 99) and Sample 2 (n = 74)

<table>
<thead>
<tr>
<th>Day</th>
<th>ActiGraph steps</th>
<th>Pedometer steps</th>
<th>Mean difference</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>11,058.4 ± 4,473.1</td>
<td>9,596.7 ± 5,026.6</td>
<td>1,461.7</td>
<td>0.87</td>
</tr>
<tr>
<td>Tuesday</td>
<td>10,650.2 ± 4,117.9</td>
<td>9,310.6 ± 4,473.0</td>
<td>1,339.7</td>
<td>0.87</td>
</tr>
<tr>
<td>Wednesday</td>
<td>10,752.9 ± 3,770.3</td>
<td>8,867.8 ± 3,715.8</td>
<td>1,885.1</td>
<td>0.86</td>
</tr>
<tr>
<td>Thursday</td>
<td>10,606.3 ± 3,902.0</td>
<td>9,109.6 ± 4,119.1</td>
<td>1,496.8</td>
<td>0.88</td>
</tr>
<tr>
<td>Friday</td>
<td>10,850.5 ± 4,560.7</td>
<td>8,906.3 ± 4,540.2</td>
<td>1,944.2</td>
<td>0.85</td>
</tr>
<tr>
<td>Saturday</td>
<td>8,949.4 ± 3,934.0</td>
<td>7,341.4 ± 3,982.6</td>
<td>1,608.0</td>
<td>0.76</td>
</tr>
<tr>
<td>Sunday</td>
<td>8,101.9 ± 4,151.3</td>
<td>6,333.4 ± 4,116.1</td>
<td>1,768.6</td>
<td>0.77</td>
</tr>
<tr>
<td>Daily Mean (7 days)</td>
<td>10,138.5 ± 2,748.1</td>
<td>8,496.0 ± 2,956.1</td>
<td>1,643.4</td>
<td>0.85</td>
</tr>
<tr>
<td>Sample 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>10,977.3 ± 4,109.0</td>
<td>9,168.0 ± 4,475.0</td>
<td>1,809.3</td>
<td>0.86</td>
</tr>
<tr>
<td>Tuesday</td>
<td>11,728.1 ± 3,747.1</td>
<td>9,303.4 ± 3,761.5</td>
<td>1,974.7</td>
<td>0.88</td>
</tr>
<tr>
<td>Wednesday</td>
<td>11,530.3 ± 4,595.9</td>
<td>9,533.3 ± 4,679.6</td>
<td>1,997.0</td>
<td>0.94</td>
</tr>
<tr>
<td>Thursday</td>
<td>10,611.6 ± 3,954.7</td>
<td>8,845.4 ± 4,142.7</td>
<td>1,766.2</td>
<td>0.90</td>
</tr>
<tr>
<td>Friday</td>
<td>11,452.1 ± 4,188.3</td>
<td>9,271.5 ± 3,893.1</td>
<td>2,180.6</td>
<td>0.86</td>
</tr>
<tr>
<td>Saturday</td>
<td>12,272.3 ± 4,841.4</td>
<td>9,696.6 ± 4,805.6</td>
<td>2,575.7</td>
<td>0.85</td>
</tr>
<tr>
<td>Sunday</td>
<td>11,266.3 ± 4,033.1</td>
<td>8,733.7 ± 4,130.2</td>
<td>2,532.6</td>
<td>0.82</td>
</tr>
<tr>
<td>Daily Mean (7 days)</td>
<td>11,341.1 ± 2,954.4</td>
<td>9,221.7 ± 3,103.2</td>
<td>2,199.4</td>
<td>0.87</td>
</tr>
</tbody>
</table>

*Note.* All Mean differences were statistically significant, \( P < .01.\)

**Figure 1** — Study 1: ActiGraph steps·d⁻¹ and pedometer steps·d⁻¹ comparison N = 99; \( r = -0.09, \ P < .34.\) Note: Middle line = mean difference, dotted lines = ± 2 SD, respectively.
time spent in moderate to vigorous PA (MVPA) the findings were not unexpected. The relationship between total accumulated MVPA (≥1-min bouts) and residual steps·d−1 was negative, insignificant, and small (r = −0.03, P = .77).

Similarly, there was a small inverse relationship between MVPA accumulated in bouts ≥ 10 minutes and residual steps·d−1 that was not significant (r = −0.08, P = .42).

**Sample 2**

Similar to Sample 1, in Sample 2 there were significant daily and weekly mean differences between steps from the devices, with the accelerometer constantly assessing more steps than the pedometer (Table 2). Pearson correlation coefficients indicated strong significant relationships for steps between motion sensors (Table 2). When examining the accelerometer and pedometer step counts, the Bland-Altman plot revealed agreement between measures with a mean difference of 1643.4 ± 1581.9 steps·d−1 and limits of agreement ranging from −1001.0 to 5326.6 steps·d−1. There were 3 individuals who recorded significantly fewer steps·d−1 than detected by the ActiGraph and 1 participant who recorded more steps·d−1 than the ActiGraph (ie, outside the limits of agreement). However, no bias was detected between the measures (r = −0.09, P = .40; Figure 1).

