

Evaluation of the Basis Band Fitness Tracker

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ABSTRACT

International Journal of Exercise Science 9(3): 258-269, 2016. Self-monitoring is a widely recommended behavioral strategy to promote regular physical activity. Commercially available activity monitors are becoming increasingly popular and provide users with the opportunity to self-monitor physical activity. The purpose of this study was to examine the ability of the Basis Band Fitness Tracker to measure heart rate and movement compared to research-grade activity monitors. Twenty participants (14 females and 6 males) aged 18-23 yrs (mean = 20.0 ± 1.1 yrs) wore a Basis Band, an NL-1000 pedometer, an ANT+ Motorola HRM1G chest strap heart rate monitor, and an Actigraph GT3X+ accelerometer for one day (at least 6 hours). A total of 3,060 matched heart rate observations were evaluated (1,144 minutes in sedentary behavior, 1,473 minutes in light physical activity, and 443 minutes in moderate-to-vigorous physical activity [MVPA]). Although the Basis Band captured 90% of heart rates during sedentary conditions, heart rates were unlikely to be recorded during movement of light intensity (51%) and MVPA (20%). Concurrent validity evidence for heart rate from the Basis Band compared to a chest-worn monitor was low overall ($R = 0.78$) and lower during light intensity ($R = 0.63$) and MVPA ($R = 0.63$). The Basis Band accurately measured steps during 100-step running trials with natural running arm movement (mean difference = 1.4 steps, mean absolute percent error [MAPE] = 4.8%) and with limited arm movement (mean difference = -1.1 steps, MAPE = 4.1%), but not during slow walking trials with natural walking arm movement (mean difference = -56.8 steps, MAPE = 57.1%) and with limited arm movement (mean difference = -53.2 steps, MAPE = 53.8%) or brisk walking trials with natural walking arm movement (mean difference = -11.3 steps, MAPE = 11.4%). MAPE was low (3.7%) during the brisk walking trials with natural walking arm movement. The Basis Band significantly underestimated number of daily steps compared to the NL-1000 pedometer (mean difference = -1,155, $p < .001$, MAPE = 15.0%). Unacceptable validity evidence for heart rate measures and steps, combined with a low proportion of heart rates recorded, suggest the Basis Band does not accurately quantify heart rate or physical activity.

KEY WORDS: Validity, activity monitoring, wrist-worn monitor, heart rate, wearable device

INTRODUCTION

Despite the well-documented health benefits of physical activity, data from objectively measured physical activity via

accelerometry demonstrated that a low percentage of 16-19 year olds in the United States (10% of males and 5.4% of females) attain sufficient physical activity to meet public health recommendations (23). In

light of the research demonstrating that we are in the midst of an epidemic of physical inactivity, developing effective strategies to promote physical activity and decrease sedentary behaviors is a public health priority. Self-monitoring, defined as the process of observing and recording specific behaviors, is a widely recommended tool to promote regular physical activity and exercise (15).

Commercially available activity monitors (e.g., Basis Band, Fitbit, Garmin vivofit, Jawbone UP) are becoming increasingly popular and provide users with the opportunity to self-monitor their levels of physical activity. The Basis B1 Band (Basis Science Inc., San Francisco, CA) differs from most commercially available fitness trackers because of its advanced optical sensing technology that has the ability to capture heart rate and blood flow at the wrist. The multiple sensors of the Basis wrist watch-style activity monitor also integrate movement data from a triaxial accelerometer.

