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Fitbit Flex: Energy Expenditure and Step Count Evaluation

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ABSTRACT

Montes J, Young JC, Tandy R, Navalta JW. Fitbit Flex: Energy Expenditure and Step Count Evaluation. **JEPonline** 2017;20(5):134-140. Energy expenditure (EE) and step count (SC) was measured with a Fitbit Flex wrist-worn activity tracker (FWAT) during a two-day walking protocol. Forty-nine volunteers participated on day 1, 46 on day 2, 31 were used for reliability. Participants walked for 3 min at 1.5, 2.5, and 3.5 mph at 0% grade on both days. An Applied Electrochemistry MOXUS Metabolic System (MX) with steps counted was the baseline comparison. Data was analyzed using dependent *t*-tests ($P<0.05$) and Cronbach's α (≥0.70). For EE; (1.5 mph; $P<0.01$, Standard Error(SE): FWAT 19.43 ± 0.73; MX 11.9 ± 0.32, α=0.56. 2.5 mph; $P<0.01$, SE: FWAT 25.0 ± 0.75; MX 14.43 ± 0.38, α=0.72. 3.5 mph; $P<0.01$, SE: FWAT 27.2 ± 0.77; MX 19.43 ± .049, α=0.67). For SC; (1.5 mph; $P<0.01$, SE: FWAT 231 ± 6.02; MC 269 ± 2.58, α=0.55. 2.5 mph; $P=0.03$, SE: FWAT 323 ± 4.39; MC 332 ± 2.18, α=0.50. 3.5 mph; $P<0.01$, SE: FWAT 366 ± 3.22; MC 380 ± 2.21, α=0.66). The FWAT significantly overestimated EE with reliability at 2.5 mph and significantly underestimated SC without reliability at any speed.

Key Words: Fitbit, Physical Fitness, Walking, Wearable Technology

INTRODUCTION

Statistics from the Center for Disease Control (CDC) estimate that 23.7% of the adult population engages in no leisure physical activity, 27.1% of the adults are physically active daily, 28.9% are obese, and 35.2% are overweight. The yearly healthcare cost for physical inactivity is estimated to be $117 billion with the inactive adults paying approximately $1,437 more than the physically active adults (2).

The American College of Sports Medicine (ACSM) recommends all persons do at least 30 min of moderate-intensity physical activity on at least 5 $d \cdot wk^{-1}$ (8). Monitoring daily step counts (SC) can be a useful tool for evaluating daily physical activity, health, and wellness. To accomplish this, one of the more common activities is the accumulation 10,000 daily steps. By comparison, the average daily SC for the general population is 6,000 to 7,000 steps. Choi et al. (3) indicate that performing a 30-min walk at a moderate intensity could add another 3,000 to 4,000 steps. The additional walking, according to Tudor-Locke and Bassett (16), was found to assist persons in leading a healthier lifestyle.

A longitudinal study by Moreau et al. (12) gave additional evidence that increasing daily SC to ~10,000 steps a day reduced systolic BP in hypertensive women by ~11 mmHg and body mass by ~1.3 kg after a 24-wk interval of daily walking. An activity Tracker (AT) that can accurately measure daily SC with a "hard step count value" could consistently prompt the wearer of how near they are to their daily fitness goals. In addition, the AT can provide a psychological boost by encouraging the wearer to increase SC when the daily count is lower than anticipated. This may cause an increase in physical activity by prompting the user to perform activities such as using stairs instead of elevators or walking to nearby stores rather than driving.

Devices that measure exercise related data such as SC and energy expenditure (EE) have become popular with the fitness community with wearable technology being the number one trend in exercise for 2016 (14). The use of wrist-worn devices has become a favorite with persons due to the low cost ($10 to $160) and user friendliness of the devices (15). Also, because they are small and non-intrusive, they do not impair the user during daily activities (4). However, the accuracy and consistency of most physiological measuring devices have yet to be fully evaluated.

