Quantifying Physical Activity via Pedometry in Elementary Physical Education

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ABSTRACT

SCRUGGS, P. W., S. K. BEVERIDGE, P. A. EISENMAN, D. L. WATSON, B. B. SHULTZ, and L. B. RANSDELL. Quantifying Physical Activity via Pedometry in Elementary Physical Education. *Med. Sci. Sports Exerc.*, Vol. 35, No. 6, pp. 1065–1071, 2003. **Purpose:** The objective of this study was to determine a pedometer steps per minute standard for quantifying the lesson time that first- and second-grade physical education students spent in moderate to vigorous physical activity (MVPA). **Methods:** The sample was divided into validation ($N = 246$) and cross-validation ($N = 123$) samples using the holdout technique. Using the criterion test model, steps per minute cut points were empirically and judgmentally determined. C-SOFIT systematic observation was the criterion instrument and pedometry was the predictor instrument. Data were collected from 45 physical education lessons implemented in six schools. The three-step analytic procedure of computing mastery/nonmastery outcome probabilities, phi coefficients, and error proportions was used to determine the optimal steps per minute cut point for quantifying 33.33% of the physical education lesson time engaged in MVPA within a 30 class. **Results:** Steps per minute was highly correlated with observation ($r = 0.74–0.86$, $P < 0.0001$). Five steps per minute scores that were accurate indicators of 33.33% of the class time engaged in MVPA in the validation sample were accurate indicators of steps per minute in the cross-validation sample. The optimal steps per minute cut point ranged from 60.00 to 63.00, which is equivalent to 1800–1890 steps in a 30-min physical education class. **Conclusion:** Data supports the use of pedometry steps per minute values as an accurate indicator of MVPA. Pedometry demonstrates promise as a viable large-scale surveillance instrument for measuring MVPA in physical education. **Key Words:** MOTION SENSOR, OBSERVATION, CRITERION REFERENCED, MEASUREMENT, MODERATE TO VIGOROUS, SURVEILLANCE

The Surgeon General's Report recommends that people of all ages perform 30 min of moderate physical activity on most days of the week (27). This recommendation stems from conclusive research indicating that health benefits are achieved in adulthood from moderate levels of physical activity. Unfortunately, most American adults do not receive the health benefits of regular moderate physical activity. In fact, 85% do not engage in moderate activity 5 or more days per week for 30 min, and 40% do not participate in any leisure-time physical activity (28). Thus, in order to impact lifetime physical activity behavior, childhood health and adult health, childhood has been identified as a critical period for nurturing lifetime activity behavior (3,5,27,28).

Now, more than ever, the United States is focusing on health promotion through physical activity interventions for all ages (3,28). Virtually all children attend school and spend much of their day at school, making school physical education a primary institution for promoting active lifestyles (3,5,25,27,28). Specifically, grade school physical educators have been called upon to deliver quality physical education programs with a physical activity and health promotion focus.

Historically, adult physical activity recommendations have been applied to children (4). Although this practice continues today, adult recommendations should be modified for application to children (4,5). Physical activity recommendations set forth by the Council for Physical Education for Children (COPEC) address the nature of childhood activity behavior and detail physical activity guidelines for children aged 5–12 yr. According to these recommendations, children should acquire their total daily physical activity by engaging in multiple sessions of moderate to vigorous physical activity (MVPA) lasting 10–15 min per session with brief rest and recovery within each session. In addition to the COPEC (5) guidelines, the President's Council on Physical Fitness and Sports recommends that children acquire 11,000 steps$\cdot$d^{-1} (17). Although no absolute number of minutes, percent of class time, or steps per minute criteria have been recommended for MVPA in elementary physical education, 10–15 min of MVPA (i.e., 33.33–50% of the class time) within a typical 30-min physical education class would significantly contribute to a child's daily activity. Unfortunately, accurate assessment of activity levels, especially for children, has been problematic (10).

