Validating Pedometer-based Physical Activity Time against Accelerometer in Middle School Physical Education

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Abstract

The purpose of this study was to validate physical activity time in middle school physical education as measured by pedometers in relation to a criterion measure, namely, students' accelerometer-determined moderate to vigorous physical activity (MVPA). Participants were 155 sixth to eighth graders participating in regularly scheduled physical education classes from a suburban public school. Physical activity levels were measured by Yamax pedometers and Actical accelerometers. Descriptive analyses were conducted to calculate steps per minute (SPM) for pedometers and time engaged in MVPA (TMVPA) and percentage of time engaged in MVPA (PMVPA) for accelerometers, respectively. Correlation analyses yielded that SPM were positively and significantly related to TMVPA and PMVPA. Additionally, the percentage of agreement and modified kappa between SPM and PMVPA were .45 and .24, respectively. In conclusion, pedometer-based SPM is a valid tool to survey physical activity time against accelerometers.

Key words: moderate to vigorous physical activity, physical activity levels, steps per minute

The number of children and adolescents in the United States who are overweight and obese has dramatically increased. Specifically, the percentage of female children and adolescents who are overweight has increased dramatically from 13.8% in 1999-2000 to 16.0% in 2003-2004. Similarly, the percentage of male children and adolescents who are overweight has increased from 14.0% to 18.2% during the same period (Ogden et al., 2006). The increased levels of overweight and obesity among children and adolescents are partly related to decreased levels of activity (Levin, McKenzie, Hussey, Kelder, & Lytle, 2001; Ogden et al., 2006). Children's physical activity levels tend to decline during the developmental years, especially during middle school (Parish & Treasure, 2003). For example, 61.5% of children aged 9-13 years do not participate in any organized extracurricular physical activities, and 22.6% of them do not engage in any free time physical activity (Centers for Disease Control and Prevention [CDC], 2003; U.S. Department of Health and Human Services [USDHHS], 1996). Although decline of physical activity in middle school years has been evident, carefully designed research can assist teachers to develop strategies that will reverse this trend and create a culture that values physical activity and realizes its full benefits.

Nearly all adolescents in school settings can participate in physical activity through physical education programs for health and wellness (e.g., maintaining healthy body composition) (Levin et al., 2001; Simons-Morton, O'Hara, Parcel, Baranowski, & Wilson, 1990; USDHHS, 1996; World Health Organization, 1996). Given that physical activity during adolescence tracks into adulthood to a certain degree, and the fact that an important health objective of Healthy People 2010 is to promote students' active participation in physical education classes to at least 50% of the class time (USDHHS, 2000), structured physical education programs represent an important avenue to promote school-based physical activities of moderate-to-vigorous intensity (Simons-Morton et al., 1990). Accordingly, effectively delivering physical education to school children becomes extremely imperative among physical educators. The ability to accurately measure physical activity levels in physical education class and classify these levels would facilitate an evaluation of the effectiveness of structured physical education programs.

To date, several different instruments for the assessment of physical activity levels exist. Self-report physical activity instruments have been scarcely used among children because of such limitations as high cognitive demanding for children and the sporadic nature of children's physical activity. Direct observation is considered one excellent way to assess children's physical activity behavior (Kohl, Fulton, & Caspersen, 2000; Scruggs, Beveridge, & Clocksin, 2005; Sirard & Pate, 2001). However, direct observation in physical education settings is cumbersome because it is costly and it requires high expertise and long measurement time periods (Scruggs et al., 2005; Sirard & Pate, 2001). Heart rate monitors have been widely used to measure physical activity in physical education because of the linear relationship between heart rate and energy expenditure during steady-state exercise (Stratton, 1996). However, they are unable to accurately distinguish between light and moderate-intensity activities and record frequency of activity within a limited time frame (Hands, Parker, & Larkin, 2006). The accuracy of heart rate monitors can also be affected by such environmental factors as temperature, heat, and humidity.

