Activity-Monitor Accuracy in Measuring Step Number and Cadence in Community-Dwelling Older Adults

P. Margaret Grant, Philippa M. Dall, Sarah L. Mitchell, and Malcolm H. Granat

The primary purpose of this study was to investigate the accuracy of the activPAL physical activity monitor in measuring step number and cadence in older adults. Two pedometers (New-Lifestyles Digi-Walker SW-200 and New-Lifestyles NL-2000) used in clinical practice to count steps were simultaneously evaluated. Observation was the criterion measure. Twenty-one participants (65–87 yr old) recruited from community-based exercise classes walked on a treadmill at 5 speeds (0.67, 0.90, 1.12, 1.33, and 1.56 m/s) and outdoors at 3 self-selected speeds (slow, normal, and fast). The absolute percentage error of the activPAL was <1% for all treadmill and outdoor conditions for measuring steps and cadence. With the exception of the slowest treadmill speed, the NL-2000 error was <2%. The SW-200 was the least accurate device, particularly at slower walking speeds. The activPAL monitor accurately recorded step number and cadence. Combined with its ability to identify primary postures, the activPAL might be a useful and versatile device for measuring activity in older adults.

Keywords: activPAL, accelerometer, pedometer, validity study

Walking is recognized as one of the best forms of physical activity for older adults, and the health benefits that can be derived from it are unequivocal (American College of Sports Medicine, 2006, p. 248; Morris & Hardman, 1997). To benefit from physical activity it is recommended that 30 min of moderate-intensity physical activity, for example, brisk walking, be accumulated on most days of the week (Pate et al., 1995). When relating this recommendation to walk, the quantity of activity can be expressed by time engaged in walking or, alternatively, step number or distance traveled. Energy expenditure increases with walking speed (Ainsworth et al., 1993), so speed is commonly used to determine the intensity of the activity, for example, brisk walking. Cadence (the frequency of stepping) has also been shown to increase with walking speed (Oberg & Karsznia, 1993) and therefore might also be considered an indicator of intensity. Ideally, instruments used to evaluate walking should measure both the quantity and the intensity of the activity.

Grant, Dall, and Granat are with the School of Health and Social Care, Glasgow Caledonian University, Glasgow G4 0BA UK. Mitchell is with the Scottish Government Health Dept., Edinburgh.
Pedometers are regularly used to quantify step number, and many studies have investigated the accuracy of different devices (Bassett et al., 1996; Crouter, Schneider, Karabulut, & Bassett, 2003; Karabulut, Crouter, & Bassett, 2005; Le Masurier, Lee, & Tudor-Locke, 2004; Le Masurier & Tudor-Locke, 2003; Melanson et al., 2004; Schneider, Crouter, & Bassett, 2004; Schneider, Crouter, Lukajic, & Bassett, 2003). Most of these studies have found pedometer accuracy to be compromised at slow walking speeds, thereby limiting their use with older populations (Bassett et al.; Crouter et al., 2003; Karabulut et al.; Le Masurier et al.; Le Masurier & Tudor-Locke; Melanson et al.). More recently, piezoelectric pedometers have been found to be more sensitive than spring-levered pedometers at slower walking speeds and have been recommended for use with the elderly (Crouter, Schneider, & Bassett, 2005; Melanson et al.).

Although pedometers record the total number of steps walked, they give no indication of the time spent walking or the intensity of the activity. Accelerometers, however, have been used to measure energy expenditure and body movement at different ambulatory speeds (Brage, Wedderkopp, Franks, Andersen, & Froberg, 2003; Foster et al., 2005; King, Torres, Potter, Brooks, & Coleman, 2004; Leenders, Nelson, & Sherman, 2003; Levine, Baukol, & Westerterp, 2001) and time spent in different-intensity activities (Tudor-Locke, Ainsworth, Thompson, & Matthews, 2002). Devices based on one or more accelerometers have been shown to be more accurate than pedometers in measuring step numbers at slow walking speeds in healthy adults and, consequently, might be more appropriate for use with older adults (Foster et al.; Karabulut et al., 2005; Le Masurier & Tudor-Locke, 2003; Ryan, Grant, Tigbe, & Granat, 2006).