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The difficulty with developing valid, reliable, and practical assessment techniques for large-scale research has hindered the understanding of the relationship between health, activity, and development. Furthermore, it is difficult to assess physical activity program effectiveness, and conduct large-scale physical activity surveillance (18,20,25). Activity monitors, direct observation, self-report, heart rate telemetry, and the doubly labeled water technique have all been used to measure activity levels in children (10). When assessing physical activity, all measures have strengths and limitations.

Systematic behavioral observation has been the most valid criterion measure for assessing children's physical activity levels within a defined space and specific time period of a day (10). One particularly effective instrument for observation of physical activity is the System for Observing Fitness Instruction Time (SOFIT; 16). SOFIT is a widely adopted physical activity measurement tool within physical education (25). SOFIT's sedentary behavior codes and activity level codes are mutually exclusive as validated through concurrent comparison with heart rate values (16,19), and they correlate highly with concurrently measured CALTRAC accelerometer counts (15). Because walking has been recommended as the minimum level for moderate physical activity in children (4,16), SOFIT identifies walking as the minimum threshold of MVPA. Unfortunately, cost and labor requirements of this technique make observation impractical for large-scale surveillance (10).

Although systematic observation has been a valid research tool (30), it lacks practicality. For an activity assessment instrument to be practical it must: (a) be low cost; (b) provide for large-scale ongoing surveillance; (c) be acceptable to participants; (d) be acceptable to program leaders at data collection sites (e.g., physical education); (e) cause minimal to no program disruption; (f) be able to assess activity duration and intensity; and (g) demonstrate acceptable levels of objectivity and validity (10,20). One such instrument, activity self-report, would appear to be a practical surveillance instrument for measuring children's physical activity. However, self-report recall as an activity assessment tool is not recommended for children under 10 yr of age (10). Due to this recommendation, an instrument with higher objectivity and validity is warranted.

Uniaxial and triaxial motion sensors (i.e., pedometers and accelerometers) have demonstrated validity as measurement tools for physical activity (7,30), but accelerometers lack practicality due to high cost. However, one motion sensor that has the potential to meet practicality guidelines is the pedometer. The uniaxial electronic pedometer is a highly recommended alternative to the more expensive activity assessment techniques (7,20).

The Yamax Digi-Walker pedometer (Yamax Corp., Japan) has been identified as a low-cost yet accurate commercial pedometer in terms of measuring vertical movement (1). High correlation coefficients have been found between steps measured with the Yamax Digi-Walker pedometer and activity measured via observation or triaxial accelerometry (7,9). Interestingly, despite the accuracy and low cost of pedometers, no one has examined how many steps equate to recommendations for MVPA in physical education.

If the previously stated COPEC (5) physical activity guideline is used to set the minimum criterion cut point for childhood activity level assessment during a physical education class, then pedometer units expressed as steps per minute should be quantified in relation to a percentage of time engaged in MVPA. A percentage of the class time was used as the criterion measure in order to be consistent with established physical education activity standards (28). Specifically, the following research question was addressed: Within a 30-min physical education lesson, what steps per minute value indicates that children have engaged in MVPA for at least 33.33% of the class time?

The objective of this study was to empirically determine a valid criterion-referenced pedometer step per minute standard for quantifying the percent of lesson time that first- and second-grade physical education students spent in MVPA. Research objectives of this study were to: (a) correlate first- and second-grade students' physical education physical activity measures of steps per minute and MVPA as measured by systematic observation, (b) determine a valid criterion-referenced step per minute standard that was predictive of 33.33% of the lesson time in MVPA, and (c) cross-validate the pedometer step per minute criterion from the validation sample.

METHOD

Participants. Based upon pilot data, recommendations by Berk (2) and Safrit (21) for adequate sample size in criterion-referenced mastery/nonmastery testing, and the one-third holdout cross-validation technique, a minimum of 300 healthy first and second-grade participants were needed for the study. A total of 410 first- and second-grade participants in 15 intact classes from six schools in a single school district in the southwestern United States were potential participants. Of the 410 students enrolled, 369 received parental consent. Two thirds of the total sample were randomly assigned to the validation sample ($N = 246$). The cross-validation sample consisted of 123 first- and second-graders. Approval was obtained from the institutional review board, and all participants obtained signed parental consent.