It is important to examine the accuracy of commercially available monitors because these monitors may be used to determine physical activity prevalence, document relationships between physical activity and other health-related outcomes, and determine if interventions increase levels of physical activity. Several authors have examined the accuracy of commercially available monitors (5, 16, 21, 24). Recently, Lee, Kim, and Welk (9) investigated the accuracy of a variety of consumer-based activity monitors for estimating energy expenditure in healthy adults under semi-structured free-living conditions. With the exception of the Basis Band, the majority of

the consumer-based activity monitors yielded reasonably accurate estimates of energy expenditure (within approximately 10%–15% error) compared to the Oxycon mobile 5.0 portable metabolic analyzer values. The Basis Band had a much higher error rate (23.5%) relative to the criterion measure in comparison to the other commercially available activity monitors investigated (9). However, energy expenditure is only one of the outcome variables provided by the Basis Band and, to our knowledge, no published research has provided evidence of reliability and validity of motion (steps) and heart rate outcomes of the Basis Band.

Commercially available monitors are developed primarily to facilitate self-monitoring and behavior change and thus investigating the relative effectiveness of these devices for promoting physical activity behavior is important. Although the accuracy of outcome variables is undoubtedly important, features such as comfort, convenience, and functionality may ultimately be more important to some consumers. To date, limited research has been conducted on the usability of consumer-based activity monitors or their effects on changing physical activity behavior.

The primary focus of this study was to examine the concurrent validity evidence of the Basis Band to continuously and accurately measure heart rate patterns and motion in comparison to activity monitors often used for research on physical activity (i.e., Actigraph GT3X+ accelerometers and NL-1000 pedometers). In addition, estimated steps from the Basis Band was compared to actual observed counted steps

and to daily steps from NL-1000 pedometers. Lastly, comfort, convenience, and functionality perceptions of Basis Band physical activity monitoring were evaluated.

METHODS

Participants

The procedures were reviewed and approved by the university Institutional Review Board. Before participating in the study, each participant signed a written informed consent. Participants included 20 volunteer undergraduate students (14 males, 6 females) who received extra credit points in their physical activity course.

Protocol

Participants were asked to wear a Basis Band, a New Lifestyles NL-1000 pedometer (New Lifestyles Inc., Lee's Summit, MO), an ANT+ Motorola HRM1G chest strap (heart rate monitor), and an ActiGraph GT3X+ accelerometer (ActiGraph Pensacola, FL). The Basis Band was worn on the non-dominant hand. Pedometer placement was standardized on the belt or waistband, in line with the mid-line of the thigh. Evidence for the validity and reliability of New Lifestyles pedometers was provided by Schneider, Crouter, Lukajic, and Bassett (20), who demonstrated that the New Lifestyles pedometers were accurate to within 3% of actual steps while walking 400 meters around an outdoor track. In addition, their results revealed that the intra-model reliability of the NL pedometers was substantial (Cronbach's $\alpha = .99$), suggesting adequate quality control and tight manufacturing tolerances. The NL-1000 was also found to be accurate in estimating minutes of activity in free-

living conditions when compared to an ActiGraph accelerometer (13).

The ANT+ Motorola HRM1G chest strap and the Actigraph GT3X+ accelerometer were worn to record heart rate in beats per minute (bpm) each minute over the programmed 60 sec epoch. The heart rate monitor chest strap was positioned across the xiphoid process of the sternum with the heart rate electrode sensors directly on the skin slightly below the bottom part of the pectoralis muscle. The GT3X+ accelerometer was worn just above the dominant hip in line with the knee superior to the NL-1000 pedometer. The accelerometer was attached to a belt that was adjusted to the participant's waist girth tight enough to ensure that the activity monitors did not move during physical activity.

Participants came to the Activity Promotion Laboratory twice during the study to complete research procedures. During the first visit, students completed a brief survey about their physical activity level for the previous 30 days [30-day PAR] (1) and underwent assessment of height, weight, and body composition. Weight was assessed without shoes in light clothing using a calibrated scale (Befour PS6600, Saukville, WI) and height was measured without shoes using a standard stadiometer (Perspective Enterprises, Portage, MI). Body composition was assessed with body mass index (BMI) and percent fat. BMI was calculated by dividing the participant's weight in kilograms by his or her height in meters squared ($\text{kg}\cdot\text{m}^{-2}$). Percent fat was estimated using a hand-held bioelectrical impedance analyzer (Omron HBF-306C, Bannockburn, IL).

