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The Validity of a Novel Low-Cost, Wearable Physical Activity Monitor in a Laboratory Setting

Direct Original Research

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Abstract

Introduction: Wearable physical activity monitors are popular and may provide a more accurate data than subjective methods. The present study assessed the validity of a novel, low-cost wearable physical activity monitor (Movband 3) relative to established measures.

Methods: Participants (N = 19) completed four treadmill stages (1.5, 3.0, 4.0, 6.0 MPH) while wearing the Movband 3 and the validated Actigraph GT1M monitor. Oxygen consumption (VO_2 ml/kg/min) and heart rate (beats/min) were recorded. The relationship between Movband data and established measures was assessed via Pearson's correlations. Tests of agreement were performed for actual and Movband miles traveled.

Results: There were large, positive, significant ($p < 0.001$) effect sizes for the associations between Movband counts and Actigraph counts ($r = 0.72$), VO_2 ($r = 0.59$), and heart rate ($r = 0.63$). There was also a large, positive, significant ($p < 0.001$) association between actual and Movband miles ($r = 0.97$). However, the difference (Δ) between Movband and actual miles was greater than a null hypothesis of zero ($\Delta = 0.77 \pm 0.45$ miles or 31.8%, $t = 7.4$, $p < 0.001$).

Conclusion: While there was evidence to support the validity of the Movband 3 for the assessment of physical activity intensity this device did not provide an accurate measure of miles traveled.

Key Words: Accelerometer, Exercise, Agreement.

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Introduction

Physical activity monitoring is prevalent in both research settings and for personal use[1]. Tools used for monitoring physical activity are commonly classified as subjective or objective[2-4]. Validated subjective measures such as questionnaires and logs are typically inexpensive options which have been effectively modified to fit different populations[3]. However, questionnaires are ultimately reliant on recall of participants, and are thus subject to bias[3]. Objective, laboratory-based assessments such as indirect calorimetry and doubly labeled water represent accurate assessments of physical activity/energy expenditure[2]. However, these assessments are expensive and require specialized training to administer making them impractical. Wearable activity monitors (e.g., accelerometers) are less expensive and easier to use than laboratory-based objective measures, yet often provide superior accuracy compared to subjective measures[5,6]. Because of their accuracy and ease of use activity monitors have become a popular objective method for assessing physical activity for both

research purposes and personal use[1,6]. However, research-grade accelerometers, which are the most well studied for validity are often expensive. This cost may drive consumers to purchase less expensive activity monitors which may not have been assessed for validity.

The purpose of this study was to assess the validity and perform a preliminary assessment of reliability of an inexpensive activity monitor (the Movband 3) in a laboratory setting. We hypothesized that data from the Movband would be positively and significantly correlated with data from a previously validated research grade activity monitor (Actigraph GT1M), oxygen consumption, heart rate, ratings of perceived exertion, and treadmill miles[7]. We also hypothesized that data from two Movbands worn simultaneously would be positively and significantly correlated providing preliminary evidence of reliability.

Scientific Methods

Participants and Protocol

Nineteen (n = 7 female) healthy adults (26.6 ± 5.6 years old) participated in a single laboratory visit. During the lab visit, participants provided written consent and were fitted with a Polar T31 heart rate monitor around their chest (Polar, Lake Success, NY). Participants were then fitted with two novel Movband 3 activity monitors (Movband, DHS Group, Brecksville, OH), one around each wrist. A validated, Actigraph GT1M accelerometer (Actigraph, Pensacola, FL), was then fitted onto the waist on the dominant-side hip of each participant[7]. Finally, participants were fitted with a mask to assess oxygen consumption via indirect calorimetry (Parvo Medic TrueOne 2400, Sandy, UT).

Four treadmill stages lasting ten minutes each requiring different speeds of walking or jogging were completed at 1.5 miles per hour (MPH), 3, 4, and 6 MPH. There was a minimum of two minutes between stages for rest and for the devices to be reset. Data from the validated Actigraph GT1M was expressed as counts per minute. Data from the novel Movband 3 were recorded as "moves" per minute and miles per stage. Treadmill miles were recorded per stage and oxygen consumption and heart rate were recorded every two minutes during each stage. Ratings of perceived exertion (RPE) were recorded once per stage using the validated Borg scale[8].

For validity assessments data was taken from the Movband worn on the dominant wrist of the participant to match the Actigraph accelerometer. Counts and moves were averaged to per-minute values for each stage. Although counts and moves are calculated by their respective devices differently, the measures should increase proportionately during controlled amounts and intensities of activity.

Statistical Analysis

Pearson's correlation analyses were performed for each participant to examine the relationship between Moves and Counts, VO_2, heart rate, and RPE across all four treadmill stages. The relationship between miles traveled according to the Movband and actual miles traveled on the treadmill was also assessed. Average correlation coefficients across all participants were then calculated for each of the relationships that were examined. This approach for assessing the relationships between the Movband and criterion variables results in data that are interdependent. Therefore, mixed model regression analyses were performed to determine the significance of each of these associations as this analysis allows for the assessment of multiple observations and interdependent data[9].

