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Promoting Children's Health Through Physically Active Math Classes: A Pilot Study

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School-based interventions are encouraged to support youth physical activity (PA). Classroom-based PA has been incorporated as one component of school wellness policies. The purpose of this pilot study is to examine the effects of integrating PA with mathematics content on math class and school day PA levels of elementary students. Participants include four teachers and 75 students. Five math classes are taught without PA integration (i.e., baseline) followed by 13 math classes that integrate PA. Students wear pedometers and accelerometers to track PA during math class and throughout the school day. Students perform significantly more PA on school days and in math classes during the intervention. In addition, students perform higher intensity (step min^{-1}) PA during PA integration math classes compared with baseline math classes. Integrating PA into the classroom is an effective alternative approach to improving PA levels among youth and is an important component of school-based wellness policies.

Keywords: *child and adolescent health; physical activity and exercise; school health*

Regular physical activity is one aspect of a healthy lifestyle linked to reducing children's risk of developing chronic diseases in adulthood (Strong et al., 2005). In an effort to support physical activity for youth, school-based interventions are advocated (Pate et al., 2006). As part of the Child Nutrition and WIC Reauthorization Act of 2004, schools with a federally funded school meals program are required to implement a wellness policy that addresses physical activity and nutrition. Traditionally, physical activity promotion has occurred during physical education class or recess. However, more recently, some schools have included classroom-based physical activity as one aspect of the wellness policy (National Alliance for Nutrition and Activity, n.d.).

BACKGROUND AND LITERATURE REVIEW

For health advocates, the school mandate for wellness policies is timely and will hopefully reverse the trend of reduced physical activity opportunities in schools as a result of legislative pressure requiring schools to achieve high academic standards (Goals 2000: Educate America Act of 1994; National Association for Sport and Physical Education, 2003). This approach of cutting physical activity time in favor of increasing academic time is challenged by research that suggests physical activity may generate improved academic achievement, both directly and indirectly (Caterino & Polak, 1999; Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Mahar et al., 2006; Pellegrini, Huberty, & Jones, 1995; Sallis et al., 1999). Physical activity is linked to increased educational achievement using grades (Coe et al., 2006) and standardized tests (Sallis et al., 1999) as academic measures. Coe and colleagues (2006) found that students who engaged in vigorous activity had significantly higher grades in school than those

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reporting no vigorous physical activity. Sallis et al. (1999) revealed that students in schools receiving the Sports, Play, and Active Recreation for Kids intervention scored significantly higher on the Metropolitan Achievement Test than those in control schools. In contrast, other studies have found no significant link between academic performance and participation in physical activity (Daley & Ryan, 2000; Fisher, Juszczak, & Friedman, 1996).

Despite the inconsistency of these findings, school-based physical activity has been shown to take place without compromising learning (Ahamed et al., 2007). Even more promising is the positive relationship between physical activity and specific facilitators of learning, such as on-task behavior (Mahar et al., 2006), concentration (Caterino & Polak, 1999), and attentiveness (Azrin, Ehle, & Beaumont, 2006; Pellegrini et al., 1995). Not surprisingly, classroom-based physical activity experiences designed to teach academic content have become common practice in many school settings. This tactic has been found to be effective at increasing physical activity levels and reducing off-task behavior in the classroom (Mahar et al., 2006; Oliver, Schofield, & McEvoy, 2006; Stewart, Dennison, Kohl, & Doyle, 2004).

According to the Ecological Model (Sallis & Owen, 1997), individuals affect and are affected by their physical and social environments. Davison and Birch (2001) suggest that children's behaviors, in particular, are primarily influenced by family and school environments. More specifically, having access to programs and facilities influences children's behaviors, such as physical activity (Sallis, Prochaska, & Taylor, 2000). Therefore, within the context of the school, the ecological model would suggest that teachers have the opportunity to engage their students in additional physical activity through the integration of physical activity within the curriculum content. By using this concept of integration, teachers can focus on academic outcomes while engaging students in greater amounts of physical activity.

Although preliminary findings regarding the effectiveness of integrating physical activity in the classroom are positive, there is limited research on the impact of integrating physical activity in the classroom on students' school day physical activity levels (Mahar et al., 2006; Stewart et al., 2004). Therefore, the purpose of this pilot study was to examine the effects of integrating physical activity with mathematics on math class and school day physical activity levels of elementary students.