After completion of the 30-day PAR and assessment of height, weight, and body composition, the activity monitors were initialized and handed to the participants. The researchers provided participants with specific instructions on how each monitor should be worn. The NL-1000 served as the criterion measure to investigate the validity of daily step estimates from the Basis Band. In addition, concurrent validity evidence of the Basis Band was examined by comparison to output from the heart rate monitor (ANT+ Motorola HRM1G chest strap and Actigraph GT3X+ accelerometer). Time on the Basis Band and Actigraph GT3X+ accelerometer was synchronized to allow for comparison. The ability of the Basis Band to continuously and accurately capture heart rate patterns at different intensities of movement was evaluated based on vector magnitude data from the accelerometer. Cut-points (18) used for classification of sedentary behavior, light physical activity, and moderate-to-vigorous physical activity (MVPA) are provided in Table 1.

Table 1. Cut-points for vector magnitude of Actigraph GT3X+.

Intensity	Actigraph GT3X+ Vector Magnitude Cut-point
Sedentary Behavior	< 100
Light Physical Activity	100 – 2689
MVPA	≥ 2690

*Cut point for sedentary behavior was set at < 100 counts/min. Note Sasaki et al. (10) did not provide a cut-point for light intensity physical activity. MVPA is moderate-to-vigorous physical activity.

To examine the accuracy of the step outputs from the Basis Band compared to actual observed counted steps, participants completed two trials of slow walking 100

steps at 1.6 km·hr⁻¹ (1.0 mi·hr⁻¹), followed by two trials of brisk walking 100 steps at 5.6 km·hr⁻¹ (3.5 mi·hr⁻¹), and then two trials of running 100 steps at 8.0 km·hr⁻¹ (5.0 mi·hr⁻¹) on a treadmill. At each speed, one trial was conducted with natural walking arm movement and the other trial involved limited arm movement (i.e., participants placed their hands on their hips). This was done to evaluate the ability of the Basis Band to accurately count steps while individuals walk or run with limited arm movement. To ensure 100 steps were taken for each trial, the researcher counted the actual steps taken by the participant using a hand-tally counter. Participants started the treadmill test by standing with their feet to the side of the treadmill. The first step was taken with the right foot and every step with the left foot was counted out loud. After the 49th step with the left foot, participants stepped their right foot to the side of the treadmill and then their left foot to the side of the treadmill so that the fiftieth step taken with the left foot (100th step overall) was the last step overall. Step outputs from the Basis Band were recorded before and one minute after each trial to ensure that possible delayed step count did not influence the outcome. In between each trial, participants were provided with instructions regarding the various functions and outputs available on the activity monitors.

After the completion of the treadmill trials, participants were asked to wear the activity monitors for the rest of the day. They were told to wear the activity monitors for at least 6 hours and remove them for bathing, showering, water-based activities, and during any activities where the instruments were likely to either be lost or damaged

(e.g., contact sports). Participants kept a log of when they put the monitors on and took them off. During their second visit the following day, participants returned the activity monitors and answered a brief questionnaire about their perceptions of physical activity monitoring based on their experience with the Basis Band.

Because each heart rate recorded by the Basis Band had to be transcribed from the Basis website into SPSS manually, it was not realistically feasible to examine every single minute-by-minute heart rate observation for all participants. Thus, physical activity patterns (timeline indicating times they are most and least physically active) determined with the GT3X+ accelerometer were scanned and one block of 180 consecutive minutes, which included a combination of sedentary behavior, light physical activity, and MVPA, was selected for each participant. For each participant, the first 180-minute block that contained various activity intensities was selected. Three participants were excluded from this analysis because the GT3X+ accelerometer had not been initialized properly and, therefore, heart rates transmitted by the ANT+ Motorola HRM1G chest strap were not stored on the accelerometer.

