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The Impact of Classroom Physical Activity Breaks on Middle School Students' Health-Related Fitness: An Xbox One Kinetic Delivered 4-Week Randomized Controlled Trial

Yli-Piipari, S.[1], Layne, T.[2], *McCollins, T.[2], Knox, T.[3]

[1] Department of Kinesiology, University of Georgia, USA
[2] School of Health Studies, University of Memphis, USA
[3] FitNexx, Memphis, USA
*Represents Graduate Student at the time of the study

Abstract

The aim of the study was to examine the effect of a 4-week classroom physical activity break intervention on middle school students' health-related physical fitness. The study was a randomized controlled trial with students assigned to the experiment and control conditions. A convenience sample comprised 94 adolescents (experiment group n = 52; control group n = 42) (48 females, 46 males, age range 11 to 15 years) from four classes in one school in the mid-south United States. Intervention was delivered with an Xbox One Kinetic system to minimize teachers-dependence when delivering the intervention. In addition, to acknowledge students' poor treatment adherence, which can occur in school-based intervention studies, analyses were conducted to both the intention-to-treat group and the students' who reached the 66.7% attendance rate benchmark. Analysis of covariance test results showed that for the intention-to-treat group there were no significant intervention effects on cardiovascular endurance ($F[2,82] = 2.58$, $p = .112$), upper body strength and endurance ($F[2,84] = 3.55$, $p = .063$), abdominal strength and endurance ($F[2,82] = .01$, $p = .973$), or flexibility ($F[2,71] = .48$, $p < .489$) tests. In addition, the analyses comparing the high attendance group to the control group showed that intervention had a moderate significant effect on students' cardiovascular endurance ($F[2,52] = 23.95$, $p < .001$, $\eta^2 = .30$) and a small effect on abdominal strength and endurance (F[2,52] = 3.24, $p = .049$, $\eta^2 = .08$). The results of this study highlighted the importance of school students' adherence to program to achieve intended and planned intervention benefits.

Keywords: *cardiovascular endurance, muscular strength, muscular endurance, flexibility, physical education*

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Correspondence should be addressed to Dr. Sami Yli-Piipari; 349 Ramsey Building, 330 River Rd. Athens, GA, 30602. E-mail: syp@uga.edu

Introduction

It has been shown that physical inactivity is the fourth highest risk factor for global mortality (The World Health Organization, 2014). Despite the well-documented benefits of regular physical activity (PA) such as improved fitness (Haskell, Montoye, & Orenstein, 1985; Strong et al., 2005; Warburton et al., 2006), PA participation has declined across the life span in the United States (Brownson, Boehmer, & Luke, 2005; Cotter & Lachman, 2010) with the steepest declines during adolescence years (Currie et al., 2008). In addition, the most recent National Youth Fitness Survey from 2012 showed that only 42.2% of youth aged 12–15 years in the United States (US) have adequate levels of cardiorespiratory fitness (Gahche et al., 2014).

School has been suggested to be an ideal institutional setting for health promotion, because public education is a cost-effective forum to reach 94%-98% of the student population enrolled in traditional school education (United States Department of Education, National Center for Education Statistics, 2012). In addition, through public education it is possible to provide students with PA opportunities that contribute toward the recommended 60 minutes of daily moderate-to-vigorous intensity PA (MVPA) with at least three muscle- and bone-strengthening PA sessions weekly (United States Department of Health, 2008). Research has shown that the school day can contribute toward meeting the national PA guideline of at least 60-minutes of daily MVPA (United States Department of Health, 2008), and the most effective ways to increase school students' daily PA are quality physical education (PE), recess, and PA breaks (Bassett et al., 2013). In addition, regular school PE and recess along with PE and school-sponsored sports have shown to contribute positively to the components of health-related fitness, i.e., body mass index (BMI) (Fernandes & Strum, 2011) and cardiovascular fitness (Beets & Pitetti, 2005), respectively.

