Published in final edited form as:

Med Sci Sports Exerc. 2017 November ; 49(11): 2343–2350. doi:10.1249/MSS.0000000000001346.

Impact of 3 Years of Classroom Physical Activity Bouts on Time-on-Task Behavior

Amanda N. Szabo-Reed¹, Erik A. Willis¹, Jaehoon Lee³, Charles H. Hillman², Richard A. Washburn¹, and Joseph E. Donnelly¹

¹Cardiovascular Research Institute, Division of Internal Medicine, The University of Kansas Medical Center, Kansas City, KS

²Department of Psychology, Department of Health Sciences, Northeastern University, Boston, MA

³Department of Educational Psychology and Leadership, Texas Tech University, Lubbock, TX

Abstract

Participation in classroom physical activity (PA) may improve time-on-task (TOT), however, the influence of sustained moderate-to-vigorous PA (MVPA) on TOT is unknown.

Purpose—To explore the influence of classroom PA delivered with academic lessons on TOT, determine if the relationship between classroom PA and TOT differs by age, sex, race/ethnicity, weight or baseline fitness, and identify the influence of MVPA on TOT when controlling for demographic variables.

Methods—Teachers in intervention schools were asked to deliver two, 10-minute PA lessons/day, 5 days/week. PA was observed in both intervention and control schools to determine the amount and intensity of PA. TOT was observed prior to and immediately following PA. Anthropometrics and fitness were assessed at baseline and end of the school year for 3 years. Multilevel modeling was utilized to estimate overall group difference, change over the study, and group difference in change while accounting for covariates.

Results—Students who participated in PA lessons engaged in significantly more MVPA than those in the control schools in all three years (all $p < .001$). There was a significant linear increase in the percent of TOT before PA lessons for both control and intervention groups over the 3-year period ($p < .001$), with no group difference. The intervention group spent significantly more TOT ($p = .01$) following PA than the control group. The percent of time spent in MVPA was significantly associated with the percent of TOT ($p < .01$).

Conclusion—Results indicate that children who received PA lessons participated in significantly more MVPA than those who did not and that PA was significantly associated with more TOT. These findings provide support for classroom PA as a means of increasing TOT in elementary aged children.

Corresponding author: Joseph E. Donnelly, Cardiovascular Research Institute, Division of Internal Medicine, University of Kansas Medical Center, 3901 Rainbow Blvd, Mail Stop #1007, ATTN: Energy Balance Lab, Kansas City, KS 66160, Phone: 1-785-864-0797, Fax: 1-913-945-8280, jdonnelly@ku.edu.

Disclosure of funding: Trial registration: US NIH Clinical Trials, NCT01699295.

There are no conflicts of interests to declare.

Keywords

Children; Time-on-task; Physical Activity; Classroom

Introduction

Physical inactivity puts children at risk for many health problems, including childhood obesity (11). In order to prevent obesity and improve health, it is recommended that children engage in 60 or more minutes of physical activity daily, however most children do not achieve this recommendation (4, 27). Therefore, methods to increase daily physical activity must be explored. One means of increasing physical activity is by utilizing schools as a delivery site, as children spend 6 or more hours in school most days of the week, for ~9 months per year. School-based physical activity can be delivered through a variety of venues including physical education classes, recess, and during classroom instruction in addition to before and after-school programs (26).

Researchers have attempted to incorporate physical activity into the classroom through academic-based physical activity lessons such as Physical Activity Across the Curriculum (PAAC)(9, 10) or “brain break” type physical activity opportunities including Energizers (21, 24) and FUNervals (13, 20). Overall, these physical activity opportunities are able to increase school day physical activity time (9, 10). In addition to increasing physical activity time, several cross-sectional studies have demonstrated that classroom-based physical activity sessions may also have an effect on a child’s attention to classroom instruction following the activity (13, 20, 21, 24). This increase in attention is hypothesized to be a prerequisite for learning and academic achievement and therefore, may have a positive impact on academic outcomes (1, 7, 12, 19, 20, 23, 30). Mahar et al. measured time-on-task following sedentary lessons or Energizers, which are 10-minute classroom-based physical activities. From before to after Energizers, average percentage of on-task behavior increased by more than 8% as compared to sedentary lessons (21, 24). Similarly, Ma et al. (20) found that off-task behavior decreased in both 2nd and 4th graders following FUNtervals (4 minute high-intensity interval exercises) when compared to a no-activity break. Additionally, Ma et al. (20) examined the effects of attention on task performance and showed that 3rd–5th grade students made fewer errors on an attention test following FUNtervals when compared to rest. Greico et al. (13) measured time-on-task following a physically active academic lesson and an inactive control lesson. Time on-task did not increase following the active lesson, but did decrease significantly following the inactive control lesson.

