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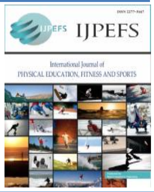

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Convergent Validity of a Consumer-Grade Accelerometer with a Research-Grade Pedometer in a Physical Education Setting

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Abstract: The cost of activity monitors has substantially reduced in recent years, making them more feasible for use in physical education programs. This study examined the convergent validity of the consumer-grade Movband activity monitor with the research-grade NL-2000 pedometer. The NL-2000 was chosen as the criterion unit because it is unaffected by BMI, pedometer tilt, or waist circumference, and has been recommended for use in research [1]. One hundred and eleven elementary school aged children (53 boys, 58 girls; 9.2 ± 0.7 yr.) from three physical education classes wore an NL-2000 on their right hip and a Movband on each wrist during a 30 minute class in which participants walked or ran on a hiking trail. A repeated measures ANOVA of mean steps indicated a significant difference ($p < .001$) between the NL-2000 (2411.74 ± 514.87) and the Movband worn on either wrist (left= 1554.33 ± 340.81, right= 1532.26 ± 329.76). Pearson product-moment correlations indicated that NL-2000 steps and Moves were significantly and positively correlated ($p < .001$; left= .79, right= .85). The correlation coefficient between left and right wrists was .87. In general, the Movband can provide reasonable estimates of physical activity for physical education teachers.

Key Words: Accelerometer, Pedometer, Physical Education, Activity Monitor

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1 Introduction

Physical educators seek activities that can help students of varying abilities reach fitness goals and tools to accurately measure such progress. Using technology to influence participatory behaviour is one way to encourage intrinsic motivation for students with varied levels of abilities and fitness. Physical education programs should strive to engage students in stimulating and motivating learning environments [1, 2]. In the last decade, the use of pedometers has become a popular way for individuals, both in and out of school-based activity programs, to monitor their own physical activity levels. In considering the use of pedometers as a tool to monitor and measure physical activity, a primary goal should be influencing and improving healthy behaviours. In a landmark review of literature on the effectiveness of pedometers, it was found that pedometer use increased physical activity by 2491 steps in the eight randomized trials reviewed and just over 2100 steps in the 18 observational studies reviewed, an increase of 27 percent in physical activity [3]. In some of the programs reported, having a step goal was a key predictor of increased physical activity, and while it was not always achieved, just having a goal seemed to help the participants stay motivated and improve their physical activity. Thus, using pedometers and including an intrinsic motivational goal can lead to increases in physical activity as measured by steps. Physical education can provide an environment where utilization of these tools and goal-setting can help to bring about change in healthy behaviour in students.

For many physical education programs, accessing these tools can be a challenge. Declining federal and state funding for education has, by extension, seen sharp declines in dollars for health and physical education programs. Physical educators must use their funds wisely to get the most for their students. There are many options for physical educators wishing to assess the amount of health-enhancing physical activity learners achieve during class sessions. Pedometers and other types of physical activity monitors can be valuable tools, providing objective and accurate activity monitoring [1, 4]. Using physical activity monitors can be effective and less time consuming than protracted observation checklists and laboratory tests, but the cost per unit is a key factor [5]. Physical educators are in need of low-cost, objective ways of measuring physical activity during class time and as technological advances in activity monitors skyrocket, the cost of the most basic, consumer-grade units tend to decrease. This is good news for physical educators wanting to use activity monitors to assess and promote physical activity.

In addition to cost, another important variable to consider when selecting an activity monitor is the unit's features, validity, and reliability [6]. In 2015, roughly 19 million people owned some kind of wearable activity tracker, and that number is expected to triple in the next three years [7]. Uniaxial, mechanical swing-arm pedometers that attach to the one's waistband have been replaced by triaxial, wrist-worn units such as the Fitbit Ionic and Nike Fuelband. At roughly 250 U.S. dollars per unit, these activity monitors claim to measure steps, miles, heart rate, quality of sleep, steps climbed, calories, and other metrics. Researchers have investigated the validity of such high-priced units with varied results [8, 9]. At their core, activity monitors all have the same basic technology. Piezoelectric or piezoresistive sensors sense a change in acceleration, produce electrical signals and log the activity as *counts* [8-11]. These counts are typically conveyed as steps, which is why many people still refer to activity monitors as pedometers. Most modern activity monitors are valid for measuring steps or other fundamental movements (e.g., elbow flexion and extension) but they do not fare as well at estimating miles, calories, etc. After all, activity monitors only *measure* movement. All other metrics are software-derived estimates based, in large part, on personal data entered into the unit (e.g., weight, age, stride length). Because of this fact, physical educators should focus on recoding the baseline metric (step data) as a way to assess and promote physical activity.