Physical fitness is a set of people's characteristics that correlates to their ability of PA performance, and it comprises health-related physical fitness and skill-related physical fitness (Caspersen, Powell, & Christenson, 1985). Health-related physical fitness involves exercise activities that you do in order to try to improve your physical health and stay healthy, particularly in the categories of cardiovascular endurance, muscular strength and endurance, flexibility, and body composition. Skill-related physical fitness, on the other hand, is a set of physical skills that are necessary to accomplish or enhance a skill or task, and it consists of six components: agility, balance, coordination, speed, power, and reaction time (Caspersen et al., 1985). Due to a strong correlation with components of health-related physical fitness (i.e., cardiovascular endurance) and metabolic risk factors, population-wide health promotion efforts have focused on improving children's health-related physical fitness (Hurtig-Wennlöf, Ruiza, Harrod, & Sjöströma, 2007; Rizzo et al., 2007).

Several classroom activity programs, such as Take 10! (grade specific activities linked to core curriculum), Physical Activity Across the Curriculum (PAAC) (90 minutes per week of PA integrated to academic lessons), Instant Recess® (10-minutes of movement based activities), Energizers (students stand and move during 10-minute intervals), Happy 10 (teacher led PA for 10-minutes), and Activity Bursts in the Classroom for Fitness (ABC for Fitness) (structured PA time during typical classroom management time), have been designed and implemented to increase school day PA, improve students' on-task behavior and classroom management, and health-related outcomes (Ward, 2011). The Active Living Research (2013) team conducted a comprehensive review of the effectiveness of classroom PA breaks on a variety of student outcomes, demonstrating a positive effect on students' PA (e.g., Bartholomew & Jowers, 2011; Beighle, Erwin, Beets, Morgan, & LeMasurier, 2010; Erwin, Beighle, Morgan, & Noland, 2011; Goh et al., 2014; Holt, Bartee, & Heelan, 2013; Mantis, Vazou, Saint-Maurice, & Welk, 2014; Whitt-Glover, Ham, & Yancey, 2011; Woods, 2011) and sedentary time (Gortmaker et al., 1999; Robinson, 1999; Salmon et al., 2005; Salmon, 2010) as well as mixed effects on some measures of health (Donnelly et al., 2009; Katz et al., 2010; Liu et al., 2008).

Although the positive effects of classroom breaks on PA behavior are well-established, one of the key questions is whether increases in PA, received from coordinated classroom PA bouts, are enough to improve fitness of school students. So far limited evidence suggests that classroom-based PA may be beneficial for student fitness levels (Active Living Research, 2013). A cluster randomized study by Donnelly and colleagues (2009; 2011) investigated the effectiveness of the PAAC program (DuBose et al., 2008), a three-year program designed to implement activity bursts spread throughout school day, implemented among 26 elementary schools in Northeast Kansas. Although there were no significant differences for change in BMI or BMI percentile (baseline to year three) for the PAAC, the change in BMI from baseline to three years was significantly influenced by exposure to PAAC. Schools implementing PAAC 75 or more minutes in a week, had a smaller increase in BMI compared to the schools with less than 75 minutes of PAAC per week (Donnelly et al., 2009; Donnelly & Lambourne, 2011). In addition, a study by Katz et al. (2010) investigated the effectiveness of the ABC for Fitness program, a one-year program (intervention group with classroom teacher initiated classroom breaks; control group with normal curricular activities) designed to implement activity bursts spread throughout the school day (warm-up, a core strength or aerobic activity, and a cool-down), implemented among 1,216 among 2nd through 4th graders in Missouri. The results of this study showed greater improvements in the intervention group's abdominal strength, upper-body strength, and trunk extensor compared to control group and an inverse development in right-side flexibility (no changes in cardiovascular endurance).

Although the few available studies examining the effectiveness of classroom PA breaks support the utility of classroom PA breaks as a potential tool to improve school students' fitness levels, the previous review (Webster, Russ, Vazou, Goh, & Erwin, 2015) together with research evidence (Donnelly et al., 2009; Donnelly & Lambourne, 2011) have shown that student-related results are heavily dependent on classroom teachers' willingness and ability to integrate PA breaks during their regular school days. The available evidence identifies several teacher characteristics, such as satisfaction with personal K-12 physical education experiences, lack of skills and education, which may impact teachers' willingness to adhere to the classroom PA break plan. In our efforts to control the teachers' role in the process, this study used an Xbox One Kinetic system as a delivery method to minimize teacher dependence when implementing PA breaks. Thus, the aim of this study was to implement and test the effectiveness of a 4-week classroom PA program on middle school students' cardiorespiratory endurance, upper-body muscle endurance, abdomen strength, and flexibility.