The activPAL professional physical activity monitor (PAL Technologies Ltd., Glasgow, Scotland) is a uniaxial accelerometer. It is a small, single-sensor unit that is attached to the user’s thigh. When attached, the monitor is unobtrusive and does not impede movement. The accelerometer produces a real-time signal related to thigh inclination and limb movement. From this signal, proprietary software classifies posture as sitting or lying, standing, or walking, allowing the measurement of both activity and inactivity. The data from the device are time stamped, so a profile of the patterns of daily activity can be produced. In walking, the pattern of the signal allows step number to be determined and cadence is calculated with respect to time. The activPAL has been validated as a measure of posture (sitting or lying, standing, and walking), postural transition (Godfrey, Culhane, & Lyons, 2006; Grant, Ryan, Tigbe, & Granat, 2006), and step count and cadence (Ryan et al., 2006) in healthy young adults.

The primary purpose of this study was to evaluate the accuracy of the activPAL in measuring step number and cadence in community-dwelling older adults. In addition, the use of the activPAL for measuring step number was compared with two leading pedometers used in clinical practice: the Digiwalker SW-200, a spring-levered pedometer, and the New-Lifestyles NL-2000, a piezoelectric pedometer.

**Methods**

This study incorporated an indoor treadmill walking protocol and an outdoor walking protocol. Similar testing procedures have been adopted in previous studies (Bassett et al., 1996; Crouter et al., 2003; Crouter et al., 2005; Karabulut et al., 2005;
Le Masurier et al., 2004; Le Masurier & Tudor-Locke, 2003; Ryan et al., 2006; Swartz, Bassett, Moore, Thompson, & Strath, 2003). In this study, the activPAL, Digiwalker SW-200, and New-Lifestyles NL-2000 were evaluated for both treadmill and outdoor walking and compared with the criterion measure (observation).

**Participants**

Twenty-one participants (10 men and 11 women) between 65 and 87 years of age were recruited from members of community-based exercise classes. The participants were either attending late-stage cardiac-rehabilitation (Phase IV) classes or exercise classes for people with osteoporosis. None of the participants used a mobility aid. Approval for the study was granted by the ethics committee of the School of Health and Social Care, and informed written consent was obtained from all participants.

**Instruments**

The activPAL is a small, single-unit, uniaxial accelerometer-based activity monitor that needs no calibration before use and requires no manipulation or maintenance by the user. The monitor has been shown to be valid and reliable for measuring step number and cadence for treadmill and outdoor walking in healthy young adults (Ryan et al., 2006). The pedometers used were the Digiwalker SW-200 and the NL-2000 (both supplied by New-Lifestyles Inc., Montana, USA). The SW-200 was used as the criterion pedometer in a previous study (Schneider et al., 2004) and, irrespective of body-mass index, was found to be accurate in measuring step numbers in healthy young adults walking on a treadmill at speeds in excess of 1.33 m/s (Swartz et al., 2003) and walking outdoors (Ryan et al.). The NL-2000 was more accurate than the SW-200 at a slower treadmill speed (1.12 m/s) and was found to be unaffected by body-mass index or waist circumference (Crouter et al., 2005).

The pedometers were clipped securely to the waistband of the trousers or skirt worn by each participant, in accordance with the manufacturers’ instructions (the SW-200 on the left side and the NL-2000 on the right). The activPAL monitor was attached by PALstickies (double-sided hydrogel adhesive pads) to the skin on the midline of the anterior aspect of the thigh (Figure 1). The devices remained in place throughout the treadmill and outdoor walking protocols. For the tests, the participants wore casual clothing and comfortable footwear.

