Validity of the *Fitbit* activity tracker for measuring steps in community-dwelling older adults

Serene S Paul,1 Anne Tiedemann,1 Leanne M Hassett,1,2 Elisabeth Ramsay,1 Catherine Kirkham,1 Sakina Chagpar,1 Catherine Sherrington1

**ABSTRACT**

**Background:** Commercially available activity monitors, such as the *Fitbit*, may encourage physical activity. However, the accuracy of the *Fitbit* in older adults remains unknown. This study aimed to determine (1) the criterion validity of *Fitbit* step counts compared to visual count and *ActiGraph* accelerometer step counts and (2) the accuracy of *ActiGraph* step counts compared to visual count in community-dwelling older people.

**Methods:** Thirty-two community-dwelling adults aged over 60 wore *Fitbit* and *ActiGraph* devices simultaneously during a 2 min walk test (2MWT) and then during waking hours over a 7-day period. A physiotherapist counted the steps taken during the 2MWT.

**Results:** There was excellent agreement between *Fitbit* and visually counted steps (intraclass correlation coefficient (ICC2,1)=0.88, 95% CI 0.76 to 0.94) from the 2MWT, and good agreement between *Fitbit* and *ActiGraph* (ICC2,1=0.66, 95% CI 0.41 to 0.82), and between *ActiGraph* and visually counted steps (ICC2,1=0.60, 95% CI 0.33 to 0.79). There was excellent agreement between the *Fitbit* and *ActiGraph* in average steps/day over 7 days (ICC2,1=0.94, 95% CI 0.88 to 0.97). Percentage agreement was closest for *ActiGraph* (mean 13%, SD 25%) and least for *Fitbit* (mean 0%, SD 25%).

**Conclusions:** The *Fitbit* accurately tracked steps during the 2MWT, but the *ActiGraph* appeared to underestimate steps. There was strong agreement between *Fitbit* and *ActiGraph* counted steps. The *Fitbit* tracker is sufficiently accurate to be used among community-dwelling older adults to monitor and give feedback on step counts.

**BACKGROUND**

Physical inactivity is a major risk factor for many chronic conditions, and contributes to early mortality1 and rising healthcare costs.2 Although prevalent throughout the lifespan, physical inactivity and sedentary behaviour (time spent sitting and lying down) are particularly common among older adults.3 Health problems that are more common in older age may also contribute to low physical activity levels.4 Moderate to vigorous physical activity is known to induce health benefits.5 There is mounting evidence that large amounts of sedentary behaviour is harmful to health even in those who also engage in physical activity.6 Current guidelines recommend older adults engage in at least 150 min of moderate to vigorous physical activity per week, in bouts lasting for 10 min or more, as well as minimise sedentary behaviours.7,8 Increasing the overall number of steps taken daily can enable people to increase their amount of moderate to vigorous physical activity5 in addition to increasing light intensity activity and reducing sedentary behaviour.8 Increasing the amount of steps taken daily may, therefore, be one method of enabling older adults to increase their overall physical activity levels.

Pedometers quantify and give feedback on physical activity and this increases physical activity levels.9 The *Fitbit* tracker (Fitbit Inc, San Francisco, California, USA) is a relatively affordable commercially-available pedometer that automatically records step counts and can provide instant feedback on either the device itself or via simple software accessed via the internet. *Fitbit* trackers come in a variety of small unobtrusive...
activity monitors that can be clipped onto a belt, attached to clothing or worn around the wrist. The Fitbit’s internet and smartphone/tablet interfaces also allow physical activity levels for each individual user to be tracked longitudinally, which can enable the user to monitor their activity trends over time and could also allow healthcare professionals to tailor physical activity recommendations for individuals, thereby encouraging maintenance of physical activity behaviour.

Recent validation studies have demonstrated that the Fitbit is accurate in tracking steps in young and middle-aged adults; however, no study to date has investigated the accuracy of the Fitbit for tracking physical activity in older adults. Older adults frequently present with a wide range of physical disabilities and evidence suggests that activity monitors are less accurate in measuring activity in people who walk with slower gait speeds, use walking aids or have gait impairments.

Determining the accuracy of commercially available activity monitors, such as the Fitbit tracker, for use in older adults would assist health professionals to decide if these devices are appropriate for use by their older clients. This study, therefore, aimed to determine the criterion validity (ie, accuracy) of a Fitbit tracker’s step count compared to visual count by a health professional and to the well-validated ActiGraph GT3X+ accelerometer. This study, therefore, aimed to determine the accuracy of ActiGraph accelerometer step counts compared to visual count in this population.

METHODS

Participants

Participants were community-dwelling older adults from Sydney, Australia, who were randomised to the intervention group of a trial investigating the effect of a behaviour change programme that aimed to increase physical activity participation and reduce fall risk. Participants were aged over 60 years, lived at home, were regular users of the internet via a computer or tablet device and left their house regularly (at least once per week) without physical assistance from another person. Individuals were excluded if they: were housebound (ie, had not gone outside without physical assistance from another person in the past month); had a cognitive impairment (a diagnosis of dementia or a Memory Impairment Screen score ≤5); had insufficient English language skills to fully participate in the programme; had a progressive neurological condition (eg, Parkinson’s disease) or a medical condition precluding exercise (eg, unstable cardiac disease); were currently participating in ≥150 min of moderate intensity physical activity per week and had undergone a fall risk assessment in the past year with subsequent adoption of recommendations.