Altenburg, Chinapaw, and Singh (2) evaluated the influence of one versus two bouts of moderate-to-vigorous physical activity (MVPA, confirmed via heart rate monitor) on classroom attention, measured by a Sky Search Task. These authors found that children who performed two 20-minutes bouts of MVPA during the morning school session had significantly better attention scores as compared to children who performed one bout or remained seated during the morning. These findings not only indicate the importance of incorporating physical activity into the school day, but also may suggest that MVPA intensity also impacts attention. Together, all of these short evaluations suggest that

participating in physical activity in the classroom may impact attention and/or time-on-task, however, the impact of sustaining MVPA, in the form of classroom activity, for multiple years and the effect of demographic variables on time-on-task behavior is unknown.

Several studies have also evaluated the longitudinal influence of other school-based physical activity interventions on attention (1, 7, 12, 29), but yielded inconclusive results. A study published by Davis et al. (7) evaluated the influence of an after-school fitness program on attention using the Cognitive Assessment System (CAS) attention subscale and found no impact. Similarly, a cluster randomized study (12) compared 10 weeks of intense physical education to a standard physical education control group in 2nd-graders and found no significant between-group differences in attention measured by the CAS. Spitzer et al. (29) also showed that extra physical education lessons in 5th- and 6th-graders for four months did not lead to improvements in attention when compared to control. On the other hand, Adsiz and colleagues (1) examined the impact of a 12-week physical activity program that added sport activities three times per week to school on attention measured by the Bourdon Attention test. These researchers found that children who engaged in the additional physical activity had 83% higher attention levels than sedentary children. Together these findings suggest that there may be a neutral or positive effect of additional physical activity on attention, however similar to the most of the classroom-based physical activity programs, physical activity intensity (i.e., MVPA) was not reported/evaluated, nor was the influence of demographic variables examined.

Therefore, the objectives of the present investigation were to utilize data from a 3-year cluster randomized physical activity intervention, “Academic Achievement and Physical Activity Across the Curriculum” (A+PAAC, NCT01699295, described below) to: 1) explore the influence of classroom based physical activity bouts delivered through academic lessons on the proportion of on- and off-task behavior, 2) determine if the relationship between classroom physical activity and time-on-task differs by age, sex, race/ethnicity, weight or baseline fitness, and to 3) identify the influence of physical activity intensity for on- and off-task classroom behavior when controlling for key demographic variables.

Methods

Participants

A detailed description of the rationale, design, and methods of A+PAAC has been previously published (8). Briefly, 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. Overall, the trial incorporated 17 elementary schools from 4 school districts in Northeastern Kansas. The schools were stratified by school district 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, >4 METs, metabolic equivalent of task) in order to increase total daily MVPA while maintaining academic instruction time. A+PAAC began when the students were in 2nd or 3rd grade and ended in 4th or 5th grade. 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 the other in the afternoon, 5 days per week (See videos for examples, SDC1.mp4, SDC 1, Language arts example of A+PAAC delivery, 55sec, 32.6MB; SDC2.mp4, SDC 2, Reading comprehension example of A+PAAC delivery, 3min 23sec, 107MB; SDC3.mp4, SDC 3 Mathematics example of A+PAAC delivery, 2min 16sec, 73.1MB). This resulted in a weekly total of school-based physical activity of ~160 minutes/week (A+PAAC=100 minutes plus PE=60 minutes), which is slightly greater than the minimum 150 minutes/week of physical activity that should be accumulated each week during school hours for children as recommended by the Institute of Medicine (6). The use of A+PAAC lessons outside the classroom, such as during field trips, was also permitted. The recommended A+PAAC lessons provided MVPA with physical activity intensity of 4–5 METs (14). A+PAAC lessons were used in a variety of academic disciplines including math, language arts, geography, history, spelling, science, and health.