To be considered beneficial to a user, certain criteria need to be met. First, it must measure what it claims to measure within an acceptable range. Second, it must be consistent. Third, it must be financially reasonable and user friendly. Fourth, its use should minimally alter the behavior of the user as to not influence its measurement (6). The FitBit Flex (FWAT) is a reasonably priced AT ($79.95) that is simple to use and understand (5). However, previous research has indicated that similar wrist worn devices are inaccurate when users walk at speeds of approximately 2.0 mph and slower (7,11). This inaccuracy can lead to incorrect estimations of physical activity and calculations of calories expended.

The purpose of this study was to evaluate significant mean differences and reliability measures for FWAT EE and SC values. We hypothesized that the FWAT measurements for EE and SC at all three speeds would: (a) not be significantly different from MX derived EE values and a manual count of steps; and (b) be reliable using the same time/day/conditions 1 to 2 wks later.

METHODS

Subjects

Forty-nine participants (26 males, 23 females, age 23.4 ± 6.6 yrs; height 172.1 ± 11 cm; weight 76.2 ± 18.5 kg) were recruited from the University of Nevada, Las Vegas student and faculty populations. All subjects completed an approved institutional review board (protocol number 1408-4894), informed consent, and an American College of Sports Medicine (ACSM) health risk questionnaire prior to beginning the first treadmill walk. Body composition was evaluated for all subjects with a bio-impedance device (TBF-521 Body Fat Monitor/ Scale, Tanita, Arlington Heights, IL, USA). Body Mass Index (BMI) was determined by the formula [(Weight (lbs) x 703 / Height^2 (in)]. Forty-six of the original subjects (24 males, 22 females, age 23.4 ± 6.7 yrs; height 172.1 ± 11 cm; weight 76.5 ± 18.7 kg) returned for the second treadmill walk. The data from 31 subjects (18 males, 13 females, age 24.4 ± 7.6 yrs; height 173.0 ± 10 cm; weight 78.0 ± 21.5 kg) were used for reliability as they retested 1 to 2 wks later at the same time and on the same day of the week as the first walk.

Procedures

The subjects' anthropologic data (gender, age, height, and weight) for the FWAT was entered via an iPad (Apple, mini 2, Cupertino, CA. USA). Subjects were instructed to stand on a treadmill (T9.14, Nautilus, Vancouver, WA, USA) while they were connected to a respiratory cart (Applied Electrochemistry MOXUS Metabolic System, Bastrop, TX, USA) (MX) by use of hoses, head harness, mouthpiece, and nose plugs. A FWAT (Fit Bit Inc, San Francisco, CA, USA) was placed on their right wrist. The MX and a manual SC provided baseline data. The FWAT values were displayed on the iPad for real time viewing.

All subjects performed a treadmill walking protocol. The protocol consisted of three distinct stages of walking at three different speeds. Each stage was separated by a rest interval that allowed for data collection and preparation for the next stage. Subjects began by walking at 1.5 mph at 0% grade for 3 min. After the rest interval, the speed was increased by 1.0 mph while the grade remained the same. This continued until the final stage of 3.5 mph was completed. The second day of walking used the same procedure.

Statistical Analysis

Significant mean differences and reliability for EE and SC were analyzed using IBM SPSS Statistics 23.0 software (IBM SPSS Statistics 23, IBM Corporation, Armonk, NY). Statistical significance was set at $P<0.05$. An α coefficient of 0.70 or higher was considered reliable. Energy expenditure and SC analysis used the values obtained for each speed's overall 3-min time interval. Both days' walks were used for dependent *t*-test analysis (n = 95). Thirty-one paired walks were used to determine reliability (n = 31). The FWAT EE was compared to those calculated from the recorded MX data. The MX EE was determined by multiplying the absolute MX VO_2 value and the RER caloric equivalent for each 1, 2, and 3-min point and adding the three together. The FWAT SC was compared to the manual count of steps. β was set at 0.80. Effect size was calculated using G*Power statistical software (G*Power version 3.1.9.2, Universität Kiel, Kiel, Germany). At the time of this study, there was no previous research data to calculate an “n” size. However, using the indicated α, β, and actual “n”, the calculated effect size for SC and EE was 0.29.

