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The Influence of Classroom Physical Activity Participation and Time on Task on Academic Achievement

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Abstract

Objectives: Determine the impact of classroom-based physically active lessons on time-on-task. Secondarily, determine the relationship of time-on-task with academic achievement controlling for key demographic variables.

Methods: Seventeen elementary schools were cluster randomized to receive classroom physical activity (A+PAAC, N=9) or control (i.e., no physical activity, N=8) for a 3-year trial. Teachers were trained to deliver physically active lessons with moderate-to-vigorous intensity targeting 100 minutes per week. Outcome measures included academic achievement (Weschler Individual Achievement Test-III), administered at baseline and repeated each spring for 3 years, time spent in moderate-to-vigorous physical activity (MVPA), and time spent on task (TOT) pre- and post-physical activity. Multilevel modeling was utilized to estimate the impacts of percent time spent in MVPA and percent TOT post-lesson on academic achievement and the change in these impacts over 3 years, accounting for dependency among observations and covariates including age, gender, race, free or reduced lunch, BMI, and fitness.

Results: A greater percentage of time performing MVPA were each significantly associated with higher math scores ($p=.034$) and spelling scores ($p<.001$), but not reading scores. Academic achievement was not associated with TOT.

Conclusion: Findings suggest that a greater percentage of time spent participating in MVPA results in higher math scores and spelling scores, but not reading scores, independent of TOT. Future studies should continue to evaluate the influence of physically active classroom lessons on time spent on task and its impact on academic achievement. Furthermore, strategies are needed to maximize impact and to determine the sustainability of physical activity's effect on classroom behavior and academic achievement.

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Keywords

Children; Time-On-Task; Physical Activity; Academic Achievement

Introduction

Physical activity lessons within the classroom have been shown to be a viable means of aiding in the accumulation of the daily recommended 60 minutes of physical activity for children (1, 2). Physical Activity Across the Curriculum (PAAC) (3–5) and “brain break” type physical activity opportunities including Energizers (6, 7) and FUNtervals (8) have been shown to result in greater than 75 minutes of physical activity each week. In addition to increasing physical activity time, several cross-sectional reports have demonstrated that school-based physical activity sessions may have effects on a child’s attention to classroom instruction (i.e., attention-to-task) following the activity (2). Similarly, classroom physical activity may also influence academic performance, however, this has yet to be established (9).

Several examples of how classroom physical activity has been utilized within the classroom exist. For example, Energizers, 10-minute classroom-based physical activities, resulted in a mean percentage increase of on-task behavior by more than 8% from pre- to post-Energizer break (6, 7). Similarly, Ma et al. (8) found that off-task behavior decreased following FUNtervals consisting of 4-minute-high-intensity interval exercises, in both 2nd and 4th graders when compared to a no-activity break. Additionally, Ma et al. (8) found that FUNtervals resulted in fewer errors during the performance of the d2 Test of Attention in 3rd-5th-grade students when compared to rest. Greico et al. (10) found that time-on-task (TOT) following an inactive control lesson significantly decreased while time-on-task remained unchanged following the physical activity lesson. In similar fashion, Szabo-Reed et al. (5) assessed physical activity (i.e., moderate to vigorous physical activity, MVPA) and TOT pre and post active and non-active academic lessons in elementary aged students over the course of 3-years. Results showed that those students receiving the active lessons not only did more MVPA than those not receiving the lessons, but they also had improved TOT. Together these studies indicate that participation in short bouts of physical activity in the classroom can help to increase attention and TOT; however, the association between TOT with academic achievement has not been studied.

Several studies have explored the effect of classroom physical activity on cognitive outcomes including executive control, reaction time and attention. However, the results have mostly been inconclusive producing no immediate change in performance(9). Howie, Schatz, and Pate (11) did find that math scores were higher in 9 to 12-year-old children after 10 and 20-minute classroom physical activity breaks as compared to sedentary activity time. Acute studies, outside of the classroom, have previously examined the influence of confined bouts of physical activity on measures of immediate academic achievement and concentration to find positive results. For example, Caterino and Polak (12) found that concentration in fourth graders improved post-recess participation. Tine (13) found that 12-minute bouts of aerobic exercise improved selective attention in children, but did not affect

reading comprehension. Similarly, Hillman et al. (14) compared a physically active condition (i.e., brisk walking on a treadmill) to an inactive condition (i.e., sitting) in the laboratory and found significant benefits for performance in reading, but not math or spelling. Duncan and Johnson (15) compared a rest condition to cycling at both moderate and vigorous intensities and found that spelling and reading were significantly higher after moderate-intensity physical activity, while math scores were significantly lower. Overall, acute bouts of physical activity appear to influence performance on standardized academic achievement tests and concentration, however, due to the conflicting findings, and lack of evidence, additional research is needed to determine the effect of long-term classroom-based physical activity participation on TOT and academic outcomes. Long-term physical activity interventions in elementary aged students have also shown positive improvements in academic performance, however, have not explored the effect of MVPA on TOT and academic performance changes (16–19).