The validation sample consisted of 246 participants, 2 were African American, 5 were Asian American, 189 were Anglo American, 22 were Hispanic, 2 were Native American, and 26 were classified as other. Of the 123 participants in the cross-validation sample, 2 were African American, 1 was Asian American, 98 were Anglo American, 8 were Hispanic, and 14 were classified as other. Gender and grade level descriptive statistics of developmental and anthropometric measures for both samples are presented in Table 1.

Setting and physical education lessons. The elementary school sites had indoor gym facilities with regulation basketball court dimensions. Physical education lessons were taught indoors during early to mid-winter months. One certified elementary physical education specialist with 4 yr

TABLE 1. Means (±SD) for developmental and anthropometric measures.

Variable	Validation Sample					Cross-Validation Sample				
	Boys	Girls	1st Grade	2nd Grade	Total	Boys	Girls	1st Grade	2nd Grade	Total
N	134	112	124	122	246	57	66	73	50	123
Age (yr)	7.33 (0.60)	7.26 (0.58)	6.81 (0.31)	7.70* (0.34)	7.30 (0.59)	7.25 (0.60)	7.21 (0.55)	6.85 (0.30)	7.78* (0.40)	7.23 (0.57)
Body mass (kg)	26.74 (6.11)	25.66 (5.31)	25.06 (5.76)	27.47* (5.55)	26.25 (5.77)	24.91 (4.85)	25.06 (5.96)	23.19 (3.49)	27.62* (6.62)	24.99 (5.44)
Stature (cm)	125.30 (6.74)	124.23 (6.54)	122.13 (6.32)	127.56* (5.85)	124.81 (6.66)	123.71 (6.96)	124.19 (5.66)	121.41 (5.33)	127.71* (5.68)	121.10 (26.35)
BMI ($kg \cdot m^{-2}$)	16.92 (2.69)	16.55 (2.52)	16.71 (2.84)	16.80 (2.38)	16.75 (2.62)	16.18 (1.87)	16.15 (2.71)	15.71 (1.66)	16.83* (2.98)	16.16 (2.35)

* $P < 0.01$ for gender and grade differences.

of experience instructed all lessons. A three-lesson locomotor skill theme unit of chasing, fleeing, and dodging was implemented for each of the intact physical education classes.

Instrumentation. The physical activity criterion and predictor instruments consisted of the computerized System for Observing Fitness Instruction Time (C-SOFIT; 8) and Yamax Digi-Walker SW-701 pedometer (Yamax Corp., Japan). C-SOFIT was the criterion instrument for measuring MVPA. C-SOFIT and the noncomputerized SOFIT have been validated and widely used for measuring student physical activity within physical education (8,11–13,15,16,19,22). The C-SOFIT three phase observation system was reduced to a single three-category (i.e., 1 = sedentary, 2 = walking, 3 = very active) coding system (14), and codes 2 and 3 combined defined MVPA.

The Yamax SW-701 Digi-Walker pedometer is an unobtrusive instrument measuring 19 mm × 39 mm × 52 mm that uses a horizontal spring-suspended mechanical lever arm to measure vertical movement. The Yamax SW-701 pedometer was set to record data in steps.

Data collection protocol. Before the implementation of physical education lessons, participant's stature and body mass were measured. Stature was measured without shoes to the nearest centimeter using a standard 1.83-m carpenter's ruler. Body mass was measured without shoes to the nearest kilogram using a commercially purchased electronic scale. Age and demographic data including sex and ethnicity were obtained from signed parental consent forms.

Systematic observation: C-SOFIT. Participant's physical activity behavior was video recorded using two Panasonic AG-188 VHS movie cameras. Video cameras were placed at opposite corners of the physical education setting. In each of the 15 intact classes, each participant's activity level was analyzed once via videotape by trained researchers. Approximately one-third of the participants per intact class were assigned to be video recorded in one of the three physical education lessons. Colored jerseys were used to identify each participant for later video analysis.

