RESEARCH LETTER

Accuracy of Smartphone Applications and Wearable Devices for Tracking Physical Activity Data

Despite the potential of pedometers to increase physical activity and improve health, there is little evidence of broad adoption by the general population. In contrast, nearly two-thirds of adults in the United States own a smartphone and technology advancements have enabled these devices to track health behaviors such as physical activity and provide convenient feedback. New wearable devices that may have more consumer appeal have also been developed.

Even though these devices and applications might better engage individuals in their health, for example through workplace wellness programs, there has been little evaluation of their use. The objective of this study was to evaluate the accuracy of smartphone applications and wearable devices compared with direct observation of step counts, a metric successfully used in interventions to improve clinical outcomes.

Methods | This prospective study recruited healthy adults aged 18 years or older through direct verbal outreach at a university. Participants gave verbal informed consent to walk on a treadmill set at 3.0 mph for 500 and 1500 steps, each twice, for no compensation. An observer (M.A.C.) counted steps using a tally counter in August 2014. This study was approved by the University of Pennsylvania institutional review board.

A convenience sample of 10 applications and devices was selected from among the top sellers in the United States. On the waistband, each participant wore the Digi-Walker SW-200 pedometer (Yamax), which has been well validated for research, and 2 accelerometers: the Zip and One (Fitbit). On the wrist, each wore 3 wearable devices: the Flex (Fitbit), the UP24 (Jawbone), and the Fuelband (Nike). In one pants pocket, each carried an iPhone 5s (Apple) simultaneously running 3 iOS applications: Fitbit (Fitbit), Health Mate (Withings), and Moves (ProtoGeo Oy). In the other pants pocket, each carried the Galaxy S4 (Samsung Electronics) running 1 Android application: Moves (ProtoGeo Oy).

At the end of each trial, step counts from each device were recorded. In rare instances that a device was not properly set to record steps (8 of 560 observations), these data were not included. The mean step count and standard deviation for each device was estimated using Excel (Microsoft).

Results | Across all devices, 552 step count observations were recorded from 14 participants in 56 walking trials. Participants were 71.4% female, had a mean (SD) age of 28.1 (6.2) years, and had a mean (SD) self-reported body mass index (calculated as weight in kilograms divided by height in meters squared) of 22.7 (1.5).

Figure 1 shows the results for the 500 step trials by device and Figure 2 shows the results for the 1500 step trials. Compared with direct observation, the relative difference in mean step count ranged from −0.3% to 1.0% for the pedometer and accelerometers, −22.7% to −1.5% for the wearable devices, and −6.7% to 6.2% for smartphone applications. Findings were mostly consistent between the 500 and 1500 step trials.

Discussion | We found that many smartphone applications and wearable devices were accurate for tracking step counts. Data from smartphones were only slightly different than observed step counts, but could be higher or lower. Wearable devices differed more and 1 device reported step counts more than 20% lower than observed. Step counts are often used to derive other measures of physical activity, such as distance or calories...
burned. Underlying differences in device accuracy may be compounded in these measures.

Our study is limited by being conducted with young, healthy volunteers in a controlled setting with a convenience sample of a small number of applications and devices. Results should be confirmed in other settings and with other devices.

Increased physical activity facilitated by these devices could lead to clinical benefits not realized by low adoption of pedometers. Our findings may help reinforce individuals' trust in using smartphone applications and wearable devices to track health behaviors, which could have important implications for strategies to improve population health.

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**Author Contributions:** Ms Case had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Ms Case and Dr Burwick contributed to the study concept and design; all authors contributed to acquisition, analysis, or interpretation of data: Case, Patel; drafting of the manuscript: Case, Patel; statistical analysis: Case, Patel; administrative, technical, or material support: Case, Burwick, Patel; and study supervision: Volpp, Patel.

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