Therefore, the objectives of the present investigation were to extend the findings of Szabo-Reed et al. (5) utilizing data from the Academic Achievement and Physical Activity Across the Curriculum (A+PAAC, NCT01699295) study to determine the long-term effects of MVPA classroom physical activity breaks and TOT on academic achievement over the course of the 3 year intervention.

Methods

Participants

A detailed description of the rationale, design, and methods of A+PAAC (20), as well as primary outcomes (4), has been previously published. A+PAAC was a 3-year, adequately powered, cluster randomized controlled trial designed to evaluate the influence of classroom-based physical activity lessons on academic achievement. The trial incorporated 17 elementary schools in northeast Kansas from 4 school districts. Schools were stratified by school district (N=3) to receive A+PAAC (9 schools) or serve as controls (8 schools). A +PAAC provided academic lessons delivered by classroom teachers using MVPA (100 minutes/week, >3 METs) to increase total daily MVPA while maintaining academic instruction time. A+PAAC instruction time began when the students were in 2nd or 3rd grade and ended in 5th or 6th grade, respectively. The primary outcome was academic achievement measured by Weschler Individual Achievement Test-III, WIAT-III (21). Parents and students provided consent and assent, respectively, prior to initiation of A+PAAC. The investigation was approved by The University of Kansas Human Subjects Committee.

Intervention procedures

Teachers were asked to deliver two, 10-minute A+PAAC lessons per day, one lesson in the morning and one in the afternoon, 5 days per week, for a weekly total of school-based physical activity of ~100 min/week. A+PAAC lessons were also encouraged outside the classroom during alternative learning, such as field trips. A+PAAC lessons provided MVPA with physical activity intensity of 4–5 METs (22, 23) and used in a variety of academic disciplines including math, language arts, geography, history, spelling, science, and health.

Classroom teachers participating in the intervention schools were trained to deliver A+PAAC during two, 4-hour in-service sessions conducted at the school prior to implementation of the intervention and were compensated. Teachers were also provided a written guide and access to a study website which included a variety of sample A+PAAC lessons with each lesson's estimated MET values (See Videos for examples, SDC1.mp4, SDC1, Language arts example of A+PAAC, 55sec, 32.6MB, SDC2.mp4, SDC2, Reading comprehension example of A+PAAC delivery, 3min 23sec, 107MB, SDC3.mp4, SDC3, Mathematics example of A+PAAC delivery, 2min 16sec, 73.1MB). Teachers in the control schools were asked to continue using traditional classroom instruction and students in both the intervention and control schools continued with their typical physical education schedule (i.e., 2, 30-minute classes/week). Evaluation of external or competing factors was completed by each school's principal at the end of each year to ensure that no new physical activity or nutritional programs were adopted by the school that could pose a threat to the internal validity of the intervention. No programs were identified.

System for Observing Fitness Instruction Time (SOFIT)

which is a validated time-moment sampling technique (24), was used to assess intervention fidelity and the amount of A+PAAC lessons delivered. Classroom activities were coded on a 5-point Likert scale (1=lying down, 2=sitting, 3=standing, 4=walking, 5=jogging/running). MVPA was defined as the fourth or fifth activity code. Schools were selected at random for observation on a specific day each week. Within the school, the classroom to be observed was randomly selected. Finally, the specific students to be observed were randomly selected from those who provided consent/assent. Students were observed individually and activity was recorded in 20-second intervals. Approximately five students were observed consecutively, yielding ~6 observations per child over a 10-minute period. The total percentage of time spent participating in MVPA during each observation for each student observed was calculated (i.e., 10 minutes observed with 6 minutes spent in MVPA is 60% MVPA). The same procedure was also performed within the control schools. Inter-observer reliability for SOFIT across the 3-year period was 92%.