When examining the relationships between the residual steps·d−1 values (ActiGraph—pedometer) and time spent in MVPA in Sample 2, the results were different from those in Sample 1. The relationship between total accumulated MVPA (≥1-min bouts) and residual steps·d−1 was negative, insignificant, and small (r = −0.04, P = .70). However, there was a significant small inverse relationship between MVPA accumulated in bouts ≥ 10 minutes and residual steps·d−1 (r = −0.28, P = .01).

**Discussion**

The purpose of this study was to examine the agreement of steps·d−1 between an accelerometer and pedometer in 2 separate samples of adults. Our results indicated that the accelerometer consistently recorded significantly more steps than the pedometer with a mean weekly difference between devices of approximately 1643 steps·d−1 in Sample 1 and 2199 steps·d−1 in Sample 2. Correlation coefficients between accelerometer and pedometer steps were strong and significant in both studies and Bland-Altman plots indicated agreement between devices in both studies. Interestingly, when the relationship between residual steps (ActiGraph—pedometer) and MVPA were examined, small inverse relationships were discovered. Although published research in this area of PA measurement has not typically reported agreement between assessment devices; rather only discussing differences and associations, our findings do corroborate with the results of the limited number of previous studies. However, in addition to the empirical base, our findings regarding residual steps may suggest that lower intensity steps from the pedometer are effectively filtered out due to documented differences in detection thresholds from different devices.15

Various studies have used steps·d−1 from an ActiGraph and a pedometer worn simultaneously.14,16,24,32-35 Each of these studies reported mean differences in steps·d−1 between devices. However, very few have attempted to address the issue of step agreement between devices. In previous studies utilizing a pedometer and ActiGraph, mean differences in steps·d−1 between devices ranged from 1001 steps·d−1 to 1875 steps·d−1. This range represents a difference of approximately 875 steps·d−1, which could be a meaningful difference in a research study. Even though the difference between the 2 studies examined in this paper were smaller than those reported in the literature, we posit that even a small difference such as that found in our study could be practically relevant.

When Bland-Altman plots were created, our findings suggested that ActiGraph and pedometer-derived steps·d−1 demonstrated acceptable agreement in both study populations (Sample 1: r = −0.09, P = .34; Figure 1; Sample 2: r = −0.09, P = .40; Figure 2), without significant bias regardless of whether the means were significantly different. This finding is consistent with the only other previously published study that has reported the agreement between steps·d−1 in a free-living population.16 In their study, the researchers used a convenience sample of participants to evaluate the validity and reliability of the International Physical Activity Questionnaire.16 Participants simultaneously wore an ActiGraph accelerometer and pedometer for 2 weeks. The reported mean difference between devices was 1845 ± 2116 steps·d−1 with a strong, significant correlation (r = 0.86, P < .0001). In addition, a Bland-Altman plot indicated agreement between steps·d−1 measures in their study.

A potentially important finding of the current study is that of the correlations between the residual steps·d−1 from the ActiGraph—pedometer and MVPA. By correlating the residual steps·d−1 with MVPA we were attempting to examine the theory that lower intensity steps·d−1 (ie, sedentary and light PA) accounted for the difference in recorded steps·d−1 between devices. Although most of the correlations presented were not significant, they were all inverse, supporting the hypothesis that the residual steps·d−1 (ActiGraph—pedometer) were from light or sedentary intensity movements not recorded by the pedometer due to sensitivity thresholds. While this may have been a long-held belief among PA researchers, little has been done to expose this theory empirically.

In a controlled study, LeMasurier and colleagues14 found that the ActiGraph recorded more “non-steps” than did a pedometer while traveling by motor vehicle. Thus, in a subsequent study24 steps from the ActiGraph were corrected by 12.5 steps per mile traveled. However, even with the correction factor applied, the reported mean difference between devices still persisted at 1442 steps·d−1. To expound on this finding, Tudor-Locke and colleagues again used the LeMasurier correction factor of 12.5 steps per mile traveled15 to investigate the accuracy of commercially available pedometers in free-living conditions.
Their results indicated that there was a mean difference of 1875 steps·d⁻¹; greater than previously reported using the identical correction factor.

Still, other researchers have attempted different methodologies to correct for the discrepancy between ActiGraph– and pedometer-determined steps·d⁻¹. Although the methodology is unpublished, Matthews et al reported in a subsequent study³² that they corrected the increased sensitivity of ActiGraphs by censoring steps from the ActiGraph when activity counts fell below 260 counts·min⁻¹. In their unpublished data, Matthews and colleagues suggest that using this data reduction methodology resulted in bringing ActiGraph step values to within 3% of pedometer step values. Further, Matthews and colleagues³⁶ have also used 100 counts·min⁻¹ as a criterion for expressing sedentary activity in a representative sample of US adults. In an effort to exploit the potential for a correction factor based on Matthews findings,³²,³⁶ Tudor-Locke and colleagues³⁷ recently reported on ActiGraph-determined steps·d⁻¹ from the NHANES dataset.