Procedures

Participants wore a Fitbit tracker (One or Zip) simultaneously with an ActiGraph GT3X+ accelerometer on their right hip. Each device was programmed with the participant’s age and gender, the Fitbit was programmed with the participant's height and the ActiGraph was programmed with the participant’s weight. The ActiGraph collected raw data at 30 Hz.

Participants performed a 2 min walk test (2MWT) in the space available in their homes (usually a corridor approximately 7–10 m in length or a circuit of approximately 15 m), during which a research physiotherapist also observed and counted (with a hand-held stationery counter) the number of steps the participant took. Participants were instructed to stand still for 10 s prior to and after the 2MWT, and the start and finish times of the 2MWT were recorded. The number of steps recorded by the Fitbit tracker was calculated as the difference between the step count displayed by the tracker at the start and at the end of the 2MWT. The number of steps recorded by the ActiGraph during the 2MWT was extracted in 1 s epochs with ActiLife 6 software.

Participants also wore the Fitbit simultaneously with the ActiGraph accelerometer during waking hours (except for water sports or bathing) for a 7-day period. Participants completed a physical activity log for the week-long period. Fitbit tracker and ActiGraph accelerometer data were checked against participants’ activity logs for obvious inconsistencies and any erroneous data were removed. Fitbit tracker data were extracted from the internet interface as the number of steps taken on each day, calculated using Fitbit’s proprietary algorithm and participants’ anthropometry. Daily step counts were extracted from the ActiGraphs in 60 s epochs using the Freedson Adult (1998) equation without any wear time validation as this process is not available with the Fitbit trackers. Step counts from the Fitbit and ActiGraph were averaged over the 7-day period for analysis.

Data analysis

Intraclass correlation coefficients (ICC_{2,1}) were used to examine agreement between step counts taken from the Fitbit, ActiGraph and by the physiotherapist. An ICC ≥0.75 was considered excellent, 0.60–0.74 good, 0.40–0.59 fair and <0.40 poor. Percentage agreement for step counts against the criterion measure of visual count, or of the ActiGraph for Fitbit versus ActiGraph comparisons, were also calculated. Bland-Altman plots were used to visualise any systematic differences between step counts from the Fitbit, ActiGraph and visual count. Data were analysed using SPSS V22 (IBM Corporation, Armonk, New York, USA).

RESULTS

Thirty-two individuals (12 male, 20 female) participated in this validation study. Demographic and health characteristics of the sample are shown in table 1.
Step counts for the 2MWT measured with the Fitbit tracker showed excellent agreement with visual count by a physiotherapist (ICC2,1=0.88, 95% CI 0.76 to 0.94). There was good agreement between Fitbit and ActiGraph counted steps from the 2MWT (ICC2,1=0.66, 95% CI 0.41 to 0.82), and between ActiGraph and visually counted steps (ICC2,1=0.60, 95% CI 0.33 to 0.79). Step counts recorded with the Fitbit during the 2MWT were on average 1.3 steps (95% CI -4.7 to 2.1) less than visual count, but 12.3 steps (95% CI 4.3 to 20.2) more than the steps recorded by the ActiGraph for the 2MWT. Step counts recorded with the ActiGraph accelerometer were on average 13.5 steps (95% CI -22.0 to -5.1) less than visual count recorded for the 2MWT. There was close percentage agreement for each device with a large proportion of participants achieving step counts within 5–15% of the criterion measure, with the Fitbit showing better percentage agreement to visual count than the ActiGraph (table 2). Bland-Altman plots revealed a bias by the ActiGraph for people who took fewer steps during the 2MWT (figure 1).

### Table 1: Participant characteristics for the sample (N=32)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (SD) or N (%)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>67.7 (5.7)</td>
<td>60–81</td>
</tr>
<tr>
<td>Gender (male; female)</td>
<td>12 (38%); 20 (63%)</td>
<td></td>
</tr>
<tr>
<td>Memory impairment screen (0–8)</td>
<td>7.6 (0.9)</td>
<td>5–8</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td>3.3 (2.4)</td>
<td>0–9</td>
</tr>
<tr>
<td>0</td>
<td>2 (6%)</td>
<td></td>
</tr>
<tr>
<td>1–2</td>
<td>13 (41%)</td>
<td></td>
</tr>
<tr>
<td>3–5</td>
<td>11 (34%)</td>
<td></td>
</tr>
<tr>
<td>6+</td>
<td>6 (19%)</td>
<td></td>
</tr>
<tr>
<td>Reported falling in the past year</td>
<td>10 (31%)</td>
<td></td>
</tr>
<tr>
<td>2 min walk test (steps)*</td>
<td>245.1 (18.4)</td>
<td>216–288</td>
</tr>
<tr>
<td>Uses a walking aid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Outdoors</td>
<td>1 (3%)</td>
<td></td>
</tr>
<tr>
<td>Living situation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives alone</td>
<td>12 (37%)</td>
<td></td>
</tr>
<tr>
<td>Lives with spouse±children</td>
<td>15 (47%)</td>
<td></td>
</tr>
<tr>
<td>Lives with friend/relative</td>
<td>5 (16%)</td>
<td></td>
</tr>
</tbody>
</table>

*Number of steps taken as counted by a physiotherapist.