Time-on-task (TOT)

was assessed by trained research staff on the same random schedule for recording classroom activity using a modification of the procedures from Mahar et al. (6). During each assessment, ~5 students were individually observed between 5–20 minutes before and 5–20 minutes after the delivery of an academic lesson (i.e., A+PAAC or traditional). Observation time fluctuated due to varying class activities (i.e., students leaving classroom to go to art). Each child was observed individually for 10 seconds, after which the appropriate behavior code was recorded. This procedure was repeated over the 5-minute interval to result in a total of ~20 observations per child per session and subsequently, the appropriate behavior code was recorded. Coding included on-task, motor off-task, noise off-task, or passive/other off-task (25, 26). A score for percent TOT, percent motor of-task, etc. was computed for each individual student based on the number of minutes of observation pre- and post-lesson. Inter-observer reliability for TOT across the 3-year period was 92%.

Demographics.

Age, race/ethnicity, sex, free/reduced lunch etc. for both participants and their parent(s) were collected at baseline via questionnaire.

Anthropometrics (Height/weight/waist circumference).

Children were weighed in duplicate wearing school clothes without shoes during the first period of the school day on a calibrated scale to the nearest 0.1 kg (Model #PS6600, Befour, Saukville, WI). Standing height was measured with a portable stadiometer (Model #IP0955, Invicta Plastics Limited, Leicester, UK). BMI was calculated as weight (kg)/height (m^2) and BMI percentile was calculated using the CDC growth charts (27).

Cardiorespiratory Fitness.

The PACER test was administered at each school in small groups (8–12 students) with a 1:4 staff to children ratio. During testing, children were instructed to run back and forth between two lines, spaced 20 meters apart, as they were paced by a tone signaling the time at which students must reach the opposite side. The pace began slowly and became progressively faster until any child was unable to traverse the 20-meter distance on two consecutive trials, at which point the test ended for that child (28, 29). A higher level of fitness was denoted by a greater number of completed laps. There has been considerable work in adults and children utilizing the PACER and it has been shown to be a useful school-based test that not only provides an accurate and viable method for identifying childhood health risks but also greatly increases the feasibility of collecting aerobic fitness information in large samples of children(30–33).

Academic achievement

Academic achievement was assessed using the Weschsler Individual Achievement Test-Third Edition (WIAT-III; (21)). The WIAT-III was individually administered by research staff trained and supervised by a qualified co-investigator. Five WIAT-III subtests (reading comprehension, oral reading fluency, spelling, mathematics problem solving, and numerical operations) were administered over 40–50 minute sessions (34). The WIAT-III was scored by the examiner and all protocols were checked for accuracy by a trained investigator. Any discrepancy in scores between examiner and the research team member were evaluated and resolved by a co-investigator. All scores were entered into the WIAT-III computerized scoring assistant, which automatically disallows out-of-range values and computes subtest and composite scores.

Statistical analysis

Descriptive statistics and bivariate tests (i.e., *t*-test, chi-square test) were utilized to summarize baseline demographic and anthropometric characteristics of the sample. Table 1 provides a description of the number of students available and included in each analysis. Independent-samples *t*-test (with Satterthwaite approximation if necessary) was performed to compare percent time spent in MVPA and percent TOT behavior before and after academic lesson delivery (A+PAAC or traditional) between students in the control schools and those in the intervention schools.

Multilevel models were fitted separately for WIAT-III math, reading, and spelling scores of students from the control and intervention schools, accounting for dependency among observations — i.e., repeated measurements (level 1) of students (level 2) who were nested within schools (level 3). In fact, schools were disaggregated in the analysis because the clustering at the school level (level 3) was negligible (intraclass correlation=.01–.05) and the number of schools was small (N=17; i.e., low power for 3-level modeling). Each fitted 2-level model examined the change in the WIAT score over the study period, the impact of percent time spent in MVPA or percent TOT post-lesson, and their interaction. Models also included covariates including age, gender, race, free or reduced lunch, BMI, and fitness (laps). All analyses were conducted using SAS 9.4 (SAS Institute, 2002–2012).

Results

Sample characteristics

Table 2 contains baseline demographics and anthropometrics adapted from Szabo-Reed et al. (5). Participants were 7.57±0.58 years old at baseline and age did not significantly differ between the intervention and control schools. BMI, height, weight, and fitness at baseline also did not significantly differ between the two groups. Ethnicity (p=.002), race (p=.012), and free or reduced meals (p=.001) did significantly differ between the intervention and controls schools, with the control schools having more minorities and a greater percentage of students enrolled in free or reduced meal plans than the intervention schools.

