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Short Communication

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Comparison of the Wrist-Worn Fitbit Charge 2 and the Waist-Worn Actigraph GTX3 for Measuring Steps Taken in Occupational Settings

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Abstract

Objectives: If consumer-based monitors such as Fitbit can measure activity accurately, it could provide opportunities for improved assessment of physical activity in general and at work for research purposes. The accuracy of the Fitbit has hardly been investigated in an occupational setting.

Methods: We compared measurements of steps taken at work, out-of-work, and in total of a wrist-worn Fitbit to a waist-worn Actigraph. Seventeen participants wore the Fitbit and Actigraph for 1 full workday.

Results: Compared with the Actigraph, the Fitbit consistently recorded more steps [mean steps at work Fitbit = 7850 (6974), Actigraph = 4396 (1991); out-of-work Fitbit = 6414 (5691), Actigraph = 4116 (3502); total Fitbit = 13 478 (10 666), Actigraph = 8009 (5167)].

Conclusions: Compared with the Actigraph, the Fitbit consistently recorded more steps at work, out-of-work, and in total. The Fitbit and Actigraph recordings were more consistent for measuring steps taken out-of-work compared with at work. Steps counts recorded by the Fitbit, especially in occupational settings, may be inaccurate.

Keywords: accelerometry; Actigraph; activity; exposure assessment; Fitbit; occupational; steps; work

Introduction

While leisure time physical activity has been linked with a myriad of health benefits (Piercy *et al.*, 2018), the effects of occupational activity are less clear (Holtermann *et al.*, 2018). Technologies for objectively monitoring physical activity have advanced considerably, allowing for new insights into the associations between physical activity and health. The Actigraph is one well-validated, waist-worn measurement device that has been used extensively including in large-scale epidemiological studies (Troiano *et al.*, 2008; Lee and Shiroma, 2014). However, despite the potential of these devices to improve assessment of physical activity, they have rarely been used in occupational studies.

The development of the Fitbit and similar devices has made daily activity tracking more accessible at

What's Important About This Paper?

The development of the Fitbit and similar devices has made daily activity tracking accessible at low cost, but they have rarely been tested in occupational settings. In this study, we sought to compare steps taken as measured by the Fitbit Charge 2 and the Actigraph GT3X at work, out-of-work, and in total. We observed positive correlation between the Fitbit and the Actigraph in work and out-of-work settings, but also considerable differences in steps measured by the two devices. Steps counts recorded by the Fitbit, especially in occupational settings, may be inaccurate.

lower cost than the Actigraph devices. The Fitbit Charge 2 is designed to be worn on the wrist, a position that improves wearing compliance for research studies (Troiano *et al.*, 2014; Tudor-Locke *et al.*, 2015). Previous studies have reported the high accuracy of Fitbit devices for measuring step counts, particularly in laboratory settings (Feehan *et al.*, 2018). However, this review also emphasized that further field-based studies are needed. Notably, only one previous study was conducted in an occupational setting (Thompson *et al.*, 2018). Therefore, the objective of this study was to compare steps taken by participants in an occupational setting as measured by the wrist-worn Fitbit Charge 2 to the waist-worn Actigraph GT3X at work, out-of-work, and in total. The Actigraph accelerometer, which is an established device to measure physical activity with many validation studies determining its accuracy (Choi *et al.*, 2011; Sasaki *et al.*, 2011), was considered the reference device.

Methods

Study design and population

A convenience sample of 19 participants working at a manufacturing company across a variety of job titles were recruited to participate in this study. A researcher met with each participant to obtain consent, place the Fitbit and Actigraph devices, and pass out the daily diaries. Participants were instructed to wear both devices for 1 full workday, including all at-work and out-of-work time, except for during sleep or when the devices could get wet (such as during showering or swimming). Participants were instructed to fill in a daily diary including information on when they woke up, started work, ended work, and went to sleep, and also completed a baseline survey. The full study protocol and consent agreements were approved by the University of Connecticut Health Center's Institutional Review Board (IRB No. 18-072S-2).

Devices

Fitbit Charge 2

The Fitbit Charge 2 (Fitbit Inc., San Francisco, CA, USA) is a wireless, wrist-worn, triaxial accelerometer that records step counts and heart rate data on a minute-by-minute frequency. A proprietary algorithm translates raw acceleration signals into steps (John and Freedson, 2012).

Actigraph

The Actigraph GT3X+ (ActiGraph Corp., Pensacola, FL, USA) is a medical grade, triaxial accelerometer that provides step counts on a minute-by-minute frequency. The Actigraph accelerometer is an established device to measure physical activity with many validation studies determining its accuracy (Choi, Liu, Matthews et al., 2011; Sasaki, John, & Freedson, 2011). For this study, the Actigraph was worn on its typical placement on participants' waists.

Data analysis

Using the time stamps on each device, we aligned the Fitbit and Actigraph to the daily diary data. We set all data to 'missing' if either the Fitbit or Actigraph step count data were missing for any period. We also set all data to 'missing' for any non-wear periods, which were defined as 60 min or more of zero step counts on either the Fitbit or Actigraph.