Classroom teachers in the intervention schools were trained by study staff to deliver A+PAAC during two, 6-hour in-service sessions conducted at the school prior to implementation of the intervention. Teachers were compensated for participation in the training sessions. To assist teachers in delivering A+PAAC lessons, teachers were provided a written guide and access to a study website which provided a variety of sample A+PAAC lessons with each lesson's associated MET values. A 1-day (4-hour) in-service session was also conducted at the beginning of intervention years 2 and 3 to provide feedback to teachers regarding the intervention and to discuss implementation of the A+PAAC intervention. Teachers that were new to the school were also trained at this time. Teachers in the control schools were asked to continue using traditional classroom instruction and students in both intervention and control schools continued with their typical physical education schedule (i.e., 2–30 minute classes/week). An evaluation of the installation of other PA or nutritional based interventions was completed by each school's principle at the end of each year to determine if competing programs were adopted by the school that could pose a threat to the internal validity of the intervention. None were identified.

Intervention fidelity

To measure the amount of A+PAAC lessons delivered, classroom physical activity was observed every other week using the activity portion of System for Observing Fitness Instruction Time (SOFIT), which is a validated time-moment sampling technique (25). Activities were coded on a 5-point Likert scale (1=lying down, 2=sitting, 3=standing, 4=walking, 5=jogging/running in place). MVPA was defined as participating in an activity coded as a 4 or 5. Of the 9 intervention schools, one school was selected at random for observation on a specific day each week. Within the selected school, the classroom to be observed was randomly selected. Finally, the specific students to be observed were randomly selected from the ones that provided consent/assent (approximately 20 per classroom). Each child was observed at least once during the 3 year period. Approximately five students were observed consecutively, in 20-second intervals for each student, yielding ~6 observations per child over a 10-minute period. The total percentage of time each student spent participating in MVPA during each observation was calculated (e.g. 2 minutes observed with 1 ½ minutes

spent in MVPA yielded 75% MVPA). The same procedure was also performed within the control schools to observe the activity that occurred during a normal academic lesson.

In addition to SOFIT observations, teachers were asked to report the number of days and minutes per day A+PAAC lessons were delivered each week on a study specific website.

Time-on-task

Time-on-task (TOT) was assessed by study staff on the same random schedule for recording classroom physical activity using a modification of the procedures from Mahar et al. (21, 24). During each assessment, approximately 5 students were observed for 5–20 minutes before and 5–20 minutes after the delivery of an academic lesson (i.e. A+PAAC or traditional). Each child was observed for 10 seconds, after which the appropriate behavior code was circled. This procedure was repeated over the 5-minute interval to result in a total of ~ 20 observations per child. Coding included on-task, motor off-task, noise off-task, or passive/other off-task (15, 28). The percent of on-task time, percent motor off-task, etc. was computed for each student based on the number of minutes of observation pre-and post-lesson (e.g. 5 minutes observed with 4 minutes on-task yielded 80% time-on-task). Inter-observer reliability for both the SOFIT and TOT across the 3-year period was 92%.

Demographics

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

Anthropometrics (Height/weight/waist circumference)

Children were weighed to the nearest 0.1 kg wearing school clothes without shoes during the first period of the school day on a calibrated scale (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 (m²). BMI percentile was calculated using the CDC growth charts (16).

Cardiorespiratory fitness

The PACER test was administered at each school in small groups (8–12 students) with a 1:4 ratio of staff to children. 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 each child was unable to traverse the 20-meter distance on two separate occasions, at which point the test ended (5, 31). A higher level of fitness was denoted by a greater number of completed PACER laps. There has been considerable work with adults and children (17, 18, 22) detailing the high reliability and validity of the PACER, which has been administered worldwide and to children as young as 6 years old (Olds et al., 2006). As such, the PACER is 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.

Statistical analysis

Baseline demographic and anthropometric variables were summarized using descriptive statistics and bivariate tests — i.e., *t*-test, chi-square test, and correlation. Independent-samples *t*-test (with Satterthwaite approximation as appropriate) was performed to compare the percent of time spent in on-task behavior before and after academic lesson delivery (A+PAAC or traditional) and MVPA between students in the intervention schools and those in the control schools. Given the nested structure of the data (i.e., students were repeatedly measured within classrooms), multilevel modeling was utilized to estimate overall group difference (group effect), linear or quadratic change over the study period (time effect), and group difference in this change (i.e., group-by-time interaction) separately for each outcome, accounting for the dependency among observations (i.e., intraclass correlations) as well as 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