Statistical Analysis

All analyses were performed using SPSS 20 for Windows (SPSS Inc., Chicago IL). Intraclass correlation coefficients (*R*) from one-way analysis of variance (ANOVA) were used to calculate concurrent validity evidence for heart rate estimates from the Basis Band as compared to the chest-worn heart rate monitor during sedentary behavior, light physical activity, and

MVPA. No specific value for validity coefficients can be considered acceptable or unacceptable for all variables and all situations. We considered previous research that examined validity of heart rate monitors (8, 10, 22) and selected a correlation of ≥ 0.90 as representing an acceptable level of validity evidence. Laukkanen and Virtanen (8) considered correlations of < 0.65 to represent inadequate evidence of validity. Minutes for which the Basis Band did not record heart rate were excluded from the analyses.

A paired-samples *t*-test was used to determine if the daily step estimates from the Basis Band were significantly different from the daily step estimates from the NL-1000 pedometer. An alpha of .05 was used to denote statistical significance.

Mean absolute percent errors (*MAPE*) were calculated to provide an indicator of overall measurement error. *MAPE* was computed as the average of absolute differences between the Basis Band-estimated steps and the NL-1000 (or observed counted steps) divided by the NL-1000 (or observed counted steps), multiplied by 100. This estimate of error takes into account both overestimation and underestimation because the absolute value of the error is used in the calculation.

RESULTS

Physical characteristics of participants are presented in Table 2.

The average number of minutes spent in sedentary behavior, light physical activity, and MVPA during the selected 3-hour period is reported in Table 3.

Table 2. Physical characteristics of participants ($n = 20$).

Variables	Total Sample ($n = 20$)	Females ($n = 14$)	Males ($n = 6$)
Age (yr)	20.0 \pm 1.1 (18-23)	19.9 \pm 1.2 (18-23)	20.0 \pm 0.9 (19-21)
Height (cm)	170.9 \pm 9.3 (158.4-185.7)	168.4 \pm 8.5 (158.4-185.7)	176.8 \pm 8.9 (162.2-185.7)
Body mass (kg)	68.0 \pm 12.0 (49.5-91.8)	65.0 \pm 12.4 (49.5-91.8)	75.2 \pm 7.9 (66.7-85.8)
BMI (kg·m ⁻²)	23.5 \pm 3.8 (19.4-36.4)	23.4 \pm 4.4 (19.4-36.4)	23.8 \pm 2.4 (20.7-27.6)
Percent fat (%)	20.7 \pm 8.1 (6.6-41.9)	23.8 \pm 7.0 (14.1-41.9)	13.6 \pm 5.9 (6.6-23.1)
30-day PAR	4.9 \pm 1.8 (1-7)	4.7 \pm 1.8 (1-7)	5.3 \pm 1.9 (2-7)

Values are mean \pm SD (range), BMI is body mass index.

Table 3. Time spent in sedentary behavior, light physical activity, and MVPA.

Variables	Total ($n = 17$)	Females ($n = 11$)	Males ($n = 6$)
Sedentary Behavior (min)	67.3 \pm 36.4 (7-146)	75.0 \pm 34.7 (30-146)	53.2 \pm 38.1 (7-104)
Light Physical Activity (min)	86.7 \pm 36.0 (23-163)	79.0 \pm 33.1 (23-142)	100.7 \pm 39.9 (60-163)
MVPA (min)	26.1 \pm 21.3 (5-77)	26.0 \pm 20.2 (5-77)	26.2 \pm 25.2 (6-71)

Values are mean \pm SD (range). MVPA is moderate-to-vigorous physical activity.

Table 4 displays the percent of minute-by-minute heart rate captured by the Basis Band at different movement intensities. When including all 3,060 observations in one analysis, participants spent 1,144 minutes in sedentary behavior, 1,473 minutes in light physical activity, and 443 minutes in MVPA. The percent of minute-by-minute heart rate recorded by the Basis Band during sedentary behavior, light physical activity, and MVPA was also calculated for each participant and then averaged. Findings were similar in both cases and suggest that the Basis Band captured most minute-by-minute heart rates during sedentary behaviors (> 85% for 11 of the 17 participants), but recorded heart rate less than 50% of the time during light physical activity for 9 of the 17 participants and less than 25% of the time during MVPA for 12 of the 17 participants.