**Treadmill Walking Protocol**

A Woodway motorized treadmill (PPS Med, Waukesha, WI) was used in the study. For safety purposes, an emergency-stop cord was attached to the participant. A familiarization period of approximately 5 min was allowed for the participants to experience the speeds to be used in the study. It has been suggested that healthy older people (>65 years) take longer to familiarize themselves with walking on treadmills (Wass, Taylor, & Matsas, 2005), but we felt that extending the familiarization period would render the protocol too long and tiring for the participants. The treadmill speed was gradually adjusted by the researcher as all participants chose to hold on to the side rails of the treadmill. When a participant reported being
confident in walking on the treadmill, a chair was placed on the treadmill and the participant sat down. This change in position was recorded by the monitor, and, in the data analysis, this allowed the activPAL output to be synchronized with the video recording. All pedometers were reset to zero before each trial.

Each participant walked on the treadmill at five different speeds (0.67, 0.90, 1.12, 1.34, and 1.56 m/s [1.5–3.5 mph increasing in increments of 0.5 mph]) for 5 min at each speed. Between speeds the treadmill was stopped and the participant sat down. Pedometer counts were recorded and the devices were reset to zero before the participant walked at the next speed. The length of time between speeds varied because participants were allowed to rest until they felt prepared to walk at the increased speed. If a participant felt unable to continue to the next speed, the trial was stopped. Throughout this study, the activity was recorded by a digital camcorder.

Outdoor Walking Protocol

For the outdoor walking protocol, the participants walked around a measured 500-m course on the university campus. They walked on paved areas and roads on the campus where they were required to negotiate gentle gradients, curbs, and both vehicular and pedestrian traffic. All testing was performed during the day in variable weather conditions. There were no incidents during testing that required the participants to stop walking.

Each participant completed one circuit of the course a total of three times, each at a different self-selected speed (normal, slow, and fast walking). Between walks the participant sat down on a chair and the pedometer counts were recorded. The participant rested for an unspecified period of time between walks, and when
he or she was ready to proceed to the next speed, the pedometers were reset to zero. A researcher walking behind the participant captured each walk on a digital camcorder.

**Data Analysis**

The data from the activPAL monitors were downloaded to a PC using proprietary software. For each participant, the total step number and the cadence for each treadmill and outdoor walk were calculated. The total step numbers recorded by the SW-200 and NL-2000 for each walk were collated.

The digital recordings were analyzed visually, and the number of steps for each walk was counted. The time line on the digital recording allowed the cadence to be calculated for each walking period. To avoid periods of acceleration and deceleration, the mean cadence for each walk was determined from the second, third, and fourth minutes of the digital recordings and the activPAL data. The visual analysis provided the criterion values for total steps walked and cadence at each speed.

All descriptive data are presented as $M \pm SD$. We used the method of Bland and Altman (1986) to assess the level of agreement for step count between the activPAL and observation and between each pedometer and observation. We used the same analysis to examine the agreement between observation and the activPAL in measuring cadence. In Bland–Altman analyses, the agreement of the measurement devices is indicated by the size of the mean difference and limits of agreement. A small mean difference and narrow limits signify greater agreement between devices. The absolute percentage error between observation and each device was calculated to facilitate comparison with other studies.

**Results**

The characteristics of the participants are shown in Table 1. Because of a problem in filming, observational data for 1 participant were lost, so only 20 sets of results were analyzed. No data were lost from the activPAL monitors used in the study.

Two participants were unable to walk on the treadmill at 1.34 m/s, and an additional 4 did not attempt to walk at 1.56 m/s. Consequently, the analysis of treadmill information included 18 data sets at treadmill speed of 1.34 m/s and 14 at a treadmill speed of 1.56 m/s. The self-selected speeds for outdoor walking are given in Table 2. The average self-selected walking speed of the women was slower than that of the men for outdoor walking (Table 2).