As motion sensors, pedometers and accelerometers are considered practical, objective, and valid assessments of physical activity (Sirard & Pate, 2001). These instruments have advantages such as minimal participant and experimenter burden for the researchers; being unobtrusive to the subjects; and being comfortable and acceptable for the subjects to wear. Pedometers count the number of steps an individual takes by lifting the lever arm mechanically or electrically or using a piezoelectric strain gauge (e.g., New Lifestyles NL-1000). Accelerometers are designed to assess total ambulatory activity levels and thus they provide an estimate of energy expenditure (Ainsworth, 2000; Bassett, 2000; Westerterp, 1999). Pedometers are less expensive (approximately \$20-\$50) than accelerometers (e.g., approximately \$100-\$500), they can measure the number of steps during a designated time period, record distance, and provide estimated calories. In comparison, accelerometers can provide very detailed information regarding the intensity (sedentary, light, moderate, and vigorous) of time spent at different intensity levels, and estimated energy expenditure. In general, these motion sensors can accurately measure physical activity among children in real world settings (e.g., physical education). However, they are not efficient to capture activity levels during such activities as stationary cycling and weightlifting (Freedson & Miller, 2000; Sirard & Pate, 2001).

Nowadays, the pedometer has been utilized as an activity surveillance tool in physical education as it holds the most promise for implementation due to validity, cost, and practicality (e.g., daily use) (Scruggs, 2007a, 2007b). Most recently, Scruggs and colleagues have established a pedometer steps per minute (SPM) guideline to quantify students' time engaged in physical activity in physical education (Scruggs, 2007a, 2007b; Scruggs, Beveridge, Eisenman, Watson, Schultz, & Ransdell, 2003; Scruggs, Beveridge, Watson, & Clocksin, 2005). In particular, these scholars have quantified the minimum SPM values indicating 50% of the lesson time in physical activity. Specifically, Scruggs and colleagues examined the number of pedometer-based steps equivalent to one third of the lesson time first through sixth-grade students engaged in during physical activity and determined 58-63 SPM was an accurate indicator. Using the lesson time of 42 to 50 minutes, Scruggs et. al. (2007b) also specified a SPM interval of 82-88 for seventh and eighth graders to comply with the 50% physical activity recommendation. In their studies, pedometer SPM and duration recorded physical activity via the System for Observing Fitness Instruction Time (SOFIT) (McKenzie, Sallis, & Nader, 1999) have been found to relate strongly, $r = .74$ to .89. These empirically derived SPM indices across different grade levels set scientifically sound application of physical education physical activity guidelines for the researchers and practitioners in the field. However, the validity of the pedometer-based physical activity outputs (e.g., SPM) against criterion measures remains largely unexplored. Further research in this area of inquiry is highly warranted.

Researchers have demonstrated that accelerometer-determined physical activity levels had a higher correlation with VO_2max scores than heart rate- or pedometer-determined physical activity levels among school children (Eston, Rowlands, & Ingledew, 1998; Louie et al., 1999). Accelerometer-determined physical activity levels have been marginally better correlated with physical activity scores measured by direct observation than with heart rate-determined physical activity levels among young children (Scruggs, Beveridge, & Clocksin, 2005). Furthermore, due to the intrusiveness of direct observation, unreliability of self-report measures, the complexity of heart rate analysis, and limited outputs of the pedometer, accelerometers have gained in popularity and have been recommended as a valid and practical tool to measure physical activity levels (Puyau, Adolph, Vohra, Zakeri & Butte, 2004; Sirard & Pate, 2001). Indeed, many researchers consider it a criterion against which other measures of physical activity can be validated (Behrens, Hawkins, & Dinger, 2005; Ward, Evenson, Vaughn, Rodges, & Troiano, 2005). Therefore, in the present study the Actical accelerometer was used as the criterion measure because it uses an omnidirectional sensor that may capture some activities not typically well assessed by accelerometer. Actical accelerometer contains a cantilevered rectangular piezo-electric bimorph plate and seismic mass, which is sensitive to movement in all directions. Its sensitivity allows for detection of sedentary movements as well as high intensity movements (Puyau et al., 2004).

To our knowledge, there is a need to examine the validity of the pedometer-based outputs against criterion measures in the field of physical activity. However, no data are available which validate pedometer outputs against accelerometer-determined physical activity concurrently in measuring children's MVPA, especially in middle school physical education settings. Therefore, the purpose of the present study was to validate one pedometer output, SPM, as a measure of students' physical activity using accelerometer-determined MVPA as the criterion. SPM was validated against accelerometer-determined outputs including time engaged in MVPA (TMVPA) and percentage of time engaged in MVPA (PMVPA). It was hypothesized that SPM would correlate strongly with both TMVPA and PMVPA and be a significant and accurate measure of PMVPA.