Actual miles traveled on the treadmill and miles reported by the Movband were assessed for agreement using the methods established by Bland and Altman[10]. A one sample t-test was performed comparing the difference between the two measures (Δ = Movband total miles - total treadmill miles) to a null hypothesis of zero and a regression analysis assessing the relationship between Δ and the mean of the two measures (mean = (treadmill miles +Movband miles)/2). Good agreement was defined as a Δ that was not significantly different from zero and a lack of a relationship between Δ and the mean of both measures.

Moves reported by the Movband device worn on the dominant wrist, and the Movband device worn on the non-dominant wrist, were assessed for agreement using the same methods as described above. All analyses were performed via SPSS Version 26 with an a-priori $\alpha \leq 0.05$.

Results

Throughout the four treadmill stages, there were large, positive effect sizes ($r > 0.50$) size between Moves and heart rate ($r = 0.63$), VO_2 ($r = 0.59$), RPE ($r = 0.65$), and Actigraph Counts ($r = 0.72$)[11]. There was also a large, positive effect

size for the association between treadmill miles and Movband miles ($r = 0.97$). All relationships were significant ($f \geq 12.5$, $p < 0.001$)

The Δ between treadmill miles (2.2 ± 0.32 miles) and Movband miles (1.5 ± 0.49 miles) was significantly different (Δ = 0.77 ± 0.45 miles, $t = 7.4$, $p < 0.001$) from a null hypothesis of zero. This suggests that the Movband significantly underestimated actual miles traveled. There was a significant, large effect size for the association between Δ and the mean of treadmill and Movband miles ($\beta = -0.46$, $p = 0.048$). This suggests that the smaller the average of treadmill and Movband miles the greater the difference between these two values. Taken together these results would suggest a lack of agreement between Movband miles and actual miles traveled on the treadmill.

The Δ between moves from the Movband worn on the dominant wrist (84.0 ± 11.2 moves) and moves from the Movband on the non-dominant wrist (84.2, ± 11.9 moves) was not significantly different from the null hypothesis of zero (Δ = 0.21 ± 8.0 moves, $t = 0.11$, $p = 0.9$). There was also no significant association between the Δ and average Moves between the two devices ($\beta = -0.09$, $p = 0.71$). These results suggest good agreement between the two Movbands worn simultaneously.

Discussion

In 2022 the American College of Sports Medicine indicated that wearable activity tracking devices were the top fitness trend of the year[1]. These devices are typically easy to use and provide objective assessments of physical activity. While there is evidence of validity in some of these devices, much of that research examines more expensive research-grade monitors[5-7]. There is a need to examine the validity of novel, inexpensive activity monitors to determine if these devices have utility for research and individual use. While prior research has supported the validity of the Movband 2, this was the first investigation we are aware of to assess the validity of the Movband 3 device[12,13] In this laboratory assessment, we observed large, positive effect sizes (i.e., $r > 0.50$) for the association between Movband moves and heart rate, VO_2, RPE, and accelerometer counts generated via the previously validated Actigraph GT1M which costs nearly five times that of the Movband[7,11]. There was also a large, positive effect size for the correlation between miles reported by the Movband device and actual miles traveled on the treadmill. Taken together these data provide evidence of both construct and concurrent validity of the Movband 3.

While there was good agreement, and thus preliminary evidence of reliability, between the two Movband monitors worn simultaneously there was a lack of agreement between treadmill miles and Movband miles. Presently the Movband underestimated treadmill miles by 31.8%. Thus, although the correlation between Movband miles and actual miles traveled on a treadmill would support validity, the tests of agreement indicate that the Movband underestimated actual miles traveled. While this lack of agreement calls into question the accuracy of the Movband for predicting actual miles traveled, this result is not unprecedented among activity monitors. Even laboratory-grade accelerometers have had varied agreement when compared to direct calorimetry[14-16]. For example, prior research indicated that while there were strong, positive relationships between accelerometer counts and energy expenditure there was also evidence that multiple research grade activity monitors underestimated energy expenditure across a range of activities. Therefore, while these devices appear to have utility for assessing changes in physical activity there are still some accuracy limitations.

This was the first study we are aware of to assess the validity of this low cost-commercial-grade physical activity monitor (Movband 3), however it is not without limitations. This study consisted of a small sample size of only healthy adults. Future investigations would be served to investigate these devices using larger, more diverse samples. Additionally, this study was performed in a laboratory setting. These devices are intended to be used during activities of daily living (e.g., walking for active transport, working, etc.). Therefore, additional research examining the validity of this device to a previously validated activity monitor during free-living physical activity is warranted. Lastly, while we provide preliminary evidence of reliability by assessing the relationship of two separate Movbands worn simultaneously future research examining the ability of this device to provide consistently similar data when worn repeatedly during multiple identical exercise protocols would provide a more robust assessment of reliability. Such research is therefore recommended.

Conclusions

The present study assessed the validity of a novel, low cost-commercial-grade physical activity monitor (Movband 3) and results were equivocal. There was evidence for construct and concurrent validity when testing the association between the Movband and a criterion device, and physiological and perceptual measures of intensity. However, miles

traveled as measured by the Movband failed tests of agreement to actual miles traveled on the treadmill. Taken together, these results indicate that the Movband 3 device may be effective in identifying fluctuations in physical activity behavior and intensity but may not be an accurate measure of actual distance traveled. As a result, this device is probably best used as a low-cost alternative to more expensive accelerometers.

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