**Table 1  Characteristics of the Participants**

<table>
<thead>
<tr>
<th></th>
<th>Total ($N = 20$)</th>
<th>Women ($n = 10$)</th>
<th>Men ($n = 10$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>$71.9 \pm 5.7$</td>
<td>$71.90 \pm 5.74$</td>
<td>$70.8 \pm 3.6$</td>
</tr>
<tr>
<td>Height (m)</td>
<td>$1.6 \pm 0.1$</td>
<td>$1.6 \pm 0.1$</td>
<td>$1.8 \pm 0.1$</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>$70.0 \pm 14.0$</td>
<td>$61.2 \pm 9.8$</td>
<td>$79.0 \pm 11.9$</td>
</tr>
<tr>
<td>Body-mass index (kg/m²)</td>
<td>$25.5 \pm 3.30$</td>
<td>$25.1 \pm 3.9$</td>
<td>$25.8 \pm 2.8$</td>
</tr>
</tbody>
</table>

Note. Values are $M \pm SD$ (range).
Step Number

The mean number of observed steps for each walking speed is displayed in Table 3. As the treadmill speed increased, so too did the number of steps walked in each 5-min trial. Outdoors, where the participants walked around a 500-m circuit, there was an inverse relationship between the number of steps walked and the self-selected speed. This group of participants, when walking faster, increased both cadence and stride length, resulting in fewer overall steps walked (Table 3) and higher cadence (Table 4).

The Bland–Altman analyses for the three monitors in all conditions are summarized in Table 3. At all speeds on the treadmill and outdoors the mean difference between observation and activPAL was less than three steps (0.6%), and the limits of agreement were narrow. The mean difference between observation and the NL-2000 was less than seven steps, with the exception of the slowest treadmill speed (0.67 m/s). In comparison with the activPAL, however, the limits of agreement were wider, indicating a greater variation in the recordings. At all treadmill speeds less than 1.56 m/s, the mean differences between observation and the SW-200 ranged from 31 to 184 steps with wide limits of agreement. At the fastest treadmill speed (1.56 m/s) and the three outdoor speeds, the mean difference between observation and the SW-200 was less than five steps, although in all cases the limits of agreement were wider than those for both of the other devices.

The absolute percentage errors for all devices are displayed in Figures 2 and 3. The absolute percentage error for the activPAL was less than 1% for all walking speeds both on the treadmill and outdoors. With the exception of the slowest treadmill speed, the error for the NL-2000 was less than 2%. For both treadmill and outdoor walking, the error in step count for the SW-200 decreased as walking speed increased. The SW-200 was more accurate in recording outdoor walking, with absolute percentage errors of 2% and less (Figure 3).

Cadence

The average cadence (steps/minute) for each walking speed recorded by observation and the activPAL is displayed in Table 4. As the treadmill speed increased, so too did the participants’ cadence. The same pattern was observed for outdoor walking, with cadence values increasing with the participants’ self-selected speed from slow to normal and, finally, fast pace. At all speeds, both on the treadmill and outdoors, there was close agreement between observation and the activPAL.
### Table 3  Bland–Altman Summary Table for Observed Step Number

<table>
<thead>
<tr>
<th>Speed</th>
<th>n</th>
<th>Step number, $M \pm SD$</th>
<th>activPAL</th>
<th>SW-200</th>
<th>NL-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean difference (steps)</td>
<td>ULOA (steps)</td>
<td>LLOA (steps)</td>
</tr>
<tr>
<td>Treadmill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.67 m/s</td>
<td>20</td>
<td>437 ± 56</td>
<td>2.6</td>
<td>8.2</td>
<td>-3.1</td>
</tr>
<tr>
<td>0.90 m/s</td>
<td>20</td>
<td>490 ± 55</td>
<td>0.6</td>
<td>6.2</td>
<td>-5.0</td>
</tr>
<tr>
<td>1.12 m/s</td>
<td>20</td>
<td>532 ± 47</td>
<td>-0.1</td>
<td>5.2</td>
<td>-5.4</td>
</tr>
<tr>
<td>1.34 m/s</td>
<td>18</td>
<td>585 ± 47</td>
<td>0.4</td>
<td>3.4</td>
<td>-2.6</td>
</tr>
<tr>
<td>1.56 m/s</td>
<td>14</td>
<td>624 ± 43</td>
<td>0.4</td>
<td>4.3</td>
<td>-3.5</td>
</tr>
<tr>
<td>Outdoors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>slow</td>
<td>20</td>
<td>698 ± 74</td>
<td>-0.5</td>
<td>3.3</td>
<td>-4.3</td>
</tr>
<tr>
<td>normal</td>
<td>20</td>
<td>663 ± 74</td>
<td>-0.2</td>
<td>5.1</td>
<td>-5.4</td>
</tr>
<tr>
<td>fast</td>
<td>20</td>
<td>635 ± 77</td>
<td>-0.5</td>
<td>5.0</td>
<td>-6.0</td>
</tr>
</tbody>
</table>