Assessment of physical activity using accelerometers takes place in three distinct contexts: laboratory settings, school-based interventions, and free-living environments. Using direct calorimetry, accelerometer data has shown varied but generally strong correlations to VO_2 [6, 8, 11, 12, 13]. The bulk of the research on school-based interventions has focused on promoting physical activity [5] and on children's motivation [14]. Free-living or free-play studies typically utilize heart rate monitors as the criterion instrument and have shown generally strong, positive correlation between accelerometer data and heart rate [13].

This study examined the convergent validity of the Movband (Brecksville, OH) activity monitor with the New-lifestyles (Lees Summit, MO) NL-2000 piezoelectric pedometer. The NL-2000 was chosen as the criterion instrument because it is unaffected by BMI, pedometer tilt, or waist circumference, and has been recommended for use in research [1].

At a cost of 70 U.S. dollars per unit, the NL-2000 is more expensive, valid, and reliable than spring-levered pedometers but less expensive than other research-grade pedometers [15]. The NL-2000 will estimate MVPA (active) minutes, distance, active calories, and total calories. It uses a triaxial piezoelectric resistance sensor to measure changes in acceleration near the centre of mass cause by physical movement. Many still refer to it as a pedometer because it works well for measuring steps during walking or running. The comparison instrument was the wrist worn Movband (Lees Summit, MO) activity monitor at a cost of 20 U.S. dollars per unit. It uses a triaxial accelerometer to sense movements of the arm (e.g., shoulder flexion, extension, abduction, adduction, rotation) which causes the unit to log one *move*.

2. Methods

Participants and Setting

The participants in this study were 111 school aged children (53 boys, 58 girls; 9.2 ± 0.7 years) from three separate physical education classes in a rural public school in the United States. The school enrolled students from kindergarten through the 4th grade, with a racial composition of 77% White, 18% Latino and 5% not reported. Exclusion criteria were limited to any medical condition that prevented a child from participating in a typical physical education class. A parent/legal guardian of each participant signed a consent form and a University institutional human subject's review board approved the research methodology prior to data collection.

Procedure

Each participant wore an NL-2000 on his/her right hip and a Movband on each wrist during a 30 minute physical education period in which participants walked or ran on a hiking trail at a self-selected speed. The half-mile (806 meter) trail was a small-scale version of the Appalachian Trail, constructed adjacent to the gymnasium with a grant from the Appalachian Trail Conservancy (www.appalachiantrail.org). The participants were familiar with the trail as they typically walked and ran on it during physical education class.

Prior to the start of each class session, investigators examined each physical activity monitor. One NL-2000 unit required a battery replacement and two Movbands, each with an internal battery, failed to power-up and were replaced. To ensure a proper fit, two research assistants aided each participant with attaching the NL-2000 to the waistband and with securing a Movband to each wrist. Participants were then instructed by the physical education teacher to walk at a moderate to vigorous pace until the teacher indicted they could stop. Participants were instructed by the teacher that they could run during downhill sections of the trail if they "felt good." Most of the participants could be observed running at some point early in each class session, however it was evident to the investigators that participants spent most of the 30 minutes walking at a moderate to brisk pace. Two of the NL-2000 units became displaced (unclipped) and were again affixed to the participant's waistband with the assistance of researchers. After 30 minutes of continuous walking or running, researchers recorded the number of steps and *moves* as indicated by the activity monitors.

Statistical Analyses

A repeated measures ANOVA was used to determine if the amount of physical activity might vary based on the number of steps as indicated by the NL-2000 or *moves* as indicated by a Movband worn on each wrist. Pearson product-moment correlations were used to determine if there is a linear, dependent relationship between steps and moves, and between *moves* as indicated on each wrist. Statistical significance was established a priori at $p < .05$.

Results and Discussions

A repeated measures ANOVA of mean steps/moves revealed a significant difference ($p < .001$) between steps as indicated on the NL-2000 (2411.74 ± 514.87) and *moves* as indicated by a Movband worn on either wrist (left= 1554.33 ± 340.81, right= 1532.26 ± 329.76) (Figure 1& 2).

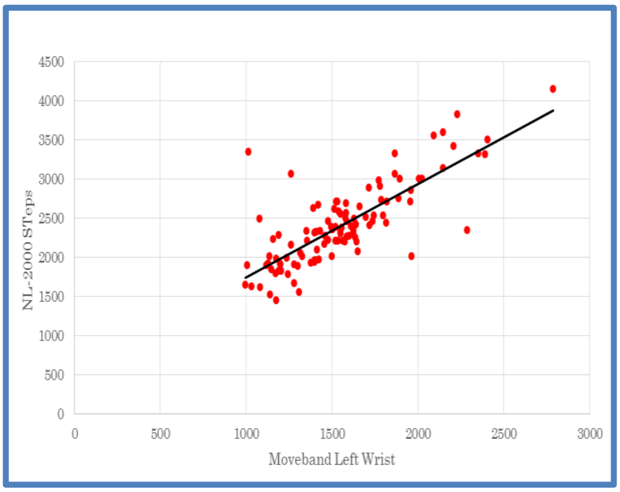

Figure 1 contains a scatter plot of the linear relationship between steps and moves.