Method

The Participants and Setting

The participants were 225 sixth - eighth graders (112 boys, 113 girls) enrolled in one public school in the Southern region of the United States. The typical class size was 30 to 35 students. Twenty-five students were randomly selected as participants for each class. In the present study, each grade level consisted of three intact classes, including 75 sixth graders, 75 seventh graders, and 75 eighth graders, respectively. The majority of the participants were from families of middle to high socioeconomic status. The participants had a 90-minute physical education class taught by three certified physical education teachers on alternate days. Given the time allotted for dress change and roll check, approximately 60 minutes was typically devoted to the physical education lesson. All the teachers had taught for more than 10 years and they shared the responsibility for the teaching assignments in the three classes of each grade. Permission to conduct this study was obtained from the university institutional review board, the school district, the principal, and the physical education teachers. Additionally, consent to participate in the study was obtained from all participants and their parents/guardians prior to the start of the study.

When students arrived in the gym, the physical education teachers took attendance. Then the students participated in warm-up, activities, and games. Typically, within each lesson component, students were introduced to the skills to be learned, organized for practice, and provided feedback when necessary. All classes ended with a closure to the lesson. The learning activities consisted of catch/kick ball (n = 66, n = participants), walking/jogging (n = 25), line dance (n = 18), soccer (n = 29), and table tennis (n = 17) during the time of data collection. Classes were held indoors for catch/kick ball, line dance, and table tennis and outdoors for walking/jogging and soccer. For the catch/kick ball, table tennis, and walking/jogging units, no formal instructions were given. However, in the line dance unit, students spent approximately 10 minutes practicing. Additionally, it is important to note that students were divided into two or more groups of 8-9 students per squads based on their sex (single sex groups) after the warm-up in the soccer unit. For this unit, instructions and basic rules were given by the physical education teachers before the start of this study. Every 15 minutes, the squads switched side of the playing field. At the start of each class, the physical education teachers reinforced the game rules and then allowed the games to commence following the warm-up activities. As a result, no formal instruction was given throughout the class.

Measures

This study involved the simultaneous monitoring of physical activity by two objective instruments: (a) Yamax Digi-Walker SW-701 (Yamax Inc., Tokyo, Japan); and (b) Actical activity monitor (Mini-Mitter Co., Inc., Bend, OR). A total of 25 units of each instrument were used in this study, allowing all the participants in a class to be monitored simultaneously. Self-report information on sex, race, grade, age, height, and weight were also obtained to characterize the study sample.

Pedometer. The Yamax Digi-Walker SW-701 has been shown to be an accurate pedometer for measuring adolescents' physical activity levels in field settings (Scruggs, 2007a, 2007b; Scruggs, et al., 2005). This pedometer can record steps, calculate distance traveled on the basis of individual stride length, and estimate caloric expenditure on the basis of total body weight. In this study, only the step-count data were used. Before the initiation of data collection, the pedometers were validated. The validation followed Vincent and Sidman's recommended procedure (2003). Specifically, the pedometer was shaken vertically 100 times and then the error between shaken and recorded steps was examined for each pedometer. Deviation from the 100 shakes for all pedometers was less than 5%. The validation demonstrated that the pedometers could provide accurate step counts. Pedometer step output was expressed as SPM, which was calculated by dividing the total number of steps taken in class by the duration of the class (Scruggs, et al., 2005). The students were advised to reset the pedometers to zero at the beginning of the warm-up, and turn in the pedometers at the end of the class.

Accelerometer. The Actical accelerometer is one of the smallest accelerometers available (28 x 27 x 10 mm, 17 grams with a watch battery), and is also water resistant. In this study, the Actical devices were worn at each student's hip, and recorded physical activity counts using 15-second epochs. The sampling frequency for the Actical devices was 32 Hz, and the sensitivity was 0.01 g. The devices collected motions in the frequency range of 0.5-3.0 Hz. That is, voltage generated by the sensor is amplified and filtered by analog circuitry. The amplified and filtered voltage is passed into an analog to digital converter, and this process is repeated 32 times per second. The resulting one second value is divided by four, and then is added to an accumulated activity value for the epoch. Actical devices were programmed and downloaded by connecting the monitor to a serial port computer interface using ActiReaders. Once data were downloaded to the corresponding software, data files were exported into a Microsoft Excel format (Microsoft Corporation, Redmond, WA).