As previously indicated in Szabo-Reed et al. (4), the participants who received A+PAAC lessons completed significantly more MVPA during the observed academic lessons than those in the control schools overall years of the intervention (p<.001). The intervention group performed MVPA 52.7%, 58.7%, and 60.1% of observed lesson time each year for 3 years, as compared to 1.6%, 3.6%, and 2.3% in the control group. Also, the greater time spent participating in MVPA was associated with a greater amount of TOT in the classroom (p<.01).

Influence of amount of MVPA on academic achievement

A series of 2-level models were fitted to examine the effect of percent time spent in MVPA on students' math, reading, and spelling scores (N=546 each). Results showed that math score significantly increased in a linear pattern during the 3-year period (p<.001, see Table 3). Greater time spent in MVPA was significantly associated with greater math achievement (p=.034); however, this effect became smaller in the later years (interaction p=.001) — Cohen's f^2=.01. Boys had significantly higher math scores than girls (p=.036) and students receiving free/reduced meals had significantly lower math scores than students who did not (p<.001). Finally, greater fitness was also significantly associated with higher math scores (p<.001). There was no significant effect of age, race, or BMI. The covariates together explained 16% of the variance in math score (Cohen's f^2=.16).

Similar to math, reading score also linearly increased throughout the 3-year period (p<.001, see Table 4), however, there was no significant effect of percent time spent in MVPA on reading achievement (Cohen's f^2=.002). Reading score was also significantly lower among

students who received free/reduced meals as compared to those who did not (p<.001). There was no significant effect of age, gender, race, BMI, or fitness on reading score. The covariates together explained 27% of the variance in math score (Cohen's f^2=.27).

Spelling score also increased in a linear pattern throughout the 3-year period (p<.001, see Table 5). More time spent in MVPA was significantly associated with higher spelling score (p<.001), and the benefit was maintained over the years (interaction p=.168) — Cohen's f^2=.02. Students receiving free/reduced meals had significantly lower spelling scores than those who did not receive free/reduced meals (p=.009), while those with higher fitness had significantly higher spelling scores (p=.045). There was no significant effect of age, gender, race, or BMI on spelling score. The covariates together explained 8% of the variance in spelling score (Cohen's f^2=.08).

Effect of time-on-task after PA on academic achievement

A second series of 2-level models were fitted to examine the effect of percent TOT post-lesson on academic achievement (N=539 for each score). Results showed that math score did not change significantly throughout the 3-year period (p=.191, see Table 6). There was no significant effect of percent TOT post-lesson on math achievement (Cohen's f^2=.001). Students receiving free/reduced meals had significantly lower math scores than students who did not receive free/reduced meals (p<.001). Finally, greater fitness was also significantly associated with higher math scores (p<.001). There was no significant effect of age, race, or BMI.

Reading score linearly increased throughout the 3-year period (p<.001, see Table 7), however, there was no significant effect of percent TOT post-lesson on reading achievement (Cohen's f^2=.01). Reading score was also significantly lower among students who received free/reduced meals as compared to those who did not (p<.001). There was no significant effect of age, gender, race, BMI, or fitness on reading score.

Spelling score did not change significantly during the 3-year period (p=.584, see Table 8). There was no significant effect of percent TOT post-lesson on spelling achievement (Cohen's f^2=.02). Students receiving free/reduced meals had significantly lower spelling scores than those who did not receive free/reduced meals (p=.007), while those with higher fitness had significantly higher spelling scores (p=.040). There was no significant effect of age, gender, race, or BMI on spelling score.

Discussion

This study expanded upon Szabo-Reed et al.'s (5) findings to suggest that a greater percentage of time spent participating in MVPA results in higher math scores and spelling scores, but not reading scores, independent of TOT. These findings were also significantly associated with higher fitness and not receiving free/reduced lunches.

The present findings suggest that physically active classroom lessons have a small positive influence on academic achievement, specifically, math and spelling as compared to participating in less classroom physical activity. In our previous 3-year cluster randomized