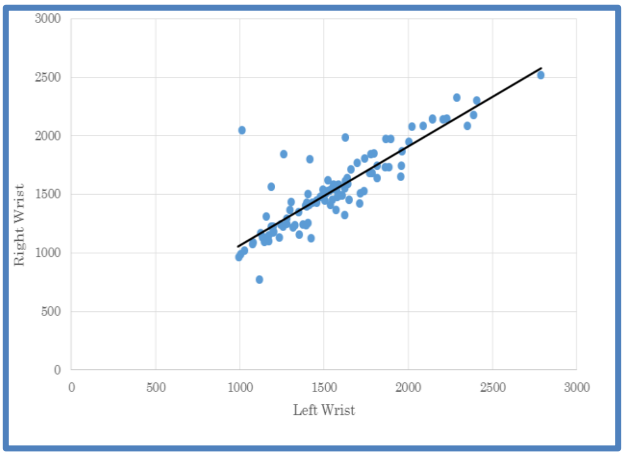

Figure 2 contains a scatter plot of the linear relationship between moves as indicted on the left and right wrist.

There were no other significant effects or interactions. One step equated to about .644 *moves* (left wrist) and .635 *moves* (right wrist). Pearson product-moment correlations indicated that NL-2000 steps and *moves* were significantly and positively correlated (p< .001; left wrist= .79, right wrist= .85). A Pearson product-moment correlation revealed that moves, as indicted on each wrist, were significantly (p< .001) and positively correlated (r= .87).

3. Conclusions

In general, the results of this study are consistent with previous research indicating that Movbands can provide valid estimates of physical activity for physical educators and other practitioners [11]. Although one step did not equate to one move, the positive and significant correlation between steps and moves indicated a predictive, linear relationship between the metrics. The low-cost, practical to use Movband demonstrated to be worthy of consideration for physical educations on a budget. Thus, an effective measure of physical activity with potentially intrinsic motivation and goal-setting benefits for students in physical education settings.

This study was not without its limitations. It did not include a laboratory test of reliability, however, the significant and positive correlation between Movbands worn on each wrist provided some indication of unit reliability. The strong correlation between left and right wrists may have been predicated on the fundamental, bilateral motor skills used in the study (walking and running). One would not expect as strong a correlation when examining a hand-dominant, unilateral motor skill such as tennis or badminton. When performing those type of activities, it is reasonable to deduce that the Movband may tend to over- or under-estimate physical activity, depending on which wrist the Movband is worn. Research has shown that wearing multiple, hip-placement pedometers is unnecessary [6], but using multiple wrist worn accelerometers to assess physical activity during a variety of activities/skills warrants additional investigation.

Participants in this study were instructed to walk or run at a moderate to vigorous pace, the ideal intensity in which to assess physical activity using an accelerometer although neither heart rate nor rated perceived exertion (RPE) was monitored. Because of advancements in heart rate monitoring devices, future research should continue to examine the convergent validity of accelerometers with such devices in a physical education setting. As previous research has indicated, at low intensities even research-grade accelerometers tend to under-estimate physical activity [12, 13, 16]. At high intensities, research-grade accelerometers have been shown to overestimate metrics such as caloric expenditure [17]. The results of this student lend cautious support for using consumer-grade accelerometers to assess physical activity during low-intensity exercise in physical education (e.g., yoga, stretching).

A primarily underestimated advantage of the Movband over the NL-2000 was its practicality. The investigators were careful to plan for two research assistants to help attach the NL-2000 to each minor child's waistband, and for the physical education teacher to oversee the process. At the conclusion of the study, research assistants noted that the Movbands were "much easier for the kids to put on themselves" than the NL-2000. When it came to practicality in terms of both cost and ease of use, the Movband offered some clear advantages. This finding lends itself to the idea that measuring activity not only helps the physical educator with data to make plans and assess their program, but also to serve as a way for each individual to monitor their own productivity and progress in fitness goals.

As technology advances and accelerometers continue to emerge, future research should continue to examine the validity, reliability, and feasibility of low-cost, consumer-grade units to assess physical activity in physical education settings. Physical educators can reap the benefits of such inquiry as accelerometers offer affordable, practical ways to assess and promote youth physical activity goals and improvements in health behaviour.

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Competing Interests:

The authors declare that they have no competing interests.