Table 4. Percent of minute-by-minute heart rate recorded by the Basis Band during sedentary behavior, light physical activity, and MVPA.

Variables	Total Sample ($n = 17$)	Average ($n = 17$)
Sedentary Behavior	1,027 / 1,144 (90%)	86% \pm 14% (56%-100%)
Light Physical Activity	751 / 1,473 (51%)	53% \pm 20% (20%-91%)
MVPA	90 / 443 (20%)	25% \pm 19% (0%-67%)
Overall	1,868 / 3,060 (61%)	61% \pm 18% (34%-93%)

Total sample values are number of minutes for which the Basis Band recorded heart rate divided by total minutes spent at each specific intensity for the overall sample (percent of heart rate recorded by the Basis Band). Average values are mean percent of minutes based on results for each participant for which the Basis Band recorded heart rate \pm SD (range). MVPA is moderate-to-vigorous physical activity.

Table 5 provides validity evidence of minute-by-minute heart rate measures from the Basis Band. For these analyses, only observations for which heart rate was recorded by the Basis Band were included. The correlations between heart rate from the Basis Band and heart rate from the criterion measure were below acceptable levels for sedentary behavior ($R = 0.85$), light physical activity ($R = 0.63$), and MVPA ($R = 0.63$).

Table 5. Heart rate values and validity evidence for Basis Band measures of heart rate during sedentary behavior, light physical activity, and MVPA.

Variables	Chest Strap Heart Rate	Basis Band Heart Rate	<i>p</i> -value	Total Sample ICC (<i>n</i> = 17)	Average ICC (<i>n</i> = 17)
Sedentary Behavior	84 ± 11 (1,027)	81 ± 11	< 0.05	0.85 (1,027)	.63 ± .35 (.00-.96)
Light Physical Activity	91 ± 13 (751)	84 ± 15	< 0.05	0.63 (751)	.36 ± .30 (.00-.83)
MVPA	123 ± 31 (90)	105 ± 22	< 0.05	0.63 (90)	.26 ± .30 (.00-.80)
Overall	89 ± 16 (1,868)	83 ± 14	< 0.05	0.78 (1,868)	.59 ± .25 (.00-.90)

Chest strap heart rates are mean ± SD (number of observations) from the ANT+ Motorola HRM1G monitor. Total sample ICC values are intraclass *R* (number of observations). Average ICC values are mean intraclass *R* ± SD (range) based on results for each participant. MVPA is moderate-to-vigorous physical activity.

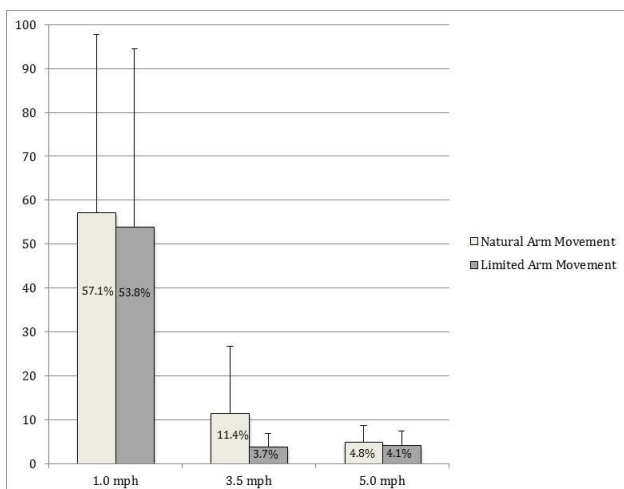


Figure 1. Mean absolute percent errors (MAPE) between mean step counts from Basis Band and observed 100 steps during 1.0 mph slow walk, 3.5 mph brisk walk, and 5.0 mph run on a treadmill.