controlled trial (16), PAAC, we found significant improvements in reading, math, spelling, and composite scores from baseline to 3 years. However, this investigation was not appropriately powered to test this exploratory aim. Other researchers have also found physically active classroom lessons to be positively associated with improved academic achievement, but the findings as to which academic subjects are not as clear. Previous research by Erwin and colleagues (17) found that a 20-week intervention of 20+ minutes of activity per day resulted in significantly higher reading fluency and mathematics scores on a validated curriculum-based measure but no differences were seen on standardized test scores. In a 2-year study of a school-based physical activity program that included physically active academic lessons (Healthier Options for Public Schoolchildren), Hollar et al. (18) found significantly higher math and reading scores for intervention participants. Reed and colleagues (35) integrated physical activity into the elementary school curriculum for four months and found significant improvements in social studies, but no differences in math, language arts, or science. Finally, Mullender-Wijnsma et al. (19) compared performance on speeded tests of math and reading following a 1-year intervention of physically active academic lessons or a control condition. The study showed that math and reading scores improved in third graders when compared to controls, but math scores of second graders were significantly lower than the controls. Thus, three out of the four studies (16–18) on physically active academic lessons showed improvements in mathematics scores. The present investigation, as well as others (16) have also found classroom physical activity lessons to have a positive influence on spelling as well.

The present study suggests that participation in MVPA is important for improvements in academic achievement. We hypothesized that these improvements may be driven by an interaction between MVPA and increased TOT. However, this was not observed. Previous findings from Syväoja and colleagues (36) found that after controlling for gender, parental education, and remedial education, MVPA collected by accelerometry, had a positive association with attention. These findings suggest that MVPA may be beneficial for classroom attention (37). However, this was a “snapshot”, one-week evaluation of MVPA and single evaluation of attention, not a 3-year investigation, like the present study. In addition, a recent review (2) suggests that the effect of MVPA on attention/concentration may be acute (immediately after PA) and not chronic or its effect may dissipate over time. It has been hypothesized that exercise-induced arousal may result in a heightened level of arousal during physical activity which facilitates gains in attention/concentration (38). However, this effect of physical activity on attention requires further research for confirmation. Such research studies should measure both the long-term and immediate effect of physical activity on TOT and/or attention. This would help to determine if there are long-term gains in attention associated with classroom physical activity bouts, as well as the short-term gains that have been observed in acute studies (39–43).

In general, physically active children have greater cardiovascular fitness compared to individuals who are sedentary and cardiovascular fitness has been associated with better cognition and academic achievement (44). The present study suggests that fitness is associated with more time spent in MVPA and TOT as well as math and spelling performance. A variety of cross-sectional studies have found a positive relationship between fitness and cognitive performance (39–43). Two prospective studies have been published that

report the changes in cognitive performance observed over time relative to baseline measures of aerobic fitness and suggest that higher aerobic fitness at baseline is associated with better cognitive performance at both baseline and follow-up (45, 46). Similarly, randomized controlled trials using MVPA in children (47–53) that measure fitness, have consistently shown significant improvements in fitness as well as cognition, specifically executive control (i.e., working memory, the ability plan, and perform goal-oriented tasks), which appears to be important for succeeding in the classroom (37).

The association among gender, socioeconomic status, and academic achievement has not been clearly established. In the present study, we observed that boys had significantly higher math scores than girls. Additionally, students receiving free/reduced meals had significantly lower math, reading and spelling scores than students who did not. The impact of the covariates within each model was substantial with 16% of the variance associated with math performance, 27% for reading and 8% for spelling. This suggests that the covariates on academic achievement including gender, socioeconomic status need to be defined. In many studies, the impact of such variables is either not explored or the reason for the association is spurious in nature (44). Thus, future studies should be designed and powered to explore the association between demographic covariates, such as gender and socioeconomic status, and academic achievement.

Limitations

A pre-intervention value or true baseline value of TOT or SOFIT was not collected prior to the students participating in the A+PAAC physical activity lessons as the intervention began when the school year started. Thus, future studies may endeavor to collect baseline assessment of classroom TOT and physical activity behavior prior to starting the intervention. In addition, students were only observed for a short time (5 to 20 minutes) following academic lessons (A+PAAC or control), therefore we are unable to determine if the length of impact physical activity participation impacts TOT in the classroom. Finally, the authors are assuming that classroom PA coded as a 4 (walking) or 5 (jogging/running) are activities that represent MVPA. This assumption was based on previous work where SOFIT and energy expenditure were collected during A+PAAC activities in the classroom (23).