Observer training and reliability. Eight observers were trained to use C-SOFIT. Training consisted of reading SOFIT (16) and C-SOFIT (8) articles, studying physical activity code definitions and observation procedures, and independent computer practice coding "gold standard" videotapes. Before recruits began videotape data collection, a 90% interobserver agreement criterion was reached on three gold standard videotapes (29). A trained observation checker served as the data quality manager in order to ensure quality data. Five percent of the total coded observations were critiqued against the 90% interobserver agreement criterion, and all observation checks ranged between 92% and 99%. Percent interobserver agreement was determined using the temporal data method (29).

Pedometer. All participants wore pedometers for each of the three physical education lessons, and established protocol for instrument placement was followed (1). However, only pedometer data collected concurrently with systematic observation were included in analyses. Immediately before lesson start, all pedometers were reset to zero and checked for proper fit and function. At lesson conclusion, research assistants recorded pedometer data. Pedometer readings were expressed as absolute steps and average steps per minute. Steps per minute were determined by dividing the absolute step value by lesson duration in minutes. Fifty pedometers were assessed for measurement accuracy before data collection by comparing observed steps counted with pedometer recordings. Forty-nine pedometers with error ≤ 2% were used in data collection.

Criterion test model. The Criterion test model was used to generate and test cut points (21). For a detailed description of the Criterion test model six-step procedure, see Safrit (21). Step 1: COPEC (5) physical activity guideline three was specifically used to establish the criterion measure true score. To standardize the criterion measure across all lessons of similar but varying time lengths, 33.33% of the lesson in MVPA was used to identify the criterion. Step 2: The predictor physical activity measure was steps per minute. Step 3: Collect data using both the criterion and predictor measures. Step 4: Three statistical methodologies were used to identify cut points on the predictor measure: (a) trim upper 25% (25% Trim) of scores on the criterion measure, (b) trim scores above the upper limit of the 99% confidence interval (99% CI) on the criterion measure, and (c) compute a simple regression equation for identifying predictor measure cut points. For both the 25% Trim and 99% CI methods, the criterion measure scores that fell between the minimum criterion cut point (i.e., 33.33% of the lesson in MVPA) and either the 75th percentile score or the upper limit of the 99% confidence interval were used to identify the predictor scores that would be used to determine predictor measure cut points. These two procedures were used to lessen the impact that upper limit scores had on constructing confidence intervals around a predictor measure mean score. From the predictor measure means of these two methods, the process of statistical estimation, specifically the lower limit of a 90%, 95%, and 99% confidence interval, were used to identify cut points on the predictor measure. Step 5: The three-step analytic procedure recom-

TABLE 2. Means (±SD) for physical activity measures.

Variable	Validation Sample					Cross-Validation				
	Boys	Girls	1st Grade	2nd Grade	Total	Boys	Girls	1st Grade	2nd Grade	Total
Steps	1844.14 (376.53)	1884.79 (308.73)	1890.44 (376.44)	1834.07 (311.41)	1862.95 (346.70)	1862.09 (313.36)	1863.81 (321.96)	1848.90 (330.52)	1884.17 (296.76)	1863.01 (316.64)
$steps \cdot min^{-1}$	62.04 (11.73)	64.42 (10.20)	63.13 (11.44)	63.16 (10.75)	63.14 (11.09)	63.30 (9.97)	64.15 (10.84)	63.47 (11.12)	64.18 (9.34)	63.75 (10.41)
%MVPA	34.56 (5.96)	35.21 (5.29)	34.70 (5.78)	35.04 (5.54)	34.87 (5.66)	35.22 (5.03)	34.70 (5.11)	34.71 (5.28)	35.31 (4.72)	34.94 (5.06)
%VPA	16.14 (6.58)	16.63 (6.89)	17.28 (6.98)	15.39 (6.30)	16.37 (6.71)	17.67 (6.10)	16.42 (6.79)	17.46 (6.78)	16.25 (5.98)	17.00 (6.48)