*Note. ULOA = upper limits of agreement; LLOA = lower limits of agreement.*
Table 4  Bland–Altman Summary Table for Cadence

<table>
<thead>
<tr>
<th>Speed</th>
<th>n</th>
<th>Observation (steps/min, M ± SD)</th>
<th>activPAL Mean difference (steps/min)</th>
<th>ULOA (steps/min)</th>
<th>LLOA (steps/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treadmill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.67 m/s</td>
<td>20</td>
<td>84 ± 11</td>
<td>0.03</td>
<td>1.24</td>
<td>−1.17</td>
</tr>
<tr>
<td>0.90 m/s</td>
<td>20</td>
<td>93 ± 10</td>
<td>−0.35</td>
<td>1.75</td>
<td>−2.45</td>
</tr>
<tr>
<td>1.12 m/s</td>
<td>20</td>
<td>101 ± 9</td>
<td>−0.10</td>
<td>0.82</td>
<td>−1.02</td>
</tr>
<tr>
<td>1.34 m/s</td>
<td>18</td>
<td>110 ± 9</td>
<td>−0.15</td>
<td>0.93</td>
<td>−1.23</td>
</tr>
<tr>
<td>1.56 m/s</td>
<td>14</td>
<td>117 ± 9</td>
<td>−0.10</td>
<td>0.62</td>
<td>−0.81</td>
</tr>
<tr>
<td>Outdoors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>slow</td>
<td>20</td>
<td>114 ± 9</td>
<td>−0.18</td>
<td>1.10</td>
<td>−1.47</td>
</tr>
<tr>
<td>normal</td>
<td>20</td>
<td>122 ± 10</td>
<td>−0.06</td>
<td>0.94</td>
<td>−1.06</td>
</tr>
<tr>
<td>fast</td>
<td>20</td>
<td>128 ± 12</td>
<td>0.00</td>
<td>0.99</td>
<td>−0.99</td>
</tr>
</tbody>
</table>

Note. ULOA = upper limits of agreement; LLOA = lower limits of agreement.

Figure 2 — The absolute percentage error for the three devices at five treadmill speeds. The error bars represent 1 SD.

Figure 3 — The absolute percentage error for the three devices at preferred speeds outdoors. The error bars represent 1 SD.
monitor for cadence. In all conditions, the mean difference was less than one step per minute and the limits of agreement were narrow.

**Discussion**

The primary purpose of this study was to evaluate the accuracy of the activPAL when measuring the step number and cadence of community-dwelling older adults. The narrow limits of agreement and small absolute percentage errors (<1%) between the criterion measure (observation) and the activPAL for both of these parameters, throughout the trial, indicate close agreement between the activPAL and observation. The accuracy of the activPAL was maintained at all walking speeds, both on the treadmill and outdoors, suggesting that the monitor could be used for measuring walking in this population. These results are similar to the findings of Ryan et al. (2006), who reported a similar level of accuracy for the activPAL when tested in a young adult population.

The accuracy of the activPAL for measuring step number was comparable to that of the ankle-worn StepWatch 3 accelerometer, which has previously been shown to have greater than 99% accuracy when measuring steps in younger adults (Foster et al., 2005; Karabulut et al., 2005). In a study of older adults (mean age 86 ± 6.1 years) recruited from a continuing-care retirement community, Resnick, Nahm, Orwig, Zimmerman, and Magaziner (2001) found the step-counting accuracy of the Step Activity Monitor, the model previous to the StepWatch 3, to be 96%. Seventy-three percent of the participants in that study required mobility aids to walk, and the lower level of physical function of the group might have influenced the accuracy of the Step Activity Monitor.