Baseline demographic characteristics and anthropometrics are available in Table 1. A total of 584 participants began the intervention in year 1 (n=268 control, n=316 intervention) and of those, 448 completed the intervention in year 3 (n=204 control, n=244 intervention). On average the students' age was 7.6 years (SD=0.58) at baseline and did not significantly differ between the intervention and control schools. BMI, height and weight at baseline also did not significantly differ between the two groups. Ethnicity (Intervention= 10.7% Hispanic/Latino, Control= 7.2% Hispanic/Latino), race (Intervention= 85.6% white, Control= 77.1% white), and free or reduced meals (Intervention= 24.1% received free/reduced lunch, Control= 32.8% received free/reduced lunch) did significantly differ, with the control schools having more minorities and a greater percentage of students enrolled in free or reduced meal plans when compared to the intervention schools.

Moderate-to-vigorous physical activity and on-task behavior

The participating teachers in the intervention schools reported an average of A+PAAC min/wk across the intervention of 60.8 ± 32.3 , 54.6 ± 34.4 , and 49.2 ± 33.6 for years 1, 2, and 3, respectively. The control school teachers reported no A+PAAC minutes. The students who participated in A+PAAC lessons engaged in significantly more MVPA during the academic lessons than those in the control schools during each of three years (all $p < .001$, see Table 2 and Figure 1A). The intervention group performed 52.7%, 58.7% and 60.1% of observed lesson time each year as MVPA for three years, as compared to 1.6%, 3.6%, and 2.3% in the control group.

Multilevel modeling results revealed a significant linear increase in the percent of time spent on-task before the academic lessons for both the control and intervention groups over the 3-year study period (time effect $p < .01$, see Table 3 and Figure 1B). There was no significant group difference in this change, but the control group was on-task in a higher percentage of academic lessons (93.3%) when compared to the intervention group (88.9%) at year 3 only ($p < .01$, see Table 2). In addition, boys spent significantly less percent of time in on-task

behavior before the observed lesson than girls during all 3 years ($p<.001$, see Table 3.). There was no significant effect of age, race, free/reduced meals, BMI or fitness on the pre-lesson on-task behavior time.

Regarding the percent of time spent on-task after the observed academic lessons, there was also a significant linear increase for both groups over the 3-year period (time effect $p<.001$, see Table 4 and Figure 1C). Throughout the entire 3 years the intervention group spent significantly more percent of time (Year 1= 88.46%, Year 2= 89.77%, Year 3= 91.58%) in on-task behavior than the control group (Year 1= 85.32%, Year 2= 88.26%, Year 3= 91.26%; group effect $p=.011$). However, the gap between the groups did become smaller in the later years and was not significant (time-by-group interaction $p=.092$).

Similar to the pre-lesson time-on-task, boys spent significantly less percent of time in on-task behavior after the lesson than girls ($p<.000$). There was no significant effect of age, race, or free/reduced lunch consumption on the post-lesson on-task behavior time. In addition, the percent of time spent in MVPA significantly predicted the percent of time spent in on-task behavior ($p<.01$, see Table 5) -- i.e., the more time spent in MVPA was associated with more time-spent on-task.

Discussion

This study found that participation in the MVPA academic lessons were significantly associated with a greater percentage of time spent in on-task behavior throughout the entire 3-year period for the intervention group as compared to the control group. Also, more time spent at a MVPA level was significantly associated with more time spent in on-task behavior following physical activity participation, however boys on-task behavior occurred for a significantly less percentage of time compared to girls.

Overall, findings from this multi-year study are congruent with shorter observational studies, and suggest that classroom based physical activity has a positive impact on on-task behavior post-physical activity participation independent of most demographic factors (13, 20, 21, 24).

The present investigation also evaluated the percentage of time students spent participating in MVPA. Previous investigations (13, 20, 21, 24) state prescribing MVPA classroom-based physical activity, but do not measure if MVPA was achieved. The present findings indicate that the presence of MVPA has a positive influence on post-physical activity on-task behavior.

Findings from this study also showed an increase in TOT with time and age. This finding is a normal and naturally occurring observation. Previous research indicates that sustained attention to a task develops continuously from age 5–10 and then plateaus until age 16 (3). As this study was initiated when the children were approximately 7.5 years of age an increase in attention span and time-on-task with age was to be expected.