Method

Participants

A sample consisted of 94 adolescents (experiment group n = 52; control group n = 42) (48 females, 46 males, age range 11 to 15 years; 98% African American, 1% White, 1% Hispanic, and 0% American Indian; student to teacher ratio 22:1; 90% of the students on free or reduced lunch) from four 8th grade classes in one school. All four classes were single-sex classes. A cluster sampling strategy was applied assigning randomly one female and one male class to the experimental condition and one female and one male class the control condition. Students' typical school week was 35 hours, and they did not have recess. Students received physical education once a week for 55 minutes. There was a small area of outdoor space, but no indoor space, available for physical education. In addition, there was no designated space for outdoor recess available at the school. The study was approved by the institutional review board of the local university as well as by the local school district. Student assents and parental consents were obtained prior to the study, and all approached students returned and signed both informed assent and parental consent. The intervention took place during four consecutive weeks in October 2014 and November 2014. Pretests were conducted the week prior to the beginning of the intervention (Week 0), and post-test were conducted immediately after the intervention (Week 5).

Intervention

Students were randomly divided into experimental and control conditions selecting two classes each. The intervention was a 4-week / 15 minutes / every school day classroom PA program delivered by the teacher, with the presence of the member of the research team, using the Xbox One Kinetic system during students' homeroom time between 7:30AM and 7:45AM. The research team -designed fitness program consisted of five exercise programs ([1] BeachBody Insanity Pure Cardio, [2] Jillian Michaels KickBox Fast Fix, [3] Jillian Michaels Shed & Shred, and [4] Beach Body Insanity Plyometric Cardio Circuit) conducted in following order: Week 1 – programs 1,2,3,4,1; Week 2 – programs 2,3,4,1,2; Week 3 – programs 3,4,1,2,3; and Week 4 – programs 4,1,2,3,4. All of these programs are commercially available. The 15min programs started off with warm ups, followed by cardiovascular endurance, strength training, and flexibility exercises. The experimental condition group participated in the program every school day, whereas the control condition group did homework or studied.

Outcome Measures

The FitnessGram test battery (Plowman & Meredith 2013) was used to assess participants' health-related fitness. Specifically, PACER test for cardiovascular endurance, push-up for upper body muscle endurance, curl-up for abdomen strength, and sit and reach for flexibility. The research team of a co-investigator (second author) and three graduate assistants conducted the data collection.

Cardiovascular endurance. Every participant completed a 20-meter Pacer test to tap participants' cardiovascular endurance. The Pacer test was taken in groups of eight to 10 with at least three research assistants supervising each group, and the Pacer tests were completed outdoors. Participants were given instructions and provided an opportunity to practice the test. The FitnessGram CD was used to notify participants of when they should run. The final lap number was recorded when the participant failed to make the line a second time (a warning was given for the first time) or a student stopped running.

Upper body strength and endurance. To measure upper body strength and endurance, participants were paired with a partner to perform the push-up test. While one participant was completing the test, the partner counted and monitored possible form errors. Participants were instructed to keep their back in a straight line from head to toes throughout the test. The FitnessGram CD would instruct participants to lower their body until their elbows bent at a 90° angle and the upper arms were parallel to the floor. Students were instructed to stop after the second form error occurred.

Abdominal strength and endurance. Participants were paired with a partner to perform the curl-up test for abdominal strength and endurance. While one would test, the other partner would record the score. The FitnessGram CD would instruct participants to curl up and reach with their fingertips to the other side of the measuring strip and curled back down with his/her head touching the mat. One research assistant supervised three to four pairs each time. The research assistant would watch for form breaks or students who were out of sequence with the cadence. Students were instructed to stop after the second error was made.

Flexibility. A standardized sit-and-reach box was used to assess hamstring flexibility. With shoes removed and one leg fully extended with the foot flat against the face of the box, participants were required to put one hand on top of the other and reach both hands forward along the scale four times and hold the position of the maximum reach for one second. The same procedure was repeated with the other leg. This helps keep the pressure off of the lower back.

Treatment Adherence Measures

Student Attendance. Students' participation in the classroom break sessions was recorded by classroom teachers. Our benchmark measure for acceptable participation was 13 sessions, that is at least 3 times per week of muscle-strengthening PA, and it was based on the Physical Activity Guidelines for Americans (United Sates Department of Health and Human Services, 2008).