Conclusion

In conclusion, the present study found that more time spent in MVPA and participation in on-task behavior after a physically active lesson was significantly associated with higher math scores and spelling scores, but not reading scores. Overall, these findings provide support that physically active classroom lessons may have a positive impact on academic achievement in elementary aged children. Future studies should continue to evaluate the influence of physically active classroom lesson on time spent on-task and their impact on academic achievement to determine the sustainability of physical activity’s effect on classroom behavior. In addition, these findings could have positive implications for the translation and further dissemination and use of MVPA in the classroom to improve TOT

and academic outcomes. Policymakers should consider the role of MVPA on academic TOT and academic achievement when formulating educational recommendations and regulations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Students by Year

Variable	Total (N = 633)		
	n	***M***	***SD***
Math score			
Year 1	562	103.18	12.00
Year 2	545	107.14	13.19
Year 3	516	107.57	12.03
Reading score			
Year 1	557	100.75	13.35
Year 2	541	105.98	14.93
Year 3	510	108.05	13.08
Spelling score			
Year 1	563	99.81	11.34
Year 2	545	102.14	12.74
Year 3	516	104.29	13.31
Spelling score			
Year 1	563	99.81	11.34
Year 2	545	102.14	12.74
Year 3	516	104.29	13.31
% time in on-task behavior: post-PA			
Year 1	544	86.84	15.45
Year 2	591	88.86	14.26
Year 3	525	91.35	16.14
% time in Sofit MVPA			
Year 1	569	25.66	31.62
Year 2	625	25.46	33.04
Year 3	524	19.37	30.39

Transl J Am Coll Sports Med. Author manuscript; available in PMC 2020 June 15.

Table 2.

Baseline Characteristics

Variable	Total (*N* = 633)			A+PAAC Intervention (*N* = 319)			Control (*N* = 314)			Group difference		
	n	*M* / %	*SD*	*n*	*M* / %	*SD*	*n*	*M* / %	*SD*	*t* / χ2	*df*	*p*
Age (year)	633	7.57	0.58	319	7.58	0.58	314	7.56	0.59	0.35	631	0.726
Gender										3.80	1	0.051
Male	313	49.4%		170	53.3%		143	45.5%				
Female	320	50.6%		149	46.7%		171	54.5%				
Ethnicity										16.90	4	0.002
Not Hispanic/Latino	536	84.7%		283	88.7%		253	80.6%				
Hispanic/Latino	68	10.7%		23	7.2%		45	14.3%				
Unknown	14	2.2%		10	3.1%		4	1.3%				
Refused	0	0.0%		0	0.0%		0	0.0%				
Missing	15	2.4%		3	0.9%		12	3.8%				
Race										16.31	6	0.012
White	515	81.4%		273	85.6%		242	77.1%				
Black/African American	21	3.3%		8	2.5%		13	4.1%				
Native Hawaiian/Pacific Islander	0	0.0%		0	0.0%		0	0.0%				
Asian	10	1.6%		5	1.6%		5	1.6%				
American Indian /Alaska Native	6	0.9%		4	1.3%		2	0.6%				
Two or more races	70	11.1%		26	8.2%		44	14.0%				
Unknown	4	0.6%		3	0.9%		1	0.3%				
Refused	0	0.0%		0	0.0%		0	0.0%				
Missing	7	1.1%		0	0.0%		7	2.2%				
Free/reduced meals										15.89	3	0.001
Yes	180	28.4%		77	24.1%		103	32.8%				
No	438	69.2%		240	75.2%		198	63.1%				
Refused	1	0.2%		0	0.0%		1	0.3%				
Missing	14	2.2%		2	0.6%		12	3.8%				

Transl J Am Coll Sports Med. Author manuscript; available in PMC 2020 June 15.

Variable	Total (N = 633)			A+PAAC Intervention (N = 319)			Control (N = 314)			Group difference		
	n	***M* / %**	***SD***	***n***	***M* / %**	***SD***	***n***	***M* / %**	***SD***	***t* / $\chi 2$**	***df***	***p***
Height (cm)	625	130.89	6.94	315	130.99	6.68	310	130.79	7.22	0.36	623	0.722
Weight (kg)	625	30.57	7.83	315	30.62	7.45	310	30.53	8.20	0.14	623	0.885
BMI (kg/m^2)	625	17.65	3.24	315	17.68	3.24	310	17.62	3.24	0.22	623	0.829
BMI percentile	625	62.28	29.27	315	62.56	29.10	310	61.99	29.49	0.24	623	0.807
Laps	560	17.29	9.36	277	17.99	9.73	283	16.61	8.96	1.74	558	0.082

Values are presented as Mean (M) or percent of total (%) and standard deviation (SD) Table adapted from Szabo-Reed et al. (2017).

Table 3.