Limitations

Despite positive findings, there are several limitations associated with this study. First, a pre-intervention value or true baseline value of time-on-task was not collected prior to the students participating in MVPA academic lessons as the intervention began when the school year started. Therefore, future studies should ensure a baseline assessment of classroom on-task behavior prior to starting the intervention. In addition, students were only observed for a short time period (5 to 20 minutes) following academic lessons (A+PAAC or control), therefore we are unable to determine the length of impact physical activity participation has on time-on-task in the classroom. Similarly, physical activity was only measured via SOFIT during the activity lessons and not objectively using accelerometry. The addition of an accelerometer during all physical activity sessions in future studies could provide a more objective/accurate measure of MVPA. However, Honas et al. (14) did measure physical activity intensity via accelerometer and COSMED energy expenditure on a subsample of children to confirm the SOFIT findings and found the average MET level of the A+PAAC activities delivered to be 4.2 ± 0.9 , thus confirming the SOFIT findings. Finally, logistical constraints prohibited daily observation and each child in the intervention was assessed a variable amount of times, however, this was controlled by incorporating random effect in the multilevel modeling.

Conclusion

In conclusion, the present investigation found that those children who received A+PAAC activity lessons participated in significantly more MVPA than those in the control group and that participation in MVPA academic lessons were significantly associated with more on-task behavior time. Overall, these findings provide support that physically active classroom lessons do not have a negative impact on classroom attention in elementary aged children, which has been found to be a main concern about schools and teachers in this matter. Future studies should continue to evaluate the influence of physically active classroom lessons on time spent on-task and its impact on academic achievement to determine the sustainability of physical activity's effect on classroom behavior.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. The authors would like to thank their funding sources from the National Institutes of Health R01-DK85317 (Donnelly) and F32-DK103493 (Szabo-Reed). The results of the present study do not constitute endorsement by ACSM.

References

1. Adsiz E, Dorak F, Ozsaker M, Vurgun N. The influence of physical activity on attention in Turkish children. *HealthMed*. 2012; 6(4):1384–9.
2. Altenburg TM, Chinapaw MJM, Singh AS. Effects of one versus two bouts of moderate intensity physical activity on selective attention during a school morning in Dutch primary schoolchildren: A

randomized controlled trial. *Journal of Science and Medicine in Sport*. 2016; 19(10):820–4. [PubMed: 26724833]