Student PA intensity. PA intensity during classroom breaks and school day was measured using the ActiGraph GT3X+ accelerometers worn by 10 randomly selected students. ActiGraph sensors have been widely studied and shown adequate reproducibility, validity and feasibility in children and adolescents (deVries, Bakker, Hopman-Rock, Hirasing, & van

Mechelen, 2006). We were expecting to see statistically significant differences in favor of the intervention sub-group over the control sub-group.

Procedures

Outcome measurements were conducted one week prior to and one week after the intervention program. If students were absent during an assessment day, the researcher went back to the school to do the measurements. Ten participants had some missing values which were due to reported injuries. Our preliminary analyses (reported in the results section) indicated that values were missing at random, and thus all 94 participants were included in the analyses.

Accelerometers were distributed daily face-to-face at schools, and they were attached to the participants' right waist. The monitoring period was twenty consecutive school days during school-hours (from 7:30AM to 2:30PM). Non-wearing time was calculated as periods of more than 30 minutes of consecutive zero counts. At least 80% of wearing time in school was required (Warren et al., 2010). Based on the recommendation of Trost, Loprinzi, Moore, and Pfeiffer (2011), the cut-points were used for estimation of time spent in different activity intensity (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008) (100 counts per minute (cpm) for sedentary, 2,296 cpm for MPA and 4012 cpm for VPA). 20,000 cpm upper limit was set to avoid spurious data (Heil, Brage, & Rothney, 2012).

Statistical Analysis

Normality checks (skewness and kurtosis) and descriptive statistics (means, standard deviations, & Pearson's correlations coefficients) were tabulated. Next, to test the intervention effect in regards of pre- and posttests, we conducted analyses of covariance separately for each research variable. In these analyses, the post-intervention score was set as a dependent variable, the baseline score as a covariate, and the intervention conditions as an independent variable. All analyses were performed using SPSS (version 23.0). Alpha was set at $p < .05$ for all tests. Standardized mean changes (i.e., Cohen, 1988) were calculated, with values of 0.2 (small), 0.5 (moderate), and 0.8 (large) used as guidelines for interpreting analyses of covariance effect sizes.

Results

Descriptive statistics are presented in Table 1. Data were normal skewness and kurtosis values ranging within -2 and +2, which can be considered as normal distribution limits (Gravetter & Wallnau, 2014). At the baseline, Pearson's correlation coefficients supported convergent validity between theorized constructs. Self-report PA and physical fitness measures other than flexibility were positively associated with each other, *r* values ranging from .20 to .40. The preliminary results showed experimental and control group values to be similar, except in upper body strength and endurance (t (89) = 2.55, p = .012) and abdominal strength and endurance (t (89) = 3.74, p < .001) in which the control group had higher baseline values. Bonferroni-corrected *t* tests showed that there were no differences between students who responded to both pre- and posttests and the ones with missing values (all paired *t* values < 1.09). This finding corroborates the assumption that missing values were at random.

Table 1. *Summary of Intercorrelations, Means, Standard Deviations, and Cronbach's Alpha Coefficients for all Variables*

Variable list	1	2	3	4	5	6	7	8	9	*M*	*SD*
1 Treatment condition	-									-	-
2 Pacer (T1)	-.09	-								16.54	11.14
3 Pacer (T2)	-.11	.91**	-							17.41	12.70
4 Push-ups (T1)	.26*	.30**	.27*	-						21.28[a]	15.00
5 Push-ups (T2)	.13	.19*	.18*	.86**	-					21.59	16.22
6 Curl-ups (T1)	.38**	.34*	.30*	.25*	.13	-				37.28[a]	24.09
7 Curl-ups (T2)	.15	.43**	.50**	.20*	.13	.55**	-			34.12	22.41
8 Sit and reach (T1)	.14	-.03	-.04	.10	.16	.18	.10	-		11.39	2.28
9 Sit and reach (T2)	.23*	.04	.01	.31**	.30**	.13	.02	.77**	-	11.64	2.77
M	-	18.76	15.08	13.90	17.18	21.00	21.68	10.64	10.49		
SD	-	12.54	10.47	11.81	12.53	14.36	11.47	3.07	2.76		
***M* (compliance)**	-	16.70	20.47	13.13	18.33	20.46	28.29	10.50	10.47		
***SD* (compliance)**	-	10.37	13.49	12.94	10.73	12.52	18.84	2.97	2.73		

*Note 1. P * < .05 and ** < .001. T1 = pretest and T2 = posttest. [a] control group pretest values higher compared to the pretest values of the experimental group.*

Note 2. Control group means and standard deviations are presented in the vertical columns and experiment group means and standard deviations in the horizontal columns.