Influence of time spend participating in MVPA on Math Achievement

Fixed effect	**Estimate**	***SE***	***z***	***p***	***F***	***p***
Intercept	105.47	6.35	16.61	0.000		
Year (linear change)	1.93	0.31	6.20	0.000	38.39	0.000
% time in Sofit MPVA	0.02	0.01	2.13	0.034	4.52	0.034
Year * % time in Sofit MPVA	−0.02	0.01	−3.20	0.001	10.22	0.001
Age	−0.81	0.83	−0.97	0.331	0.95	0.331
Gender					4.42	0.036
Male	2.08	0.99	2.10	0.036		
Female (reference)	-	-	-	-		
Race					1.28	0.273
White (reference)	-	-	-	-		
Black/African American	−4.80	2.51	−1.91	0.056		
Asian	4.86	4.00	1.21	0.225		
American Indian /Alaska Native	−4.67	5.57	−0.84	0.402		
Two or more races	−0.76	1.63	−0.47	0.640		
Unknown	−5.60	8.04	−0.70	0.487		
Free/reduced meals					17.48	0.000
Yes	−4.63	1.11	−4.18	0.000		
No (reference)	-	-	-	-		
BMI percentile	0.01	0.02	0.42	0.672	0.18	0.672
PACER Laps	0.23	0.04	6.56	0.000	43.09	0.000
Random effect	Estimate	*SE*	*z*	*p*		
Student	111.61	7.78	14.35	0.000		
Residual	26.89	1.32	20.34	0.000		

Transl J Am Coll Sports Med. Author manuscript; available in PMC 2020 June 15.

Table 4.

Influence of time spend participating in MVPA on Reading Achievement

Fixed effect	**Estimate**	***SE***	***z***	***p***	***F***	***p***
Intercept	91.31	7.75	11.78	0.000		
Year (linear change)	3.49	0.31	11.16	0.000	124.55	0.000
% time in Sofit MPVA	0.01	0.01	0.80	0.424	0.64	0.424
Year * % time in Sofit MPVA	0.00	0.01	−0.37	0.713	0.14	0.713
Age	1.69	1.01	1.67	0.095	2.79	0.095
Gender					0.22	0.640
Male	−0.56	1.20	−0.47	0.640		
Female (reference)	-	-	-	-		
Race					0.30	0.910
White (reference)	-	-	-	-		
Black/African American	−2.92	3.06	−0.96	0.339		
Asian	1.38	4.87	0.28	0.777		
American Indian /Alaska Native	−0.81	6.80	−0.12	0.905		
Two or more races	−1.58	1.99	−0.79	0.428		
Unknown	0.02	9.75	0.00	0.999		
Free/reduced meals					11.28	0.001
Yes	−4.53	1.35	−3.36	0.001		
No (reference)	-	-	-	-		
BMI percentile	−0.01	0.02	−0.51	0.613	0.26	0.613
PACER Laps	−0.02	0.04	−0.55	0.583	0.30	0.583
Random effect	Estimate	*SE*	*z*	*p*		
Student	171.85	11.48	14.97	0.000		
Residual	25.87	1.28	20.21	0.000		

Table 5.

Influence of time spend participating in MVPA on Spelling Achievement

Fixed effect	**Estimate**	***SE***	***z***	***p***	***F***	***p***
Intercept	95.39	6.90	13.83	0.000		
Year (linear change)	1.01	0.26	3.80	0.000	14.45	0.000
% time in Sofit MPVA	0.04	0.01	3.88	0.000	15.04	0.000
Year * % time in Sofit MPVA	−0.01	0.01	−1.38	0.168	1.91	0.168
Age	0.48	0.90	0.53	0.597	0.28	0.597
Gender					0.50	0.479
Male	−0.76	1.07	−0.71	0.479		
Female (reference)	-	-	-	-		
Race					0.33	0.896
White (reference)	-	-	-	-		
Black/African American	0.41	2.74	0.15	0.881		
Asian	4.05	4.36	0.93	0.354		
American Indian /Alaska Native	−4.14	6.10	−0.68	0.498		
Two or more races	−0.73	1.77	−0.41	0.680		
Unknown	2.76	8.73	0.32	0.752		
Free/reduced meals					6.78	0.009
Yes	−3.13	1.20	−2.60	0.009		
No (reference)	-	-	-	-		
BMI percentile	0.01	0.02	0.74	0.457	0.55	0.457
PACER Laps	0.07	0.03	2.01	0.045	4.04	0.045
Random effect	Estimate	*SE*	*z*	*p*		
Student	139.27	9.20	15.14	0.000		
Residual	18.60	0.91	20.34	0.000		

Transl J Am Coll Sports Med. Author manuscript; available in PMC 2020 June 15.

Table 6.