$steps \cdot min^{-1}$, total step value is divided by time in minutes; %MVPA, percent of lesson time moderately to vigorously active; %VPA, percent of lesson time vigorously active.

mended by Berk (2) was applied to the predictor cut points. The three step analytic procedure consisted of the following statistical computations: (a) classification of outcome probability (c), (b) phi (ϕ), and (c) Type I false nonmaster (i.e., FNM) and Type II false master (i.e., FM) error criteria. The predictor cut point with the highest classification outcome probability (c), validity coefficient (ϕ), and an error criteria of FM < FNM was considered the optimal cut point. See Berk (2) and Safrit (21) for a complete description of the three-step analytic procedure. Step 6: Cross-validate the step per minute cut points using the analytic procedure.

Data analysis. All data were entered into the Statistical Package for the Social Sciences (SPSS) 10.0. Descriptive statistics were generated on anthropometric, developmental, and physical activity measures. Participant codes (i.e., 1–369) were generated for each participant. The total sample was randomly assigned to either the validation or cross-validation samples via SPSS. Independent *t*-tests and 2 × 2 (gender by grade) ANOVA were used to examine differences on anthropometric, developmental, and physical activity measures for validation and cross-validation samples, and between samples. Total sample, gender, and grade level Pearson r correlation coefficients were generated between percent MVPA and the concurrently measured steps per minute, for both samples. To control for Type I error, $P < 0.01$ was set for all statistical tests.

RESULTS

Physical education lessons. Mean lesson time for all 45 lessons was 29.48 ± 1.93 min. Mean lesson times for the three-lesson unit were 29.43 ± 1.67 min for lesson 1, 29.15 ± 2.11 min for lesson 2, and 29.82 ± 2.08 min for lesson 3. Mean total steps for each lesson were 1892.33 ± 311.22, 1896.06 ± 309.14, and 1793.96 ± 382.19 for lesson 1, 2, and 3, respectively.

Developmental and anthropometric data in Table 1 provides support for making comparisons between validation and cross-validation samples. The similarity between boys and girls in both samples supports grouping boys and girls data. Grade level differences did exist within both samples on measures of weight, height, and age; however, these differences were expected.

Physical activity measures. On measures of physical activity, validation and cross-validation samples were not significantly different (see Table 2). Within each sample, no significant physical activity differences existed between gender or grade level, further justifying combining data. These data highlight the similarity between first- and second-grade boys and girls on the measures of physical activity within structured chasing, fleeing, and dodging lessons.

Research objective results. The first objective was to correlate steps per minute and percent MVPA. Steps per minute were strongly correlated with percent MVPA in both validation ($r = 0.85$, $P < 0.01$) and cross-validation ($r = 0.74$, $P = 0.01$) samples. Correlation coefficients for gender and grade level in both samples ranged from $r = 0.74$ to $r = 0.85$ ($P < 0.01$).

The second objective was to determine a steps per minute standard for quantifying 33.33% of the lesson time that students spent in MVPA. Following the Criterion test model procedures, seven predictor measure cut points were generated. However, more cut points of steps per minute were needed to examine the trend in Type I and II error, (c), and ϕ. Four new scores less than the lowest empirically generated cut points were selected based on experimenter judgment. Therefore, 11 total steps per minute cut points were generated. Steps per minute cut points generated from the 25% Trim method, 99% CI method, and regression model, and accompanying (c), ϕ, and mastery/nonmastery classifications are presented in Table 3.

A simple regression model was constructed with percent MVPA as the independent variable and steps per minute as the dependent variable for predicting 33.33% of the lesson time in MVPA. The regression model was significant ($t(235) = 24.57$, $P < 0.0001$), and the 95% confidence interval of the slope was 1.54–1.81. The equation used for calculating the steps per minute value of 60.63 was $Y = 1.677(33.33) + 4.736$, with a significant correlation ($r = 0.85$).