The NL-2000 performed well; with the exception of the slowest treadmill speed the mean absolute percentage errors were less than 2% in all test conditions. At the slowest treadmill speed (0.67 m/s), the mean absolute percentage error for the NL-2000 was 23%, and the pedometer substantially undercounted the number of steps taken. These results at slower treadmill walking speeds (<1.12 m/s) are better than those previously reported in studies with younger participants (Crouter et al., 2003, 2005; Karabulut et al., 2005). The high level of accuracy of the NL-2000 outdoors supports the findings of Schneider et al. (2003), who reported the device’s accuracy to be within 3% of actual steps taken over a 400-m walk at a normal speed.

In recording steps, the SW-200 was the least accurate of the three devices tested for walking both on a treadmill and outdoors. At walking speeds less than 1.56 m/s on the treadmill, absolute percentage errors ranged from 7% to 42% and the limits of agreement were wide, reflecting considerable differences in measurement between the SW-200 and observation. These findings agree with those from previous studies in which slow walking speeds were found to compromise the accuracy of this spring-levered pedometer (Crouter et al., 2005; Le Masurier et al., 2004; Le Masurier & Tudor-Locke, 2003; Melanson et al., 2004; Ryan et al., 2006; Swartz et al., 2003).

In this study, the mean absolute percentage error for the SW-200 at all speeds outdoors was ≤2%. The participants’ self-selected outdoor speeds for slow, normal, and fast walking were 1.37 ± 0.13, 1.54 ± 0.14, and 1.69 ± 0.18 m/s, respectively (M ± SD). In a previous study, the SW-200 was found to underestimate steps taken
Grant et al. by elderly people walking indoors at self-selected speeds (Cyarto, Myers, & Tudor-Locke, 2004). In a group of 26 nursing-home residents age 79.4 ± 8.2 years, the SW-200 underestimated steps at slow (0.42 ± 0.17 m/s), normal (0.64 ± 0.28 m/s), and fast (0.80 ± 0.13 m/s) walking speeds by 74%, 55%, and 46%, respectively. The device was more accurate when the study was repeated with 28 community-dwelling adults age 70.6 ± 5.5 years, when the SW-200 underestimated steps at slow (0.95 ± 0.20 m/s), normal (1.27 ± 0.20 m/s), and fast (1.61 ± 0.21 m/s) walking speeds by 25%, 13%, and 7%, respectively (Cyarto et al.). The walking speed of participants in the current study was considerably faster than that of the nursing-home residents and community dwellers reported by Cyarto et al. The disparity in accuracy might be partly a result of the different tasks and environment between the two studies (500 m unconstrained walking outside vs. 13-m corridor walk) but is more likely attributable to the physical ability of the participants.

To allow users to make direct comparisons between ambulatory monitors, researchers have tended to follow protocols similar to the one used in this study. These protocols have included treadmill walking when the devices are tested at predetermined speeds under controlled conditions and overground walking when the monitors are assessed on different surfaces, either at preferred ambulatory speeds or at imposed paces. There are considerable kinematic and physiological differences between treadmill and overground walking (Alton, Baldey, Caplan, & Morrissey, 1998; Marsh et al., 2006; Wass et al., 2005), and one kinematic difference that has been reported is altered pelvic alignment (Murray, Spurr, Sepic, Gardner, & Mollinger, 1985). In this study, all but one of the participants required the use of the support rails for some, or all, of the walking speeds, and this external support undoubtedly influenced the participants’ walking patterns while on the treadmill. It is possible that a change in pelvic alignment and walking pattern alters the movement and tilt of waist-mounted pedometers, with a detrimental effect on the accuracy of the devices. Investigating the difference between overground and treadmill walking was not the focus of this study, but the difference in device accuracy between the two conditions in this and previous studies (Ryan et al., 2006) raised some questions about the use of treadmill walking to test devices that are primarily designed for free-living use.