Influence of time-on-task (TOT) on math achievement

Fixed effect	**Estimate**	***SE***	***z***	***p***	***F***	***p***
Intercept	106.80	6.64	16.09	0.000		
Year (linear change)	1.81	1.38	1.31	0.191	1.72	0.191
% TOT post-lesson	0.00	0.02	−0.13	0.898	0.02	0.898
Year * % TOT post-lesson	−0.01	0.02	−0.38	0.704	0.14	0.704
Age	−0.90	0.84	−1.07	0.287	1.14	0.287
Gender					3.62	0.057
Male	1.91	1.01	1.90	0.057		
Female (reference)	-	-	-	-		
Race					1.24	0.290
White (reference)	-	-	-	-		
Black/African American	−4.79	2.53	−1.90	0.058		
Asian	4.61	4.03	1.14	0.254		
American Indian /Alaska Native	−4.79	5.61	−0.85	0.393		
Two or more races	−0.85	1.64	−0.52	0.603		
Unknown	−5.57	8.10	−0.69	0.492		
Free/reduced meals					17.53	0.000
Yes	−4.71	1.13	−4.19	0.000		
No (reference)	-	-	-	-		
BMI Percentile	0.01	0.02	0.51	0.614	0.26	0.614
PACER Laps	0.25	0.04	6.87	0.000	47.22	0.000
Random effect	Estimate	*SE*	*z*	*p*		
Student	113.19	7.98	14.18	0.000		
Residual	27.13	1.38	19.73	0.000		

Table 7.

Influence of time-on-task (TOT) on reading achievement

Fixed effect	**Estimate**	***SE***	***z***	***p***	***F***	***p***
Intercept	90.69	7.91	11.47	0.000		
Year (linear change)	3.90	1.37	2.85	0.005	8.12	0.005
% TOT post-lesson	0.00	0.02	0.15	0.883	0.02	0.883
Year * % TOT post-lesson	−0.01	0.01	−0.35	0.730	0.12	0.730
Age	1.77	1.01	1.74	0.082	3.04	0.082
Gender					0.38	0.539
Male	−0.74	1.20	−0.61	0.539		
Female (reference)	-	-	-	-		
Race					0.36	0.874
White (reference)	-	-	-	-		
Black/African American	−3.07	3.02	−1.02	0.310		
Asian	1.63	4.82	0.34	0.735		
American Indian /Alaska Native	−1.02	6.73	−0.15	0.880		
Two or more races	−1.74	1.97	−0.88	0.377		
Unknown	−0.20	9.65	−0.02	0.983		
Free/reduced meals					11.75	0.001
Yes	−4.62	1.35	−3.43	0.001		
No (reference)	-	-	-	-		
BMI Percentile	0.00	0.02	−0.19	0.850	0.04	0.850
PACER Laps	−0.02	0.04	−0.61	0.540	0.38	0.540
Random effect	Estimate	*SE*	*z*	*p*		
Student	167.98	11.34	14.81	0.000		
Residual	26.03	1.32	19.67	0.000		

Table 8.

Influence of time-on-task (TOT) on spelling achievement

Fixed effect	**Estimate**	***SE***	***z***	***p***	***F***	***p***
Intercept	96.42	7.12	13.55	0.000		
Year (linear change)	0.65	1.18	0.55	0.584	0.30	0.584
% TOT post-lesson	−0.01	0.02	−0.44	0.660	0.19	0.660
Year * % TOT post-lesson	0.00	0.01	0.21	0.834	0.04	0.834
Age	0.55	0.91	0.60	0.549	0.36	0.549
Gender					0.49	0.486
Male	−0.76	1.09	−0.70	0.486		
Female (reference)	-	-	-	-		
Race					0.38	0.864
White (reference)	-	-	-	-		
Black/African American	0.04	2.75	0.02	0.987		
Asian	4.29	4.38	0.98	0.328		
American Indian /Alaska Native	−4.06	6.12	−0.66	0.508		
Two or more races	−1.07	1.78	−0.60	0.547		
Unknown	2.74	8.77	0.31	0.755		
Free/reduced meals					7.29	0.007
Yes	−3.29	1.22	−2.70	0.007		
No (reference)	-	-	-	-		
BMI Percentile	0.01	0.02	0.84	0.403	0.70	0.403
PACER Laps	0.07	0.03	2.06	0.040	4.25	0.040
Random effect	Estimate	*SE*	*z*	*p*		
Student	139.90	9.34	14.98	0.000		
Residual	19.39	0.98	19.77	0.000		