On average, students participated in the PA breaks 13.42 (ranging from 9 to 15mins, standard deviation [SD] 3.04) times during a 4 week intervention (theoretical range from 0 to 15). An evaluation of the attendance record showed that 19 students (9 males and 10 females) (37% of the intention-to-treat students) met the 13 session benchmark for minimum participation. Students' exercise intensity per every 15-minute session in five different programs is presented in Table 2, and school day PA is presented in Table 3. On average, female students' intensity levels were across programs 5.21 mins (1.90), 9.03 mins (2.50), .62 mins (.61), 1.08 mins (.57), sedentary, light intensity PA, moderate intensity PA, vigorous intensity PA minutes, respectively (standard deviation presented in the parentheses). On the other hand, male students' intensity levels were 3.00 mins (.90), 6.90 mins (1.79), 2.80 mins (.61), and 2.81 mins (1.34).

Analysis of covariance test results showed that there were no significant intervention effect on cardiovascular endurance ($F[2,82] = 2.58$, $p = .112$), upper body strength and endurance ($F[2,84] = 3.55$, $p = .063$), abdominal strength and endurance ($F[2,82] = .01$, $p < .973$), or flexibility ($F[2,71] = .48$, $p < .489$) tests between the intention-to-treat and control groups. The analysis for the high adherence group, reaching the 13 session benchmark, showed that intervention had a significant effect on students' cardiovascular endurance ($F[2,52] = 23.95$, $p < .001$, $\eta^2 = .30$) and abdominal strength and endurance (F[2,52] = 3.24, $p = .049$, $\eta^2 = .08$).

Table 2. *Intensity of the Classroom Physical Activity Breaks*

Activity Program	BeachBody Insanity Pure Cardio	Jillian Michaels KickBox Fast Fix	Jillian Michaels Shed & Shred	Mossa Core Workout	Beach Body Insanity Plyometric Cardio Circuit
Sedentary Activity	Female: 6.60(1.76) Male: 1.92(.72)	Female: 3.11(5.05) Male: 2.08(.16)	Female: 5.22(1.25) Male: 4.75(2.47)	Female: 6.97(5.00) Male: 3.91(.11)	Female: 4.16(3.44) Male: 2.25(1.06)
Light Intensity	Female: 8.00(.50) Male: 6.27(1.12)	Female: 9.73(3.08) Male: 6.09(2.71)	Female: 8.32(4.02) Male: 8.58(1.29)	Female: 6.32(4.18) Male: 7.18(2.99)	Female: 8.60(.71) Male: 6.25(.83)
Moderate Intensity	Female: .34(.44) Male: 3.08(.35)	Female: .16(1.66) Male: 3.08(.35)	Female: .92(.55) Male: 1.50(.23)	Female: .50(.72) Male: 3.33(1.88)	Female: 1.17(1.17) Male: 2.83(.23)
Vigorous Intensity	Female: .06(.86) Male: 3.75(2.24)	Female: 2.00(.88) Male: 3.75(2.24)	Female: .54(.75) Male: 2.33(.94)	Female: 1.20(.19) Male: .58(.58)	Female: 1.08(.15) Male: 3.66(.70)

Note. Values presented minutes per a 15-minute activity session.

Table 3. *Comparison of the School-Day Physical Activity between Experimental and Control Groups*

	Experiment Group (*n* = 10)	**Control Group (*n* = 10)**
Sedentary min/h	49.18(4.41)	48.65(4.66)
LPA min/h	9.30(2.26)	10.48(3.43)
MPA min/h	.88(.45)	.67(.50)
VPA min/h	.61(.62)	.21(.17)
MVPA min/h	1.48(1.00)	.87(.66)
MVPA min/day	11.87(8.00)	6.98(5.29)

Note 1. These values are average values between the experiment and control groups.
Note 2. MPA = moderate physical activity, VPA = vigorous physical activity, MVPA = moderate-to-vigorous physical activity. Standard deviations of the arithmetic means are presented in the parentheses.