METHOD, STRATEGY, AND INTERVENTION APPLICATION

Participants

Prior to recruitment, institutional review board approval was received for all procedures outlined below. Teacher and parental consent and child assent were obtained from all individuals in the study. Initially, two fourth-grade and two fifth-grade teachers from a K-5 elementary school in the Southeastern region of the United States were asked to participate in this study. These teachers were selected based on recommendation from their assistant principal and by their willingness to design and implement physical activity integration activities.

Student participants were recruited from the classrooms of the four participating teachers to take part in this 18-day study (5 baseline school days and 13 school days incorporating physical activity integration). Seventy-five students aged 8 to 12 years participated in this study. In addition, 35% of students enrolled at the school were eligible for the free or reduced-price lunch program. Table 1 includes student participant demographic data. All student participants received a pass to a local indoor playground and the participating teachers each received a monetary incentive.

Instrumentation

Physical activity was measured via a standard protocol using Walk4Life MLS-2505 pedometers (Plainfield, Illinois). This pedometer is considered to be a valid and reliable instrument for measuring children's physical activity (Beets, Patton, & Edwards, 2005). Because pedometers measure steps, without indicating

TABLE 1
Participant Demographic Data ($N = 75$)

Demographic Variable	n	%
Gender		
Male	44	58.7
Female	31	41.3
Ethnicity		
Caucasian	62	82.7
African American	5	6.7
Hispanic	3	4.0
Asian	1	1.3
Other	4	5.3
	M	SD
Age, year	10.07	0.86
Height, m	1.44	0.07
Weight, kg	40.99	13.30
Body Mass Index, kg/m^2	19.48	4.57

as to when the steps accrued (e.g., in the morning, after-school), each student was assigned a *school* pedometer that was worn during school hours (including math class) and a *math* pedometer that was worn only during math class for the duration of the study. This protocol was used to determine the independent effect of the classroom intervention and the contribution of the intervention to overall activity levels during school. Hence, the school pedometer was designed to assess school day physical activity, whereas the math pedometer was meant to measure physical activity accrued during math time only. Each school and math pedometer was marked with a unique 3-digit code. The codes of each participant's pedometers were tracked by the investigators. In addition, the classroom teachers were given a form matching each participant's name with his or her assigned school and math pedometer codes to assist with pedometer distribution and collection.

In addition to measuring all participants' physical activity with pedometers, a subsample of 11 participants was recruited to wear an ActiGraph accelerometer (model GT1M, ActiGraph LLC, Pensacola, FL) during the entire day for the duration of the study. An accelerometer is a small device (dimensions: weight = 27 g; width = 38 mm; height = 37 mm; thickness = 18 mm) that uses a uniaxial accelerometer to sense vertical accelerations that are typical of human locomotion (i.e., 0.05 to 2.0*g*). An increase in the frequency and magnitude of vertical accelerations is indicative of a higher level of physical activity (e.g., running). The accelerations are summed per specified time period (i.e., epoch) and reported in the form of an activity count. One activity count is equivalent to 4 m*g* s^{-1}. The ActiGraph uses a rechargeable battery that can be plugged into a USB port on a computer. The ActiGraph was calibrated at the manufacturer prior to this study. Accelerometer data were collected by the device in 1-min intervals (i.e., epochs). The raw accelerometer data (i.e., activity count min^{-1}) were used to determine the number of minutes in each math class that participants spent in various intensity classifications using child-specific threshold activity counts for light-intensity physical activity (≥800 to ≤3199 counts min^{-1}) and the combined classification of moderate- to vigorous-intensity physical activity (>3199 counts min^{-1}; Puyau, Adolph, Vohra, & Butte, 2002). The raw data were also used to estimate the Metabolic Equivalent (MET; Freedson et al., 1997) and rate of gross and activity energy expenditure (Puyau et al., 2002) using valid child- and accelerometer-specific equations.

These 11 participants were selected based on recommendations from the classroom teachers. Participants who wore accelerometers also wore pedometers. The accelerometer data were collected concurrently with pedometer data. Each participant was required to have accelerometer data from at least two baseline math classes and seven intervention math classes to be included in the study. Owing to lack of participant compliance and accelerometer malfunction, data from 7 of the 11 (64%) accelerometer participants were used in the analysis. Of these 7 participants, there were 3 males (5th grade: $n = 3$; M_{age}: 10.3, $SD = 0.6$ years; $M_{height} = 143$, $SD = 4.4$ cm; $M_{weight} = 32.2$, $SD = 2.3$ kg; $M_{BMI} = 15.7$, $SD = 0.7$ kg m^{-2}) and four females (4th grade: $n = 2$; 5th grade: $n = 2$; $M_{age} = 10.5$, $SD = 0.6$ years; $M_{height} = 142.5$, $SD = 7.6$ cm; $M_{weight} = 36.0$, $SD = 9.8$ kg; $M_{BMI} = 17.5$, $SD = 3.2$ kg m^{-2}).