Cut points established by Puyau et al. (2004) were applied to the data: (a) 0-99 counts per min. = sedentary; (b) 100-1499 counts per min. = light; and (c) ≥ 1500 counts per min. = moderate to vigorous physical activity. According to Puyau et al. (2004), optimal thresholds for classifying counts into sedentary, light, moderate and vigorous levels of physical activity have been determined by regression and receiver operating characteristic analysis. Data were categorized into sedentary, light, moderate, and vigorous levels based upon the thresholds as follows: (a) sedentary level was defined as activity energy expenditure (AEE) less than .01 $kcal \cdot kg^{-1} \cdot min^{-1}$, encompassing physical activities of minimal body movements in the sitting or reclined position; (b) light level was set as AEE larger than .01 $kcal \cdot kg^{-1} \cdot min^{-1}$ and less than .04 $kcal \cdot kg^{-1} \cdot min^{-1}$, reflecting a low level of exertion in the standing position; and (c) moderate and vigorous level was set at AEE larger than .04 $kcal \cdot kg^{-1} \cdot min^{-1}$, involving medium and high levels of exertion in the standing position. The Actical cut points were then calculated based on the AEE cutoffs and the prediction equations.

Most recently, researchers have demonstrated acceptable validity and reliability of Actical activity monitors when used with children (Pfeiffer, McIver, Dowda, Almeida, & Pate, 2006; Puyau et al., 2004). For example, Puyau et al. (2004) validated Actical activity monitors as measures of children's (7-18 yrs.) physical activity using energy expenditure as the criterion measure. They found that activity counts accounted for the majority of the variability in activity energy expenditure (as basal metabolic rate) and physical activity ratio (energy expenditure/basal metabolic rate), with small contributions of age, sex, weight, and height. Pfeiffer et al. (2006) also provided strong support for the validation for this monitor by revealing a high correlation ($r = .89$) between VO_2 and activity counts.

Given that longer epochs are unable to detect bursts of high activity counts (Nilsson, Ekelund, Yngve, & Sjöstrom, 2002) and the aims of this study, the Actical monitors were set to 15-second epochs in order to better capture the short bursts of activity typical of school children (Pfeiffer et al., 2006). In this study, students' time engaged in MVPA (TMVPA) was used as the first outcome variable. The second outcome variable (i.e., percentage of time engaged in MVPA [PMVPA]) was quantified as the time students engaged in MVPA divided by the duration of the physical education class (Arnett & Lutz, 2003). These outcome variables were retrieved from the Actical outputs directly.

Procedures

Data collection took place during a typical instructional day for one physical education class. A schedule was coordinated with the physical education teachers for the data collection so as to not interrupt instructional time. One accelerometer and one pedometer were attached to the left side of students' waistband, before the beginning of class. Each student was assigned an identification number which corresponded to the number on his or her waistband. The waistbands with the attached monitors (accelerometers and pedometers) were then distributed to students when the teachers were taking roll. The researchers helped the students wear the waistbands and verified that they fit closely around their waists. Then the students reset the pedometers to zero. At the end of each class, the students were told to return the accelerometers and pedometers to the start location by placing the waistband on the floor (i.e., visual cue to stop lesson time). Accelerometer and pedometer data were collected concurrently by synchronizing accelerometers. In other words, accelerometer time began with pedometer reset and concluded with waistband removal. In this way, all the data from the two objective instruments reflected an identical time frame.

Data Analyses

Means and standard deviations were generated for age, body mass index (BMI), and physical activity measures (SPM, TMVPA, and PMVPA). Percentage statistics were calculated to describe the proportion of participants who achieved and did not achieve physical activity guideline compliance for SPM and PMVPA. Pearson product-moment correlations and coefficients of determination were used to determine the concurrent validity of the instruments for the total sample. The general cutoffs established for correlation coefficients were set as follows: above .76 is high, .51 to .75 is fair, .26 to .50 is moderate, and .25 and below are weak (Berg & Latin, 1994). Percentage of agreement and modified kappa (Landis & Koch, 1977) were obtained after dichotomizing the data for meeting or not meeting 50% of lesson time for SPM and PMVPA. According to Landis and Koch (1977), modified kappa value above .61 is substantial, .41 to .60 is moderate, .21 to .40 is fair, and .20 and below are weak. All statistical analyses were performed using SPSS statistical software, version 13.0 (SPSS Inc., Chicago, IL).