Of the 11 $steps \cdot min^{-1}$ scores, eight had (c) scores greater than 80%. Of the eight scores, six met *a priori* error criteria (i.e., FM < FNM). Although no established cut point value of ϕ was set, higher coefficients were desirable. Three steps per minute scores had ϕ coefficients ≥ 0.70. Based upon the criteria for determining optimal steps per minute cut points, steps per minute scores of 60.00, 60.63, and 61.14 were the best indicators for 33.33% of the lesson time in MVPA within a 30-min physical education lesson.

The third objective was to cross-validate the results. Cross-validation sample statistics of (c), ϕ, and mastery/nonmastery proportions for each steps per minute cut point from the validation sample are presented in Table 4. Of the 11 $steps \cdot min^{-1}$ cut points, all (c) values were above 80%, eight had error scores of FM < FNM, and only two ϕ coefficients were above 0.70. The 2 $steps \cdot min^{-1}$ scores of 62.71 and 62.95 were the most accurate predictors. These values were greater than the most accurate steps per minute scores in the validation sample. However, close inspection

TABLE 3. Summary table of validation sample steps per minute cut points for 33.33% MVPA.[a]

Cut Points	(c)[b]	ϕ[c]	TM[d]	TNM[e]	FM[f]	FNM[g]
64.58	77.30	0.60	0.414	0.359	0.017	0.211
64.47	77.20	0.60	0.418	0.354	0.021	0.207
63.32	79.70	0.63	0.443	0.354	0.021	0.181
62.95	82.20	0.66	0.468	0.354	0.021	0.156
62.71	81.80	0.66	0.468	0.350	0.025	0.156
61.14	85.60	0.70	0.523	0.333	0.042	0.101
60.63	85.60	0.71	0.523	0.333	0.042	0.101
60.00	86.10	0.71	0.540	0.321	0.055	0.084
59.50	85.70	0.69	0.549	0.308	0.068	0.076
59.00	84.40	0.66	0.561	0.283	0.093	0.063
58.50	83.50	0.65	0.561	0.274	0.101	0.063

[a] 33.33% MVPA, 33.33% of the class time in MVPA criterion.
[b] (c), classification of outcome probability.
[c] ϕ, phi correlation coefficient.
[d] True mastery (TM), criterion and predictors scores above cut points.
[e] True nonmastery (TNM), criterion and predictor scores below cut points.
[f] False mastery (FM), Type II error.
[g] False nonmastery (FNM), Type I error.

of the steps per minute cut point error (i.e., FM < FNM), (c), and ϕ, data indicates similar results for both samples as five of the steps per minute scores overlap as meeting all established criteria for determining an accurate predictor measure score. More appropriately, data suggest a range of scores should be used to identify a valid steps per minute threshold that is predictive of meeting the MVPA criterion.

DISCUSSION

This study sought to advance the practicality of physical activity surveillance within elementary physical education. For measurement of this magnitude to occur, the assessment instrument must meet criteria of practicality alluded to in the introduction. The pedometer has been recommended by researchers as demonstrating promise for such an arduous task (7,20). The issue of practicality remaining to be solved is that of the pedometer assessing activity duration. Specifically, this study was designed to quantify percent of time spent in MVPA in physical education via pedometer steps per minute. However, before the pedometer can be used to quantify MVPA, it must demonstrate a relatively strong relationship with a criterion measure (21).

The validity of the pedometer as an instrument to assess physical activity was supported. Percent MVPA and steps per minute were highly correlated. This is in agreement with other researchers who reported high correlation coefficients between pedometer steps and criterion measures (7,9). The advantage of observation as the criterion when validating other instruments is that the nature of the instrument allows for data to be accurately collected on activity mode, intensity, duration, and frequency. This mode of physical activity assessment is well suited for the natural behavior of children's MVPA, especially when computer-generated duration recording is used. Duration recording allows for behavior to be coded continuously, unlike interval recording, which makes the assumption that what is seen during the observation interval is characteristic of the behavior during recording.