Procedure

One month prior to data collection, teachers met with the researchers for an all-day in-service conducted by the researchers to develop physical activity integration activities in the form of lesson plans. The concept of integration activities was grounded in the ecological model, suggesting that teachers influence children's behaviors by providing them with more physical activity opportunities.

During the in-service, teachers modified and/or created a total of 23 activities in which physical activity would be included with core content during the

TABLE 2
Physical Activities Integrated With Kentucky Mathematics Core Content

Name of Activity: Deal or No Deal (with locomotor or nonlocomotor activities)
Kentucky core content: MA-04-1.1.3 Students will compare (<, >, =) and order whole numbers, commonly used fractions and decimals, and explain the relationships (equivalence, order) between and among them.
Formation: Students are at desks with enough space to move around.
Equipment: None
Rules/Directions:

- Write math expression on board (this can be a basic problem up to inequalities or order of operations).
- If the problem is true, the students do a locomotor activity (e.g., hopping, jumping, walking). If it is false they do a nonlocomotor activity (e.g., bending, twisting, curling).
- If false, they must decide how to make the statement true. They must then tell a neighbor how to make it true and explain the correct answer.

Variations:

- Choose a student to create the problem to be put on the board. The student then becomes the teacher to decide if students are correct or not.
- Instead of writing the problem on the board, require the students to use mental math.

Name of Activity: Movin' Multiples
Kentucky core content: MA-04-1.3.2 Students will skip-count forward and backward by 2s, 3s, 4s, 5s, 10s, 20s, 25s, 50s, 100s, 1,000s, and 10,000s.
Formation: Students stand at their desks with enough room to move around
Equipment: None
Rules/Directions:

- Students do jumping jacks, lunges, or squats to the multiples of a given number. For example, if the chosen number is 6, the students do the activity while naming the multiples of that number (6, 12, 18, 24, etc.).

Variations:

- Begin with multiples of 2 and simple numbers and go to 10. Increase to multiples' higher numbers and complete multiples to 12 or 15.

Name of Activity: Frac-Attack
Kentucky core content: MA-04-1.5.1 Students will identify and determine odd numbers, even numbers, multiples of a number and factors of a number, and will apply these numbers to solve real-world problems.
Formation: Students stand in back of room in a large group
Equipment: None
Rules/Directions:

- All students stand in back of room. The total number of students becomes the whole group. For example, if there are 24 students, 24 is the whole. This may need to be modified to accommodate the group.
- Choose a "fraction of" problem (¼ of 24) and announce it to the students.
- Students determine ¼ of 24. Nonverbally they decide how many (6) students will sit. These 6 students go to their seats until the next problem is presented.
- Teacher chooses one student to explain the problem and the method in which the problem was solved.

Variations:

- Work in small groups to create smaller groups.

integration portion of the study. All lessons included a component of physical activity that was specifically integrated into the math core content (see Table 2). In addition to the creation of integrative physical activities during the in-service, teachers were educated on the use of pedometers and accelerometers as well as proper procedures for student wear.

Intervention Design and Data Collection

Changes in step counts during math class and for the entire school day were examined using a multiple baseline design. Physical activity was monitored throughout 5 school days and during five math classes within those school days prior to integration of physical