Results

Univariate outliers were detected by transforming the data to z-scores. Following a recommendation of Stevens (1992), when the sample size is relatively large (e.g., n >100), any z value greater than + 4.00 or less than – 4.00 indicates an unlikely value and this extreme value should be considered an outlier. If the researcher determines that the extreme value was correctly entered and that the subject is simply different from the rest of the sample, then it is appropriate to drop the case from the analysis (Mertler & Vannatta, 2005). In the present study, nine univariate outliers and 61 missing data were identified and excluded from the study. Therefore, the final sample size comprised 155 students (80 boys, 75 girls). The participants consisted of sixth (28.4%), seventh (34.8%), and eighth (36.8%) graders ranging in age from 10 to 14 years (*M* age = 12.52, *SD* = 1.02). The majority of the participants, 88.4%, were Caucasian, 7.7% were African American, 2.6% were Hispanic American, and 1.3% were Asian American. The average BMI was 19.79 $kg{\cdot}m^{-2}$, with a range of 14.01 $kg{\cdot}m^{-2}$ to 32.11 $kg{\cdot}m^{-2}$.

Table 1 shows the descriptive statistics for the whole sample.

Table 1. ***Descriptive Statistics among Variables (N = 155)***

	Minimum	Maximum	Mean	SD
age	10	14	12.48	1.01
Body mass index	14.01	32.11	19.81	3.10
Steps per minute	19.2	104.68	52.99	20.36
Time in MVPA	2.00	57.00	39.96	10.29
Percentage of time in sedentary	.00	61.67	8.86	9.56
Percentage of time in light intensity	.00	58.33	24.25	11.83
Percentage of time in MVPA	3.34	92.20	66.89	17.02

Notes. *SD* = Standard Deviation.
MVPA = moderate to vigorous physical activity.

Overall, the students spent 66.89% of the class time engaged in MVPA as measured via accelerometer. Among them, 85.8% of the students spent more than 50% of the lesson time in MVPA. In addition, the physical education classes provided a mean MVPA for more than 50% of the class time for the students across all learning activities (i.e., catch/kick ball: 62.99%, walking/jogging: 77.09%, line dance: 59.37%, soccer: 78.84%, and table tennis: 54.63%). In terms of the pedometer SPM, 44.5% of the students achieved physical activity guideline established by Scruggs (2007a, 2007b).

The relationship between SPM and PMVPA was significant ($p < .01$) and fair ($r = .57$). The pedometer data shared 32.49% of variance with PMVPA. Similarly, SPM was positively related to TMVPA ($r = .55$, $p < .01$), accounting for 30.25% of variance with TMVPA. After dichotomizing the SPM data for meeting or not meeting 50% of lesson time based on Scruggs' physical activity guideline (Scruggs, 2007a, 2007b), the percentage of agreement and modified kappa between SPM and PMVPA were .45 and .24, respectively.

Discussion

Validating the assessment of the 50% of lesson time in MVPA recommendation using pedometers in middle school physical education was the primary purpose of this study. Students' accelerometer-based MVPA (TMVPA and PMVPA) were used as a criterion instead of physical activity time measured via direct observation. Evidence has shown a decline in students' physical activity levels across the middle school years (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Parish & Treasure, 2003), therefore there is a call for providing adequate school-based structured physical education for all middle school students (National Association for Sport and Physical Education [NASPE], 2000; USDHHS, 1996). Middle school students should accumulate enough physical activity to at least achieve the 50% physical education class time recommendation. In this study, 85.5% of the students met or exceeded the 50% of the lesson time engaged in MVPA when the activities were assessed via accelerometer. Recently, Scruggs (2007b) reported that 68.9% of middle school students enrolled in physical education met the 50% physical activity recommendation. Accordingly, this result of this study echoes the recommendations indicating that 50% of the physical education time should involve MVPA (CDC, 2004; Sallis & Patrick, 1994) and is consistent with recent research (Arnett & Lutz, 2003; Scruggs, 2007b).