The population under study was first- and second-graders. First- and second-grade mark the first 2 yr of full-day exposure to our nation's educational institution: an institution that has been charged with adopting our nation's health promotion agenda; and of specific action is increasing our children's school time physical activity (3,27,28). The first- and second-grade sample of this study, although not ran-

TABLE 4. Summary table of cross-validation sample steps per minute cutoff scores for 33.33% MVPA[a]

Cut Points	(c)[b]	ϕ[c]	TM[d]	TNM[e]	FM[f]	FNM[g]
64.58	81.20	0.642	0.504	0.308	0.026	0.162
64.47	81.20	0.642	0.504	0.308	0.026	0.162
63.32	84.60	0.694	0.538	0.308	0.026	0.128
62.95	85.50	0.707	0.547	0.308	0.026	0.120
62.71	85.50	0.707	0.547	0.308	0.026	0.120
61.14	84.70	0.664	0.573	0.274	0.060	0.094
60.63	82.90	0.620	0.573	0.256	0.077	0.094
60.00	83.70	0.638	0.581	0.256	0.077	0.085
59.50	83.80	0.633	0.590	0.248	0.085	0.077
59.00	85.50	0.668	0.607	0.248	0.085	0.060
58.50	85.50	0.668	0.607	0.248	0.085	0.060

[a] 33.33% MVPA, 33.33% of the class time in MVPA criterion.
[b] (c), classification of outcome probability.
[c] ϕ, phi correlation coefficient.
[d] True mastery (TM), criterion and predictors scores above cut points.
[e] True nonmastery (TNM), criterion and predictor scores below cut points.
[f] False mastery (FM), Type II error.
[g] False nonmastery (FNM), Type I error.

domly selected, was considered normal, healthy first- and second-grade students.

Interestingly, significant physical activity differences were not found for between sample, within-sample grade level, or within-sample gender comparisons. These results may indicate that the instrumentation and defining physical activity methodologies used in this study and for this age group to measure physical activity are unbiased indicators of physical activity when gender and grade level are examined. Data also indicate that both boys and girls, and first- and second-grade students responded to chasing, fleeing, and dodging lessons similarly. The similarities are likely due to the structure of developmentally appropriate lessons and the developmental level of first- and second-grade boys and girls. In first- and second-grade, boys and girls are quite similar in terms of growth and maturation. Although social factors influencing boys and girls physical activity participation may be experienced in or before second grade, the interaction between social factors and puberty has not been experienced and the accumulated years of gender-biased physical activity experiences are fewer.

Published studies of physical activity gender differences in physical education at the early elementary level (i.e., K, 1, 2) are nonexistent. However, it is believed that boys are typically more physically active than girls (3). The difference becomes more pronounced with increasing age through childhood and adolescence. Physical activity context is suggested as a determinant of gender physical activity differences for third- and fifth-grade children (11,23). McKenzie and colleagues (11) and Sarkin and colleagues (23) found that unstructured free-play environments resulted in higher physical activity levels in middle elementary grade boys, but these authors found that when in structured physical activity contexts, boys and girls demonstrate similar physical activity levels. In unstructured activity contexts, such as recess, children as young as preschool and kindergarten age demonstrate gender differences in activity level with boys demonstrating higher levels (13).

From a public health perspective, elementary physical education appears to be a context in which boys and girls acquire similar activity. It also suggests that the context of free-play recess needs modification, such that both girls and boys will benefit from the activity break (13). Structured activity breaks (i.e., fitness breaks) have demonstrated promise for delivering quality physical activity behaviors for both girls and boys (6). The combination of quality daily elementary physical education and fitness breaks within the elementary school community would likely reach most children and contribute similarly to boys and girls, and the overall strategic plan of our nation's effort to promote better health for children. Presently, of critical importance for furthering the public health agenda of school-site activity interventions is the ability to quantify MVPA.