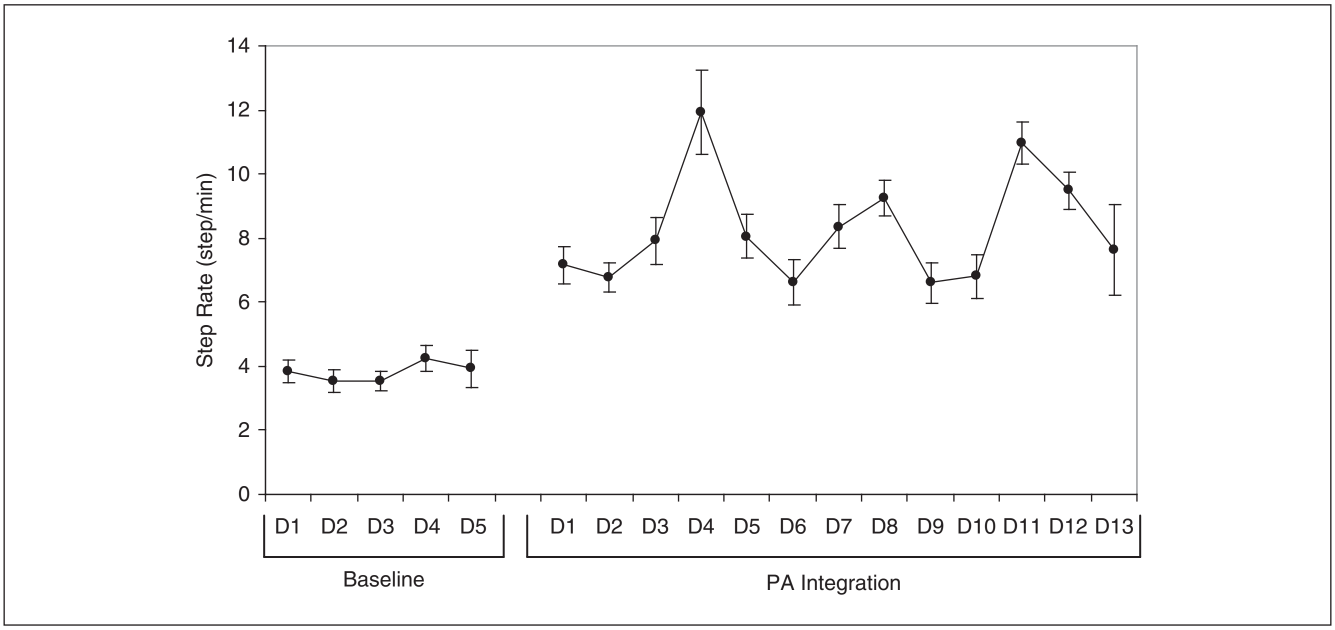

FIGURE 1 Mean ± Standard Error Step Rate During Baseline and Physical Activity (PA) Integration Math Classes

Note: D = Day.

activity to serve as baseline measures of physical activity. The 5 baseline days were collected over a span of 2 weeks because of school scheduling conflicts. Math lessons were scheduled for an average of 60 min per day in fourth grade and for 90 min per day in fifth grade.

During the weeks immediately following baseline data collection, physical activity integration took place for a total of 13 days. On each day of the intervention, teachers reviewed math concepts with learning experiences that integrated physical activity and the math content. Each physical activity (such as those found on Table 2) lasted approximately 10 min and was implemented during the math instruction time. The learning experiences were selected from those created during the in-service. Because teachers were addressing different math content, they did not necessarily use the same activities on the same days as other teachers throughout the intervention.

Data Analysis

Math class and school day pedometer step counts for each participant were averaged over the baseline and intervention periods and used in subsequent analyses. Paired samples *t* tests were used to compare pedometer outcomes (e.g., math class step counts, math step min^{-1}, and school day step counts) and accelerometer output from baseline to the intervention. The level of significance was set at $p < .05$ for comparisons of pedometer output, whereas a Bonferroni adjustment was used to account for the inflation of Type I error and set the level of significance at $p < .007$ (.05 of 7 comparisons of accelerometer output: total activity counts, activity counts min^{-1}, MET min^{-1}, gross energy expenditure, activity energy expenditure, light activity time, and moderate- to vigorous-intensity activity time) for accelerometer output.

RESULTS

Participants accumulated significantly more steps during physical activity integration math classes (M = 692.93, SD = 321.10 steps) compared with baseline math classes (M = 297.16, SD = 181.08 steps), $t(71) = 14.78$, $p < .001$. On average, math classes were longer in duration during the physical activity integration period (M = 90.69, SD = 18.95 min) compared with the baseline period (M = 77.74, SD = 10.88 min; $p = .015$). To account for the discrepancy in math class duration, math class pedometer step counts were analyzed relative to math class duration (i.e., step min^{-1}). Participants averaged significantly more steps per minute during physical activity integration math classes (M = 8.27, SD = 3.05 step min^{-1}) compared with baseline math classes (M = 3.61, SD = 1.87 step min^{-1}), $t(71) = 14.01$, $p < .001$ (Figure 1). Participants accumulated more school day