For each participant, we calculated the number of steps taken at work, out-of-work, and in total, for the Fitbit and the Actigraph (Supplementary Figures 1–3). We calculated the mean number of steps taken by the Fitbit and Actigraph, as well as the mean difference and mean percentage difference, with standard deviations (SD). Intraclass correlations and related 95% confidence intervals (CIs) were also calculated (Sushames *et al.*, 2016; Chu *et al.*, 2017). Intraclass correlation coefficient (ICC) values <0.5, between 0.5 and 0.75, between 0.75 and 0.9, and >0.90 are indicative of poor, moderate, good, and excellent correlation, respectively (Chu *et al.*, 2017).

Results

Of the 19 participants recruited for the study, 17 (11 females, 6 males) completed at least 1 full day of data collection and provided daily diaries. Participants on average were 55 (SD = 8) years old. Participants represented a variety of job titles within the manufacturing company including both production and administrative positions.

Overall, the mean number of steps recorded by the Actigraph was 8009 (SD = 5167) steps, whereas the mean number of steps recorded by the Fitbit was 13 478 (SD = 10 666) steps (Table 1). Relative to the Actigraph, the Fitbit recorded more steps taken both at work and out-of-work: at work, the mean number of steps recorded by the Actigraph and Fitbit, respectively, were 4396 (SD = 1991) and 7850 (SD = 6974), and out-of-work, the average number of steps recorded by the Actigraph and Fitbit, respectively, were 4116 (SD = 3502) and 6414 (SD = 5691) (Table 1). The mean (SD) difference for steps recorded by the Fitbit compared with the Actigraph at work, out-of-work, and overall were 3495 (5417), 2298 (3495), and 5675 (7124), with mean percentage differences of 71% (80%), 68% (72%), and 88% (83%) (Table 1). The Fitbit had moderate correlation with the Actigraph during work (ICC = 0.44), and good correlation out-of-work (ICC = 0.73), and overall (ICC = 0.64) (Table 2).

Discussion

Compared with the Actigraph, the Fitbit consistently recorded more steps at work, out-of-work, and in total. The Fitbit and Actigraph recordings were more consistent for measuring steps taken out-of-work compared with at work.

We opted to report steps as our primary outcome. Steps taken continue to be a primary output of interest in research and practice, facilitating translation between studies and communication between different users (Tudor-Locke *et al.*, 2011). We considered the Actigraph as the reference device for this study since its' step count measurements have been well validated (Choi, Liu, Matthews et al., 2011; Sasaki, John, & Freedson, 2011), and it has been used to measure steps in large-scale epidemiological studies (Troiano *et al.*, 2008; Lee and Shiroma, 2014). In this study, compared with the Actigraph, the Fitbit over-estimated steps, especially in an occupational setting. We should note that our findings do not necessarily indicate that Fitbit devices are useless for measuring occupational physical activity. Rather, the Fitbit may be recording a different measure of activity, possibly reflecting more upper extremity activity. It remains to be determined whether occupational activity recorded by a Fitbit can be a useful indicator of worker safety, health, or well-being.

We opted to compare steps measured by the wrist-worn Fitbit to the waist-worn Actigraph. While the Actigraph is typically worn at the waist, there is interest in moving the accelerometer to a wrist-worn attachment site in an effort to improve wearing compliance (Rosenberger *et al.*, 2013). In our study, as was also reported in previous studies, participants reported no complaints with the Fitbit, while some participants disliked wearing the Actigraph (Tudor-Locke *et al.*, 2015). The differences that we observed between the steps measured between the Fitbit and Actigraph, which reflected the findings of previous studies (Rosenberger *et al.*, 2013; Hildebrand *et al.*, 2014; Tudor-Locke *et al.*, 2015; Chu *et al.*, 2017) may be partially explained by the different site locations.

Along with differences in site location, there may be several other explanations for the differences observed between Actigraph and Fitbit step counts. First, there may be intrinsic differences between devices or their calibration that could affect step counts. This has been explored previously in laboratory studies (e.g. Sushames *et al.*, 2016). Second, the types of work performed by participants may have affected the counts. For example, previous studies have reported that the accuracy of Fitbit measurements varied depending on the activity performed (Feehan *et al.*, 2018).

With only 17 participants, the sample size of our study was limited, which might limit the generalizability of the results. However, the sample size of this study is similar to other studies (e.g. Dierker and Smith, 2014;

Table 1. Mean steps taken at work, out-of-work, and in total, difference between methods, and percentage difference comparing the Actigraph and Fitbit.

	Actigraph	Fitbit	Difference	Percentage difference
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Total	8009 (5167)	13 478 (10 666)	5675 (7124)	88 (83)
Work	4396 (1991)	7850 (6974)	3495 (5417)	71 (80)
Out-of-work	4116 (3502)	6414 (5691)	2298 (3495)	68 (72)

Table 2. Intraclass correlation coefficients of the Fitbit steps taken compared with the Actigraph values.

Parameter	ICC (95% CI)
Work	0.44 (−0.04, 0.75)
Out-of-work	0.73 (0.39, 0.89)
Overall	0.64 (0.24, 0.85)

Dominick *et al.*, 2016; Sushames *et al.*, 2016). Further, the Actigraph is not the gold standard for measuring step counts, although it has been used extensively in epidemiological studies (Welk, 2002). Nevertheless, ours was the first study to compare steps measurements for the Fitbit and Actigraph in an occupational setting.

Conclusions

We observed positive correlation between the wrist-worn Fitbit and the waist-worn Actigraph in work and out-of-work settings, but also considerable differences in steps measured by the two devices. Steps counts recorded by the Fitbit, especially in occupational settings, may be inaccurate.

Supplementary data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

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