Figure 1 shows the MAPE for the various treadmill trials computed as the average absolute value of the errors of the Basis Band relative to the actual observed counted steps. The magnitude of errors was least for the brisk walking trial with limited walking arm movement (3.7%) and for the running trials with both natural walking arm movement (4.8%) and limited arm movement (4.1%). Errors rates were higher for the brisk walking trial with natural walking arm movement (11.4%), and for the slow walking trials with both natural

running arm movement (57.1%) and limited arm movement (53.8%).

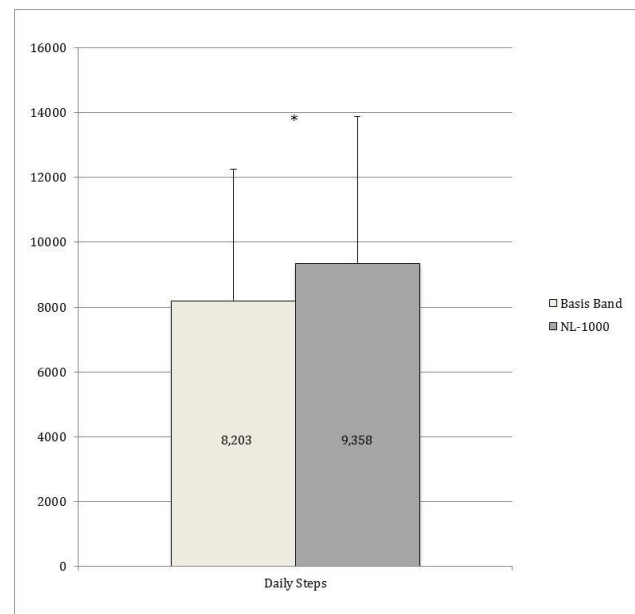


Figure 2. Comparison between mean daily step counts from Basis Band and mean daily step counts from NL-1000 pedometer. * *p* < 0.05.

Figure 2 displays mean differences between average daily step outputs from the Basis Band and the NL-1000 pedometer. Although the correlation between step output from the Basis Band and NL-1000 pedometer was high (*R* = .97), the Basis Band significantly underestimated number of daily steps compared to the NL-1000

Table 6. Perceptions of participants ($n = 20$) about the Basis Band.

Variables	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean \pm SD
"The monitor was comfortable to wear during the day"	0	2	4	7	7	3.95 \pm 1.00
"The monitor was embarrassing to wear in public"	7	10	1	2	0	1.90 \pm 0.91
"I was always aware of the monitor while wearing it"	0	3	2	10	5	3.85 \pm 0.99
"This monitor was easy to wear while being active/exercising"	0	0	3	11	6	4.15 \pm 0.67
"I felt this monitor was intrusive"	7	10	2	1	0	1.85 \pm 0.81
"I was more active because I was wearing the monitor"	4	4	8	3	1	2.65 \pm 1.14
"This monitor motivated me to be more physically active"	0	1	11	3	5	3.60 \pm 0.94

Values for strongly disagree, disagree, neutral, agree, strongly agree are frequencies. Values for mean \pm SD were calculated based on strongly disagree = 1, disagree = 2, neutral = 3, agree = 4, strongly agree = 5.

pedometer ($t_{(19)} = -5.15$, mean difference = -1,155, $p < .001$, $ES = 0.26$). The magnitude of errors between average daily step outputs from the Basis Band and the NL-1000 pedometer was 15.0%.

Table 6 presents subjective ratings of the Basis Band. On average, participants felt that the monitor was comfortable to wear during the day and while being physically active. In addition, participants did not seem to think the monitor was embarrassing to wear in public or intrusive. However, participants' ratings reflect limited change in level of physical activity and motivation to become more physically active while wearing the monitor.