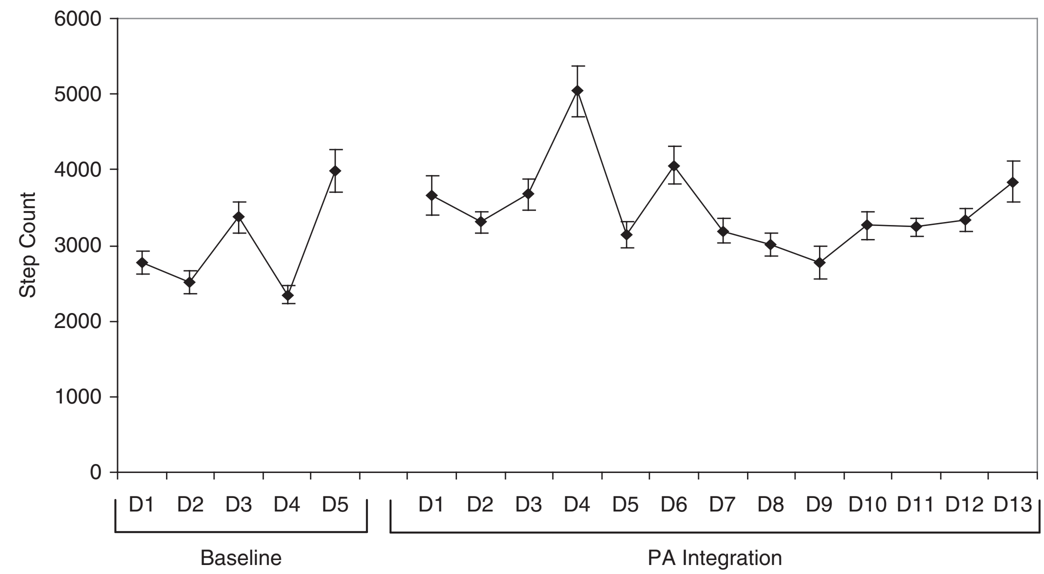

FIGURE 2 Mean ± Standard Error Step Counts for Baseline and Physical Activity (PA) Integration School Days

Note: D = Day.

step counts during physical activity integration school days (M = 3396.52, SD = 725.38 steps) compared with baseline school days (M = 2835.71, SD = 1261.93 steps), $t(71) = 4.55$, $p < .001$ (Figure 2). Non–math class school day step counts were similar between baseline (M = 2616.09, SD = 977.02 steps) and physical activity integration periods (M = 2568.40, SD = 623.31 steps), $t(61) = 0.47$, $p = .64$.

For the subsample of participants wearing accelerometers, physical activity integration during math class resulted in greater total activity counts, $t(6) = 4.93$, $p < .01$; activity count min^{-1}, $t(6) = 5.23$, $p < .01$; MET min^{-1}, $t(6) = 5.18$, $p < .01$; the rate of gross, $t(6) = 5.35$, $p < .01$, and activity energy expenditure, $t(6) = 5.86$, $p < .01$; and time spent in light activity, $t(6) = 4.79$, $p < .01$. There was no statistical difference in time spent in moderate- to vigorous-intensity physical activity, $t(6) = 3.93$, $p = .01$.

DISCUSSION

This study demonstrated that using classroom teachers to integrate physical activity in the classroom significantly improved students' physical activity levels during math class and throughout the entire school day. These findings are supported by other investigations that reported that classroom-based physical activity increased students' school day physical activity (Mahar et al., 2006) and entire day physical activity (Oliver et al., 2006). Specifically, the present study demonstrated that physical activity integration produced higher levels of physical activity during math class compared to baseline on all pedometer and most accelerometer output measures. Furthermore, non–math class school day step counts were similar between the baseline and the intervention. This suggests that the additional school day step counts (approximately 500 steps) that were taken during the intervention were largely due to the additional steps taken during the physical activity integration math classes. These additional steps account for approximately 5% of the daily recommendation for children (11,000 for girls and 13,000 for boys; President's Council on Physical Fitness and Sports, 2003). Thus, integrating physical activity with core content appears to help students meet the physical activity recommendations.