RESULTS

Significant mean differences were observed in all speeds for EE (1.5 mph Standard Error (SE); FWAT 19.43 ± 0.73; MX 11.9 ± 0.32) (2.5 mph SE; FWAT 25.0 ± 0.75; MX 14.43 ± 0.38) (3.5 mph SE; FWAT 27.2 ± 0.77; MX 19.43 ± 0.49) (Figure 1). One speed was reliable (1.5 mph α = 0.56, 2.5 mph = 0.72, 3.5 mph = 0.67) (Table 1). Significant mean differences were observed in all speeds with regards to SC (1.5 mph SE; FWAT 231 ± 6.02; MC 269 ± 2.58) (2.5 mph SE; FWAT 323 ± 4.39; MC 332 ± 2.18) (3.5 mph SE; FWAT 366 ± 3.22; MC 380 ± 2.21) (Figure 2). No speeds were reliable (1.5 mph α = 0.55, 2.5 mph = 0.50, 3.5 mph = 0.66) (Table 1).

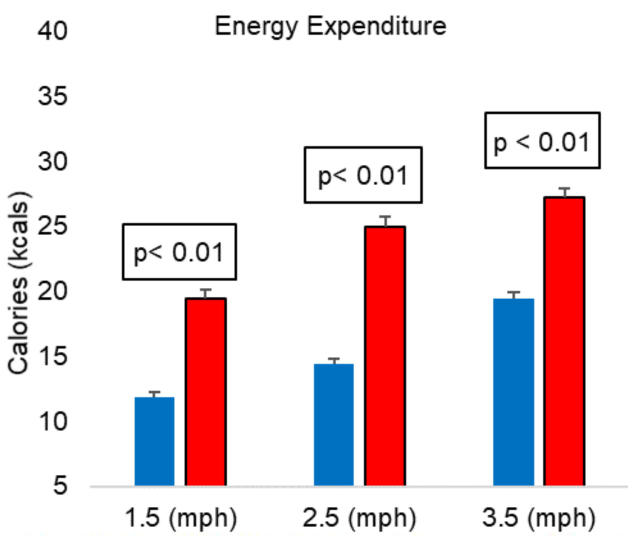

Figure 1. Comparison of calories calculated from MOXUS respiratory cart to calories estimated by the Fitbit Flex.
Calculated Value
FitBit

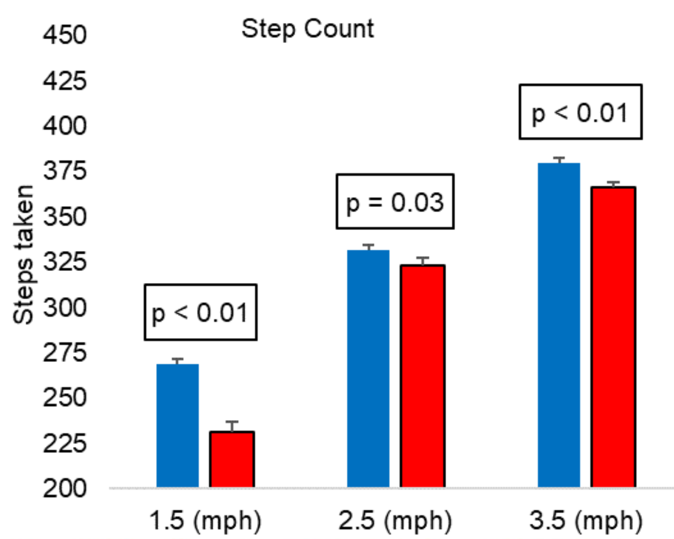

Figure 2. Comparison of a manual count of steps to steps registered by the Fitbit Flex.
Manual Count
FitBit

Table 1. Reliability of Fitbit Flex energy expenditure and step count.