DISCUSSION

The main purpose of this study was to evaluate the accuracy of physical activity

outcome variables (i.e., heart rate and steps) assessed by the Basis Band. This is the first study to examine validity of both the heart rate and step outcome variables of the Basis Band. Findings from this study suggest that the optical blood flow sensing technology of the Basis Band may not have the ability to continuously measure heart rate. Although the Basis Band captured on average 90% of minute-by-minute heart rate during resting or sedentary conditions, it was unlikely to capture heart rate during movement and exercise of light intensity (51%) and of moderate or vigorous intensity (20%). Thus, it seems that as the intensity of activity increases, the ability of the Basis Band to record heart rate diminishes. Possible factors that can contribute to inconsistent readings may include arm movement, wrist fit, and obstructions such as arm hair. In addition, the current study suggests that the accuracy

of heart rate estimates from the Basis Band is questionable. Overall, the correlation between heart rate measures from the Basis Band and the heart rate monitor was 0.78. The correlations were even lower when considering only light physical activity ($R = 0.63$) and MVPA ($R = 0.63$). Thus, the Basis Band does not appear suitable for use as a replacement for a chest strap heart rate monitor based on the low proportion of minute-by-minute heart rate recorded by the Basis Band combined with an unacceptable level of accuracy.

Another focus of this study was to investigate the accuracy of the step output of the Basis Band. The Basis Band failed to provide an accurate measure of steps in comparison to actual observed steps at slow walking speeds on a treadmill (e.g., MAPE > 50%). On the other hand, error rates for average step outcomes from the Basis Band were only slightly higher than error rates reported for step output from other commercially available monitors at brisk walking and running speeds (7, 20). In comparison to criterion measures (i.e., observed counted steps), several accurate self-monitoring tools were found to have mean absolute percent errors lower than 3%. Grant et al. (7) provided evidence that the activPAL accelerometer and two pedometers (e.g., New Lifestyles NL-2000 and Yamax Digi-Walker SW-200) recorded steps within 2% of actual steps during outdoor walking at slow, normal, and fast self-selected speeds. Schneider et al. (20) examined the accuracy and reliability of ten pedometers for measuring steps over a 400-m walk and found that three pedometers (i.e., Kenz Lifecorder, New Lifestyles NL-2000, Yamax Digi-Walker SW-701) displayed values that were within $\pm 3\%$ of

the actual steps taken 95% of the time. Thus, it appears that the Basis Band may quantify movement at higher intensities (e.g., running) with acceptable accuracy, but may underestimate steps at lower intensities (e.g., walking).

The finding that Basis Band was inaccurate in measuring steps during slow walking speeds (e.g., mean absolute percent error of 57.1% and 53.8% during slow walking trials with natural walking arm movement and limited arm movement, respectively) is consistent with conclusions from previous studies in which slow walking speeds were found to compromise the accuracy of step counts from various self-monitoring tools (4, 11, 12, 14, 17).

The ability of the Basis Band to quantify physical activity and movement in free-living conditions is also questionable. Schneider, Crouter, and Bassett (19) suggested that an acceptable difference between daily steps from a pedometer and a criterion should be within 10% in free-living conditions. The mean absolute percent error of the Basis Band was 15% for measuring daily steps compared to the criterion measure (i.e., NL-1000).

The accuracy of the Basis Band to estimate energy expenditure has also been examined (9). Lee et al. (9) concluded that the majority of the commercially available activity monitors that they examined provided reasonably accurate estimates (i.e., MAPE: 10% - 15%) of energy expenditure compared to the criterion measure (i.e., a portable metabolic analyzer). However, the MAPE for the Basis Band was considerably higher (i.e., 23.5%) than the MAPE for the other monitors.