### Table 2: Mean (SD) percentage agreement and number (%) of participants with scores within 5%, 10% and 15% of the criterion measure for each comparison

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Percentage agreement</th>
<th>5% agreement</th>
<th>10% agreement</th>
<th>15% agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>2MWT Fitbit versus visual count</td>
<td>0% (4%)</td>
<td>27 (84%)</td>
<td>31 (97%)</td>
<td>32 (100%)</td>
</tr>
<tr>
<td>2MWT Fitbit versus ActiGraph</td>
<td>7% (16%)</td>
<td>24 (75%)</td>
<td>27 (84%)</td>
<td>27 (84%)</td>
</tr>
<tr>
<td>2MWT ActiGraph versus visual count</td>
<td>6% (10%)</td>
<td>22 (69%)</td>
<td>25 (78%)</td>
<td>28 (88%)</td>
</tr>
<tr>
<td>7-day average steps/day Fitbit versus ActiGraph</td>
<td>13% (25%)</td>
<td>11 (34%)</td>
<td>16 (50%)</td>
<td>21 (66%)</td>
</tr>
</tbody>
</table>

The latter measure in each comparison was used as the criterion measure. 2MWT, 2 min walk test.

DISCUSSION

This study found that in community-dwelling older adults, step counts measured by the Fitbit tracker strongly agreed with visually counted steps by a health professional, but the agreement with steps measured by the ActiGraph accelerometer was lower. Agreement was good between ActiGraph and visually counted steps. The ActiGraph appears to undercount steps in this cohort. This discrepancy was most apparent in people who took fewer steps during the 2MWT.

Our results extend the findings from other populations, including young adults,10 11 23 middle-aged adults10 12 and...
people with stroke and traumatic brain injury,15 showing that step counts measured by the Fitbit tracker are highly correlated with step counts from other validated accelerometers and pedometers commonly used in research settings. Consistent with previous findings,10 23 the strong agreement and low absolute discrepancy (<10% error) between Fitbit and visually counted steps verifies the clinical utility of the Fitbit tracker for monitoring physical activity in older adults. The Fitbit tracker is relatively affordable, simple to use and allows self-monitoring and goal setting by providing feedback on the device itself or through the internet interface.24 The Fitbit’s internet interface also stores long-term physical activity levels. As such, the feedback provided by the Fitbit may be used by older adults, individually or with guidance from a health professional, to encourage increased physical activity over time.

Our results demonstrated that ActiGraph accelerometers undercounted steps in older adults who had good overall mobility. This is evident in the lower proportion of participants whose Fitbit step counts were within 5–15% of ActiGraph steps over a 7-day period in the presence of close percentage agreement between Fitbit and visually counted steps. The Bland-Altman plots also revealed that discrepancy between ActiGraph steps and both Fitbit and visually counted steps was exaggerated in individuals who took fewer steps during the 2MWT. These individuals were observed to have minor gait alteration, such as limping due to arthritic pain or peripheral neuropathy, and to walk more slowly. This finding is in agreement with previous findings demonstrating that accelerometers may not adequately identify steps or physical activity in people with gait alterations.16
The smaller leg accelerations generated during slower walking speeds in people with gait alterations are unlikely to trigger recognition of a step in accelerometers due to the high thresholds used to detect movement in these devices. However, this needs further investigation. It was also observed that many participants used pivot steps to turn during the 2MWT, particularly in corridors, which may explain the systematic undercounting of steps by the ActiGraph accelerometer over a short distance.

This study has established criterion validity of the Fitbit tracker for measuring physical activity in community-dwelling older adults. Yet the rapidity with which newer and cheaper pedometers are becoming available means that research validating these pedometers is unlikely to keep pace with the evolving technology, making it difficult for consumers and clinicians to determine the accuracy of each individual pedometer. Nevertheless, future studies are needed to confirm the effectiveness of physical activity monitors such as the Fitbit for increasing physical activity levels in older adults who do not currently meet physical activity recommendations; one such study is currently underway.

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Contributors
AT and CS conceived the study. SSP, AT and CS initiated the study design. SSP, LMH, ER, CK and SC helped with implementation. SSP conducted the statistical analyses and drafted the manuscript. All authors reviewed the manuscript for critical intellectual content and all authors approved the final manuscript. SSP is responsible for the overall content of this manuscript as guarantor.

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Competing interests
CS receives salary funding from the National Health and Medical Research Council of Australia.

Ethics approval
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No additional data are available.

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