In their study, Tudor-Locke and colleagues³⁷ sought to describe the population and sex-specific steps·d⁻¹ patterns of a representative US sample. To examine a proxy of the Matthews et al censoring strategies³²,³⁶ the researchers reported both censored and noncensored steps·d⁻¹. A cut point of < 100 counts·min⁻¹ was used to classify sedentary behaviors, whereas 100 to 499 counts·min⁻¹ was used to classify inactivity. Their results indicated large differences between censored and noncensored steps·d⁻¹ for both men (noncensored: 10,578 steps·d⁻¹; censored: 7431 steps·d⁻¹) and women (noncensored: 8882 steps·d⁻¹; censored: 5756 steps·d⁻¹).

Step differences reflected by this censoring strategy resulted in a difference of 3147 and 3126 steps·d⁻¹ for men and women, respectively. While this censoring strategy may hold promise for researchers when attempting to explain accelerometer-determined steps·d⁻¹, there is still no empirical evidence that has attempted to compare censored accelerometer-determined steps·d⁻¹ with simultaneous pedometer-determined steps·d⁻¹.

Given the efforts of researchers to control for differences between step counting devices, it is evident that a "common" mean value between ActiGraph and pedometer-derived steps remains elusive. Thus these findings indicate, as noted by LeMasurier and Tudor-Locke,¹⁴ it is most likely premature to specify a common correction factor between ActiGraph and pedometer-determined steps·d⁻¹ given the seemingly wide range of step differences found in different studies. Rather, instead of comparing differences between device, researchers and practitioners should be concerned with how well the devices are measuring the behavior of physical activity (ie, agreement).

In total, the findings presented in this paper, and those from previous research suggest that although there are significant differences in steps that are recoded from ActiGraph and pedometer. While the Bland-Altman plots suggest that these differences are not systematic differences that result in measurement bias, the inverse correlations observed may suggest otherwise. Thus, the issue of step counting comparability between devices is not clear. Findings from this study, as well as others reported in this paper, suggest that the ActiGraph consistently records more steps than the pedometer. However,
researchers have also indicated that the ActiGraph records steps with greater accuracy than a pedometer. Therefore, the issue becomes one of practical utility for the researcher and/or practitioner. Does the question of interest for the research study justify the use of ActiGraph or pedometer-derived steps? Practical consideration such as finances, etc. may make the use of research-grade pedometers a more viable option for researchers investigating steps. Still, our findings from 2 different populations suggest that both devices can be used to assess steps with confidence for intervention and descriptive studies. However, if devices are to be used for measurement purposes, step discrepancies can become problematic.

This study is not without its limitations. Although we have presented data from 2 different study populations, both samples were predominantly Caucasian and of higher socioeconomic class. Thus, these findings should be interpreted with care when attempting to generalize to other racial/ethnic and social groups. Further, participants in both of these studies were active. Some researchers have suggested that speed (and perhaps total volume) of ambulatory PA may affect steps outputs from motion sensors. Because the 2 populations were generally homogenous in that respect, it is possible that when comparing steps from more sedentary populations the findings may not be similar. Further, we caution researchers and practitioners that these results were derived from a particular accelerometer/pedometer pairing, and may not be consistent across all accelerometers and pedometers. This is an issue that warrants future investigation as the ease of use and technological innovations with motions sensors encourage increased use among researchers and practitioners alike.

Results from the current study illustrate that identifying a mean difference between ActiGraph steps·d⁻¹ and pedometer steps·d⁻¹ is an important issue. The wide range of the mean difference in steps·d⁻¹ between devices in the literature, and those reported in this study indicate that step values from the different motion sensors are not interchangeable and caution should be exercised when interpreting findings from studies using different motion sensors to report steps. This is an important finding, and deserves further inquiry to examine the differences between ActiGraph-derived and pedometer-derived steps·d⁻¹, particularly under free-living conditions.

Accordingly, the findings from this study provide additional questions for future research. First, researchers should address the consistency between ActiGraph-derived and pedometer-derived steps·d⁻¹. There is a need for more studies to report mean differences between the 2 measures, particularly in free-living populations where conditions cannot be controlled. In addition, the public health impact of these measurement issues should be addressed. Specifically, what is the impact of steps·d⁻¹ based recommendations for PA, and should these recommendations be revised in light of known step differences between different motion sensors? These findings are important to the field of physical activity research and practice. Researchers using steps·d⁻¹ as an outcome measure can use them with confidence that they are accurate representations of PA, but should use caution when comparing steps·d⁻¹ from different devices.

**References**