Activity promotion is arguably the most important underlying goal of physical activity self-monitoring with commercially available activity monitors. Increasing self-awareness of levels of physical activity through self-monitoring with commercially available activity monitors may enhance motivation to be more physically active. Wang et al. (25) examined the utility of a consumer-based monitor (i.e., Fitbit One) for increasing physical activity over six weeks in overweight and obese adults. They reported a significant increase in levels of MVPA of 4.3 minutes per week in the group that only wore a Fitbit, but a decrease of 433 steps per day also occurred in this group. The group that wore a Fitbit and received three daily text messages had a small decrease in MVPA of 1.1 minutes per week. The authors concluded that providing a commercially available device for self-monitoring was not sufficient to achieve meaningful increases in physical activity in their sample. In a longer intervention study, Cadmus-Bertram et al. (3) reported significant and meaningful increases in MVPA in the group that received the Fitbit One monitor, with web-based tracking (e.g., increase of 62 minutes per week of MVPA, increase of 789 steps per day) over the 16-week intervention. The comparison group that received a basic pedometer and printed material had a non-significant increase of 13 minutes per week of MVPA and 362 steps per day. Research on the ability of commercially available monitors to increase physical activity levels is sparse and additional research in this area is essential.

Even though most participants rated the Basis Band as comfortable and easy to wear during exercise, ratings of the perceptions

of physical activity monitoring with the Basis Band suggest that, on average, participants were neutral when asked if the monitor motivated them to be more physically active and most participants mentioned not being more active because they were wearing the monitor. Thus, it is unclear whether or not the Basis Band can be used as an effective tool to promote physical activity in young adults. One day of monitoring is probably not enough time to estimate the effectiveness of self-monitoring tools to promote physical activity. Cadmus et al. (3) reported in their sample of overweight, post-menopausal women that barriers to Fitbit One use were low and that 96% of participants rated the Fitbit One as “somewhat helpful” or “very helpful” for increasing physical activity. Further investigation of the effects of physical activity self-monitoring with commercially available activity monitors on motivation over extended periods is warranted.

This study is not without limitations. Because of the substantial time commitment required for the transcription of all the heart rate observations from the Basis website into SPSS, the sample size was limited to 20 participants; however, over 3,000 paired minutes of measurement were compared. In addition, only healthy, young individuals participated in this study and, therefore, the findings may not be generalized to other age groups or unhealthy populations. Although the number of matched observations examined was large enough to allow confidence in the study conclusions, it would be desirable to test the ability of the Basis Band to continuously and accurately measure heart rate patterns and movement on a larger and

more diverse sample. Furthermore, although the criterion measures selected for this study were instruments that are often trusted in research on physical activity, no instrument is free of measurement error. Therefore, possible error in measurements from the criterion measures may have affected the results. Another limitation concerns the possible improper wearing of the Basis Band. Participants were told to wear the Basis Band snug against their wrist, but it is possible that in some cases the monitor was not worn tightly enough for the optical blood flow sensing technology to continuously capture heart rate patterns.

Considering the importance of self-monitoring in promoting physical activity (15) and the need for reliable and valid assessments of physical activity in research settings (2, 6), evaluating popular commercially available activity monitors matters from both physical activity promotion and physical activity research viewpoints. The findings from this study suggest that the validity of both the heart rate and step outcome variables of the Basis Band are questionable. In addition, Lee et al. (9) examined the accuracy of the Basis Band for estimating energy expenditure in healthy adults and suggested that the Basis Band had a much higher error rate relative to the criterion measure (Oxycon mobile 5.0 portable metabolic analyzer) in comparison to the other commercially available activity monitors investigated. Thus, the limited research currently available suggests that the outcome variables provided by the Basis Band, including heart rate, steps, and energy expenditure, may not be accurate.

It is important to examine the accuracy of commercially available monitors as the popularity of these devices with consumers may lead to increased physical activity-related research possibilities. One important issue with assessment of physical activity in research is participant compliance. The use of popular commercially available monitors may help researchers to achieve greater compliance in physical activity-related studies. In addition, because it is possible that inaccurate assessments of physical activity outcomes result in an unintended consequence of reducing motivation for physical activity in some individuals, being aware of validity and reliability of different commercially available activity monitors also matters from an activity promotion standpoint.

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