The results from this study have shown that the activPAL and the two pedometers recorded steps that were within 2% of actual steps during outdoor walking at self-selected speeds. The cost of pedometers is considerably less than that of accelerometers, but before opting to purchase the less expensive option, it is important to consider in more detail the information provided by the devices and their potential clinical use.

Essentially, pedometers provide a cumulative step count that is easy to interpret but lacks information about activity that can be provided by the activPAL and some ankle-mounted accelerometers (Gildenhuys, Fyfe, MacDonald, & Stergiou, 2004). Because accelerometer data are time-stamped, the devices can identify not only what time during the day a person walks but also how long each walk lasts, how many steps are taken during each walk, and the cadence (steps per minute) of the activity. An example of this detail is described in a recent study using the StepWatch 3 monitor, which identified age-related differences in the patterns of ambulatory activity in community-dwelling adults (Cavanaugh, Coleman, Gaines, Laing, & Morey, 2007). The authors found no difference in the total number of
daily steps taken by healthy younger and older adults but did find that the older adults undertook fewer walks throughout the day. A further clinical example was described by Clarke-Moloney et al. (2007), in which information derived from the activPAL revealed mobility differences between people with venous ulcers and healthy controls. Not only did the patients take fewer steps than the controls, but also the median cadence was less. When the walks were broken down to occasional steps (<20 continuous steps), short walks (20–100 continuous steps), and continuous walks (>100 continuous steps), it was found that patients took fewer short and continuous walks than the controls. As a result of the activPAL attachment on the thigh, Clarke-Moloney et al. were able to differentiate between upright (standing and walking) and sedentary periods; this level of analysis is not available with waist- or ankle-worn accelerometers.

Cavanaugh et al. (2007) suggested that activity patterns might be used to analyze walking in a more clinically meaningful way, and, because walking is strongly encouraged for health benefits in older adults, aspects of walking other than daily step targets might be used to progress the activity. In healthy adults, manipulating activity patterns might provide different ways of acquiring the recommended daily 30 min of moderate-intensity physical activity. In patients who are unable to meet the recommended activity levels, changing activity by increasing the number of episodes of walking, converting occasional steps to short walks, or increasing cadence might help combat the sedentary behavior that negatively affects those with chronic diseases.

The participants found the activPAL comfortable to wear, and no problems were experienced with attachment to the skin. Because the total test time was short (<1 hr), the feasibility of the monitor was not fully assessed in this study. The researchers have used the device with different groups, however, including the elderly, for extended periods (up to 10 days) and have not encountered problems with the attachment. The activPAL is not waterproof and must be removed for bathing. To prevent the possibility of the activPAL’s falling off, participants have been advised to change the adhesive pad on a daily basis.

It should be noted that the participants in this study were recruited from community-based exercise classes intended for clinical groups (late-stage cardiac-rehabilitation [Phase IV] classes or osteoporosis). Promoting physical activity is a key element of all classes, and members are strongly encouraged to walk. Despite their clinical backgrounds and age (65–87 years) it is evident, from the speeds selected, that the participants walked at a faster pace than has previously been reported in older adults (age 60–85 years) who walk for exercise (Parise, Sternfeld, & Samuels, 2004). This finding is of great interest to the class instructors; however, the results from this study cannot be extended to a frail elderly population or to older adults with gait abnormalities.

Conclusions

The findings from this study suggest that the activPAL, NL-2000, and SW-200 are appropriate devices for measuring the number of steps taken by community-dwelling older adults walking at self-selected speeds outdoors. The activPAL and NL-2000 are suitable to measure walking on a treadmill, although the NL-2000 is less accurate at speeds of less than 0.90 m/s. Although the NL-2000 might be appropriate for
recording step number, the pedometer does not measure cadence or identify walking patterns throughout the day. This information can be accurately recorded by the activPAL, and the additional detail might be very useful for health and exercise professionals when promoting walking as an activity in older adults.

The activPAL activity monitor is accurate for recording step number and cadence in community-dwelling older adults. The accuracy of the monitor is unaffected by walking speed and surface (treadmill or overground). The NL-2000 pedometer is more accurate than the SW-200 in recording step number in this population.

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