Given that the mean duration of math classes was longer during the intervention compared to baseline, one may expect that the daily math class step counts and total accelerometer-derived activity counts would be greater during the intervention because of a longer math class. However, when this output was compared relative to math class time, the intervention still yielded a higher *rate* of activity as assessed by pedometry and accelerometry. The higher mean activity level (expressed as MET min^{-1}) and greater rates of activity and gross energy expenditure during the longer intervention math classes also support this contention. Finally, the intervention resulted in more time spent in light activity. One may again speculate whether this was the result of the longer intervention math class time. However, a comparison of time spent in light activity relative to the total math class time for baseline and intervention classes illustrates that these seven participants spent, on average, only 3.8% of baseline math classes in light activity compared with 5.5% of the longer intervention math classes.

Stewart and colleagues (2004) conducted a similar study and reported promising findings among elementary students using the TAKE 10! physical activity program. Although this investigation also assessed physical activity levels using pedometry and accelerometry, it is difficult to compare their findings because the present study evaluated physical activity output during the entire length of math class (both sedentary and physically active portions), whereas Stewart et al. (2004) evaluated physical activity during the 10-min period of time when the TAKE 10! program was used. Thus the accelerometer-based intensity levels appear substantially lower in the present study. Furthermore, Stewart et al. (2004) descriptively assessed physical activity during the TAKE 10! program but did not use a control group or baseline condition, so comparisons between the relative improvements in physical activity cannot be made between these investigations.

Future investigations on the utility of classroom-based physical activity programs should use a control group to serve as a comparison for physical activity levels. In addition, it would be useful to study the impact of classroom physical activity on youth at high risk for chronic disease, such as those who are overweight or obese or come from low-income families.

CONCLUSIONS

Although this study did not use a true experimental design inclusive of a control group, the use of a multiple baseline design demonstrated stability of the behavior across the 5 days of preintervention monitoring, with a clear increase in physical activity volume and intensity during the intervention (see Figures 1 and 2). These preliminary findings demonstrate the potential for using teachers as facilitators of physical activity in the classroom. However, future educators and researchers may consider the following suggestions to further improve the effectiveness of physical activity integration in the classroom. The specific activities selected by the teachers (e.g., fraction relay races to the chalkboard) may not have incorporated *maximum* physical activity participation by all students, which may have left some students without optimal improvements in physical activity levels during the intervention. To improve teacher and student compliance for future interventions, we suggest having the teachers and students complete daily physical activity integration logs. The teachers could log information regarding the type and duration of the activity. The students could track their step counts and indicate whether they enjoyed the activities. The educators or researchers could then compile and distribute a list of the most effective and enjoyable physical activity integration activities to teachers for use in future lessons.

Along with the positive effect of the intervention on students' physical activity, the teachers indicated that integrating physical activity with core content for 10 min per day was a practical and realistic option in the classroom. Prior to participation, the teachers were asked to describe the major facilitators and barriers to integrating physical activity in the classroom. They were also asked what benefits they thought students would receive from the additional physical activity. Despite the fact that lack of time, pressures of academic test scores, and small space were described as barriers, the teachers felt that the benefits of physical activity (e.g., student attentiveness, concentration) outweighed the constraints. All four teacher participants demonstrated very favorable attitudes toward including movement with their core content, thus indicating feasibility.

Sustainability of physical activity integration in the classroom as a means of supporting children's health is definitely feasible. Several procedures have been put into practice since the conclusion of this study. First of all, the elementary teachers who participated in this study continue to implement movement with core content throughout the curriculum. Also, teachers from other schools within the same district have begun to incorporate physical activity during their academic instruction time. The researchers continue to facilitate or offer in-services for these teachers to provide assistance with their planning and implementation.

In addition to practicing teachers using these techniques in their classrooms, the movement of integrating physical activity is now being introduced to future elementary teachers in the community. As is commonplace in many College of Education curricula, all elementary teacher candidates at the university in which the study took place are required to take a course regarding physical education for the classroom teacher. The preservice teachers who take this course are responsible for creating physical activity integration lessons to be implemented during field experiences in elementary classrooms throughout the county school district. This experience provides continual ideas for in-service teachers and valuable preparation for future teachers. The hopes are that these future teachers will understand the importance of physical activity for children's health and, consequently, continue to integrate physical activity in their classes when they have teaching jobs of their own.

In conclusion, integrating physical activity with core content is a viable option for classroom teachers to use to increase the amount of physical activity performed at school. As a result, students may increase their overall physical activity levels. Elementary teachers and teacher educators should be encouraged to use classroom-based physical activity with their students because it provides a practical means to improving children's physical activity levels, thus promoting healthy lifestyles.

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