It is assumed that, if students accumulated more pedometer steps in class, they would be more physically active. In this study, the pedometer outcome variables (SPM) were consistently significantly and positively associated with TMVPA and PMVPA. That is, those students with higher SPM tended to engage more in MVPA in class. This finding is in line with recent studies indicating that pedometer outputs were positively and moderately related to accelerometer data (Behrens, Hawkins, & Dinger, 2005; Treuth et al., 2003). In addition, we dichotomized the SPM data for meeting or not meeting 50% of lesson time according to the physical activity guideline established by Scruggs (Scruggs, 2007a, 2007b) and found that percentage of agreement and modified kappa between SPM and PMVPA was good. This finding indicates that the pedometer SPM guideline is valid to quantify students' time engaged in MVPA in physical education. Taken together, the finding supports the notion that a pedometer is a valid assessment tool to measure school children's physical activity levels (Kilanowski, Consalvi, & Epstein, 1999; Rowlands, Eston, & Ingledew, 1997). Given their low prices and easiness to use, pedometers have been extensively employed as a valid and practical tool for physical activity surveillance within the physical education context (Scruggs, et al., 2005).

In this study, 45.5% of middle school students engaged in pedometer-determined MVPA for more than 50% of the lesson time using Scruggs' guideline (Scruggs, 2007a, 2007b). It should also be noted that correlations between SPM and the criterion measures (.55 to .57) were slightly lower than those in Scruggs and colleagues' studies (.74 to .89). We can speculate two explanations. First, when interpreting SPM results, Scruggs et al. (2005) suggested that application be made when physical education parameters of grade, lesson time, and learning content are similar. In their studies, 10 minutes of lesson time were used for elementary students, while 42-50 minutes were used for the middle school students (Scruggs, 2007a, 2007b; Scruggs et al., 2003; Scruggs, et al., 2005). However, in the present study 60 minutes of the lesson time was used which includes warm-up, activities, and games. Different lesson times might make a significant difference in terms of MVPA between studies. In addition, the learning content may also influence students' MVPA in physical education (Fairclough & Stratton, 2006). In general, team-based invasion games (i.e., soccer and football) usually promote relatively high MVPA levels. In Scruggs' studies (2007a, 2007b), a large variety of activities such as basketball, speedball, archery, interval running, soccer, flag football, volleyball, ball exploration and routine, dance, floor hockey, hula-hoop exploration and routine, obstacle course, paddle birdie, and ultimate ball/Frisbee were utilized as learning contents for physical education classes. In this study, only five learning contents (catch/kick ball, walking/jogging, dance, soccer, and table tennis) were used which might result in different MVPA for students. Second, the criterion measures for Scruggs and colleagues' studies and our study were different. Scruggs et al. (Scruggs, 2007a, 2007b; Scruggs et al., 2003; Scruggs, et al., 2005) used direct observation as the criterion measure to assess MVPA. Although the interrater coefficients have been substantiated in their studies, the MVPA generated from direct observation was subjective and sometimes inaccurate. In this study, we used the Actical accelerometer which can capture MVPA accurately and reliably. It is plausible that the use of different criterion measures might cause the different correlations between SPM and the criterion measures.

In summary, the findings of this study support the supposition that pedometer-based SPM is a valid tool to survey the 50% physical activity recommendation in comparison to accelerometer-determined MVPA in a middle school physical education setting. As expected, pedometer outcome variable (SPM) was a good indicator of school children's MVPA in class. Because the pedometer is low cost, objective, and easy for researchers and teachers to use and implement, physical educators and health promoters can use pedometers to capture changes in physical activity levels (i.e., MVPA) following different interventions in educational practice. Important study limitations, however, should be identified when interpreting the results. First, when the nature of physical activity cannot be captured by the pedometer, additional errors would occur in the estimation of time engaged in MVPA in physical education. Therefore, the pedometer SPM recommendations should not be applied when learning contents are activities that cannot be measured by pedometer (e.g., swimming, weight lifting, and rock climbing). Scruggs (2007a) has proposed that there is a need to develop a physical activity assessment tool which combines pedometer-assessed physical activity and self-report of activity content. In this way, the odds of misapplication of pedometer SPM recommendation in physical education can be decreased. Second, researchers (e.g., Stratton, 1996; Vincent & Pangrazi, 2002) have reported that students differ in their physical activity levels in physical education classes across different gender and age groups. However, the gender and age differences were not examined in this study. Future studies might focus on the moderate effects of gender and age on children's MVPA in physical education. Additionally, only one middle school was used in this study. The participants came from middle to upper-middle class families and their ethnic/racial background was homogeneous. Future studies need to recruit a large number of diverse students (in both socioeconomic status and ethnicity/race) from multiple school sites to increase the generalizability of the findings.

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