Speed	Energy Expenditure (Cronbach α)	Step Count (Cronbach α)
1.5(mph)	0.56	0.55
2.5(mph)	0.72	0.50
3.5(mph)	0.67	0.66

DISCUSSION

The purpose of this study was to determine if the FWAT accurately measures SC and EE and its consistency to do so. A simple walking protocol using 3-min stages at 3 speeds; 1.5 mph, 2.5 mph, and 3.5 mph; all at 0% grade was used to establish a pool of data for evaluation purposes. These speeds represented: (a) slower walking speeds (<2.5 mph) such as in elderly populations (13); (b) the general population (2.5 to 3.5 mph) (1); and (c) persons using walking as a means of exercise (>3.5 mph) (9). It was hypothesized that measurements taken by the FWAT for EE and SC at all three speeds would not be significantly different from MX derived EE values and a manual count of steps, respectively. It was hypothesized that measurements between both days' walks would be reliable when compared to one another using the same conditions and time/day 1 to 2 wks later.

The FWAT significantly overestimated EE for all three speeds. It was reliable only at 2.5 mph. It can be assumed that the FWAT uses its own SC value as a basis for EE calculations. By overestimating calories burned, it is likely that persons trying to count calories or evaluate potential weight loss will be using incorrect data. Because they believe they are burning more calories than they are, they may not see the weight loss that they are expecting over time. This can result in confusion or discouragement by the user. Given that the subjects only performed a 3-min walk at each speed and each resulted in higher than the actual calories burned, the use of the device over an entire day may give the user a final calorie count that is entirely too high. It has been reported that elderly adults spend 48 min each day being physically active (10). Utilizing our energy expenditure data for walking at 3.5 mph (which had the least difference between measurement devices), an elderly individual would be expected to burn 311 $kcal \cdot d^{-1}$ through physical activity. However, the FWAT would lead them to believe that they had expended 435 $kcal \cdot d^{-1}$, which is an overestimation of 29%. The difference in absolute calories expended would be conceivably higher as physical activity level increased.

The FWAT significantly underestimated steps taken and was not reliable at any speed. One reason for this finding may be in the different mechanics involved when a person walks at slower speeds (1.5 mph) when compared to the faster speeds (such as 3.5 mph). The FWAT relies on motion to register what it considers a step. When walking at 1.5 mph, there was a noticeable reduction in the counter-motion swing in both arms. Also, the subjects appeared to have lower body leg movements that seemed unnatural, i.e. it appeared the slow speed forced them to deliberately concentrate on and purposefully place their feet when stepping to accommodate the slower speed instead of using their natural walking motion. Anecdotally, many subjects commented that the 1.5 mph walk was awkward and felt unnatural. These factors may have directly affected the FWAT SC value through these reduced movement patterns. However, even at the faster speeds (2.5 and 3.5 mph), although the differences between FWAT and manual count were not as great, the FWAT still returned a significantly lower mean value. This did not correspond to the previous literature that supports evidence that at speeds of approximately 2.0 to 2.5 mph, most SC devices are accurate (7). Additionally, the low reliability scores are curious. Based on the data, it is reasonable to conclude that the FWAT device is not reliable with respect to EE (except for at 2.5 mph) and SC. One factor that may have affected the reliability measurements could be a small learning effect where the unfamiliar movement patterns of walking so slow during the first bout were expected and adjusted for by subjects in the second bout performed 1 to 2 wks later. This learning factor could have led to a better efficiency and a smoother movement pattern the second time.

CONCLUSIONS

Based on the results of this study, the FWAT does not accurately measure nor is it consistent in returning energy expenditure or step count measures. Because of this finding, the use of the FWAT device as a weight loss tool or an activity tracker should be treated with caution. Measurements of SC and EE cannot be directly accepted as valid for the user to confidently accept as actual scores. One positive trait that the FWAT does possess is its application for the creation of social groups. Adults who use this device can form interlinked groups with other FWAT users that allow all individuals in the group to observe daily activity scores. This sharing of daily activity data may lead to increased levels of daily activity in two ways. First, given that adults are generally competitive in nature, the daily comparison of steps taken or calories burned may inspire other adults to be more active simply to have higher scores than their peers. Second, not being active may lead to peer pressure. Adults who see that the user is not getting enough daily activity may initiate contact to get them more active. On the other hand, some adults may not want to let the other adults see their scores drop and, therefore, become more active simply to avoid being singled out. The best opinion that can be given for the FWAT device at this time is that it should be used as a psychological tool to motivate individuals to become more active. Even if the reported values are incorrect, there may be a level of self-induced motivation to become more physically active.

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