Discussion

To address the limited evidence on the effectiveness of classroom PA breaks on school students' health-related fitness, this study aimed to examine the effect of the 4-week classroom PA break intervention on middle school students' cardiorespiratory endurance, upper-body muscle endurance, abdomen strength, and flexibility. The results showed a weak support to the notion that increased PA during school day will improve students' health-related fitness levels. In addition, this study highlighted the importance of school students' adherence to program to achieve intended and planned intervention benefits.

The results of this study showed that the 4-week daily 15-minute school classroom PA intervention did not have hypothesized positive intervention effect on middle school students' cardiorespiratory endurance, upper-body muscle endurance, abdomen strength, and flexibility between experimental and control schools. The findings of this study are in accordance with the study by Donelly and Lambourne (2011) that showed no statistical significance on students' anthropometrics or selected health markers, such as blood pressure, blood lipids, glucose, or insulin. However, the results of our study contradicts with the findings of Katz et al. (2010) that showed a positive effect on student participants' abdominal strength, upper-body strength, and trunk extensor. Katz et al.'s study was a one year study in which teachers were asked to implement activity breaks during classroom "downtime", and teachers were able to make choices on the length and the daily number of activity bursts. Therefore, the results of their study and the current 4 week study are not fully comparable.

Acknowledging the importance of the teacher compliance on intervention effect (Webster et al., 2015), this study delivered the intervention using an Xbox One Kinetic system to minimize teacher dependence on the research. In addition, experimental group students' adherence to the program was carefully monitored by recording student attendance and measuring participants' exercise intensity. These adherence measures showed that the positive effect of the intervention were dependent on the student attendance. The results of the study showed that intervention had a significant effect on students' cardiovascular endurance and abdominal strength and endurance among the high adherence group, experiment group students' who participated in 2 out of 3 exercise sessions. This finding shows that classroom environment is a sensitive context and the compulsory nature of formal education places restriction upon students and teachers alike (Cothran, Kulinna, & Garn, 2010; Vazou & Skrade, 2014; Webster et al., 2015). Previous research has showed that teacher constraints related to scheduling and academic testing are among the most common ones (Cothran et al., 2010).

This study showed that student adherence to the program is an important factor on the intervention success. It is often assumed that school students will be motivated to participate in the classroom PA breaks, but we could not find any scientific studies investigating this assumption. This assumption is more likely to be true, when the breaks are to replace instructional time, which traditionally sedentary students are sitting in their pulpits and studying. In our study, PA breaks replaced homeroom "free time", however, with showing that, on average, students participate in the PA breaks less than 14 times out of 20 potential chances with less than 37% achieving the 13 contact session benchmark for a minimum participation. It may be that low adherence was due in part to this replacement of free time. In addition, this study was implemented among middle school students. One may argue that elementary school students may be more motivated toward classroom PA breaks compared to middle school students. The role of motivation in the student adherence needs to be addressed in future studies. Not only the frequency of PA breaks but length and intensity are important determinants impacting the positive health-related outcomes (Webster et al., 2015). Due to a lack of studies examining the role of classroom PA breaks on children and adolescent fitness, there are neither consensus nor recommendations about the modality, frequency, or intensity of PA breaks needed to achieve intended health benefits (Webster et al., 2015). In a way this is understandable, considering the urgent need to reduce children and adolescent sedentary time and increase PA as a pathway to improved health-related fitness.

This study was not free of limitations. Firstly, we utilized a quasi-experimental design and, therefore, the findings of the study may not be replicable across the United States. Secondly, the study population was predominantly African American and had a high proportion of low-income students. The sample size was small. Only one school was used for the study, which made it difficult to develop a large enough power to assess outcome measures. Finally, the length of the study was 4 weeks and no follow-up data were available.

This study demonstrates the feasibility of media-delivered classroom PA breaks to improve cardiovascular endurance and abdominal strength and endurance of middle school aged students. These possible changes are possible, if students will buy in to the program. The program can easily be incorporated into almost any school routine. It is likely, however, that student participation adherence rate will be better if PA programs do not replace students' free time.

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