The results of this study indicate that physical education MVPA can be quantified via pedometry. Thus, first- and second-graders in a typical 30-min physical education class can be assessed via pedometry in terms of meeting or not meeting the 33.33% of the class time engaged in MVPA criterion, which is derived from physical activity guideline three set forth by COPEC (5). This 10- to 15-min session has been deemed developmentally appropriate for children from 5 to 12 yr of age and should occur at a frequency of three to six or more per day. Over the course of a day, a child, by engaging in these activity sessions, should accumulate 30 min to several hours of MVPA on most days of the week.

Data from this study indicate that MVPA for 33.33% of the class time within a 30-min class is achievable. No student engaged in 50% of the class time in MVPA in any of the lessons taught, which was Objective 1.9 of the *Healthy People 2000* (26). Later, in *Healthy People 2010*, the objective similar to 1.9 of *Healthy People 2000* only included the adolescent population (28), most likely because of the inability to assess childhood physical activity practically. Few studies have been designed to determine whether the 50% MVPA objective is realistic (11,12,22,24). These studies examined MVPA of third- through fifth-grade students and found the objective achievable when teachers were trained to implement an MVPA-focused curriculum. Importantly, when only third-grade students comprised the study sample, the 50% objective was not achieved. A multicenter study conducted by McKenzie et al. (11) found that within a 30-min class, students engaged in MVPA 36% of the class time. This result is similar to what first- and second-graders in this study achieved. It is likely, due to elementary physical education prescribing to meet multiple objectives, that 33.33% of the lesson time engaged in MVPA is most applicable for the overall goals and objectives of elementary physical education. In the case of these studies, this study and Healthy People 2010 objective 22-10, the percent of time engaged in physical activity represents accumulated physical activity and not continuous activity.

Within a 30-min first- or second-grade physical education class, a step per minute value between 60.00 and 63.00 would be highly indicative of 33.33% of the lesson time in MVPA, so it would be reasonable to expect between 1800 and 1890 steps. A minimum standard of 11,000 steps$\cdot$d^{-1} is recommended for children (17). If this daily step recommendation was met, elementary physical education would contribute 16% of a child's total daily steps.

Based upon the results of this study, pedometry shows promise as a practical tool for measuring time spent in MVPA during early elementary physical education and as a physical activity surveillance instrument. For physical activity surveillance to take place, it is recommended that all grade school physical education teachers adopt pedometry into their programs. However, it is not recommended that the 60–63 steps$\cdot$min^{-1} criterion be applied to grade levels other than first- and second-grade, due to the probable influence of class time, student height, and stride length on step per minute outcomes. Although all physical education grade levels share responsibility in influencing daily physical activity levels of youth, it should be noted that physical education alone cannot and should not be expected to meet a child's total daily physical activity needs. However, quality daily physical education taught by specialists would contribute significantly to boys and girls' total daily MVPA.

A strength of this study was that objective data were collected on 369 first- and second-grade age participants in 15 different intact classrooms from six different schools. The diversity of the sample strengthened the study, in that it was similar to the national ethnic makeup when ethnicity was categorized as Anglo American and not Anglo American. Also, cross-validating the results from the validation study strengthened the findings. However, delimiting the study to only chasing, fleeing, and dodging lessons does potentially weaken generalizing the results to other elementary physical education skill and movement concept themes, as not all themes require movement in the vertical plane. Potentially, the limitation of pedometry-measuring movement in the vertical plane does bias data in instances when movement is nonvertical. Due to the exploratory nature of this study, much future research is warranted.

In conclusion, this study provided evidence that quantifying MVPA via pedometry is a valid measurement approach for surveying first- and second-grade students' physical education physical activity levels. To further this research, factors such as teacher, curriculum, lesson time, and grade level need to be manipulated for setting step per minute criteria in structured school physical activity settings. If valid steps per minute benchmarks can be established for all school physical activity settings, then physical activity health promotion programs within schools can be assessed practically with objectivity.

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