3. Betts J, McKay J, Maruff P, Anderson V. The development of sustained attention in children: the effect of age and task load. *Child neuropsychology : a journal on normal and abnormal development in childhood and adolescence*. 2006; 12(3):205–21. [PubMed: 16837396]
4. Brooke HL, Atkin AJ, Corder K, Brage S, van Sluijs EMF. Frequency and duration of physical activity bouts in school-aged children: A comparison within and between days. *Preventive Medicine Reports*. 2016; 4:585–90. [PubMed: 27843758]
5. Carrel AL, Bowser J, White D, et al. Standardized Childhood Fitness Percentiles Derived from School-Based Testing. *The Journal of Pediatrics*. 2012; 161(1):120–4. [PubMed: 22364851]
6. Committee on Physical A, Physical Education in the School E, Food, Nutrition B, Institute of M. HW Kohl, III, HD Cook. , editor. *Educating the Student Body: Taking Physical Activity and Physical Education to School*. Washington (DC): National Academies Press (US); 2013. Copyright 2013 by the National Academy of Sciences. All rights reserved
7. Davis CL, Tomporowski PD, Boyle CA, et al. Effects of aerobic exercise on overweight children's cognitive functioning: a randomized controlled trial. *Research quarterly for exercise and sport*. 2007; 78(5):510–9. [PubMed: 18274222]
8. Donnelly JE, Greene JL, Gibson CA, et al. Physical activity and academic achievement across the curriculum (A + PAAC): rationale and design of a 3-year, cluster-randomized trial. *BMC Public Health*. 2013; 13:307. [PubMed: 23565969]
9. Donnelly JE, Hillman CH, Greene JL, et al. Physical activity and academic achievement across the curriculum: Results from a 3-year cluster-randomized trial. *Prev Med*. 2017; 99:140–5. [PubMed: 28193490]
10. Donnelly JE, Sullivan DK, Gibson C, et al. Physical activity across the curriculum: Effects for BMI and academic achievement. *Obesity*. 2007; 15(9):A18.
11. Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *The Lancet*. 2002; 360(9331):473–82.
12. Fisher A, Boyle J, Paton J, et al. Effects of a physical education intervention on cognitive function in young children: randomized controlled pilot study. *BMC Pediatrics*. 2011; 11(1):97. [PubMed: 22034850]
13. Grieco LA, Jowers EM, Bartholomew JB. Physically active academic lessons and time on task: the moderating effect of body mass index. *Medicine and science in sports and exercise*. 2009; 41(10):1921–6. [PubMed: 19727020]
14. Honas JJ, Willis EA, Herrmann SD, Greene JL, Washburn RA, Donnelly JE. Energy Expenditure and Intensity of Classroom Physical Activity in Elementary School Children. *J Phys Act Health*. 2016; 13(6 Suppl 1):S53–6. [PubMed: 27392380]
15. Katz RC, Singh NN. Increasing recreational behavior in mentally retarded children. *Behavior modification*. 1986; 10(4):508–19. [PubMed: 3800857]
16. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: methods and development. *Vital Health Stat*. 2002; 11(246):1–190.
17. Leger LA, Lambert J. A maximal multistage 20-m shuttle run test to predict VO2 max. *Eur J Appl Physiol Occup Physiol*. 1982; 49(1):1–12. [PubMed: 7201922]
18. Leger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci*. 1988; 6(2):93–101. [PubMed: 3184250]
19. Ma JK, Le Mare L, Gurd BJ. Classroom-based high-intensity interval activity improves off-task behaviour in primary school students. *Appl Physiol Nutr Metab*. 2014; 39(12):1332–7. [PubMed: 25263695]
20. Ma JK, Le Mare L, Gurd BJ. Four minutes of in-class high-intensity interval activity improves selective attention in 9- to 11-year olds. *Appl Physiol Nutr Metab*. 2015; 40(3):238–44. [PubMed: 25675352]
21. Mahar MT. Impact of short bouts of physical activity on attention-to-task in elementary school children. *Prev Med*. 2011; 52(Suppl 1):S60–4. [PubMed: 21281665]

22. Mahar MT, Guerieri AM, Hanna MS, Kemble CD. Estimation of aerobic fitness from 20-m multistage shuttle run test performance. *Am J Prev Med*. 2011; 41(4 Suppl 2):S117–23. [PubMed: 21961611]
23. Mahar MT, Murphy SK, Rowe DA, Golden J, Shields AT, Raedeke TD. Effects of a classroom-based program on physical activity and on-task behavior. *Medicine and science in sports and exercise*. 2006; 38(12):2086–94. [PubMed: 17146314]
24. Mahar MT, Murphy SK, Rowe DA, Golden J, Shields AT, Raedeke TD. Effects of a classroom-based program on physical activity and on-task behavior. *Med Sci Sports Exerc*. 2006; 38(12): 2086–94. [PubMed: 17146314]
25. McKenzie TL. Observational measures of children's physical activity. *J School Health*. 1991; 61(5):224–7. [PubMed: 1943048]
26. Pate RR, Davis MG, Robinson TN, Stone EJ, McKenzie TL, Young JC. Promoting physical activity in children and youth: a leadership role for schools: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. *Circulation*. 2006; 114(11):1214–24. [PubMed: 16908770]
27. Prevention CfDca. Healthy People 2010: Objectives for improving health. Atlanta: Centers for Disease Control and Prevention President's Council on Physical Fitness and Sports; 2010. Physical Activity and Fitness; p. 3-23.
28. Shimabukuro SM, Prater MA, Jenkins A, Edelen-Smith P. The effects of self-monitoring of academic performance on students with learning disabilities with ADD/ADHD. *Educ Treatment Child*. 1999; 22:397–414.
29. Spitzer US, Hollmann W. Experimental observations of the effects of physical exercise on attention, academic and prosocial performance in school settings. *Trends in Neuroscience and Education*. 2013; 2(1):1–6.
30. Tine MT, Butler AG. Acute Aerobic Exercise Impacts Selective Attention: An Exceptional Boost in Lower-Income Children. *Educational Psychology*. 2012; 32(7):821–34.
31. Welk, GJ., Meredith, MD. Fitnessgram/Activitygram Reference Guide. Dallas TX: The Cooper Institute; 2008.

Figure 1.

A. Percent of time spent doing MVPA per SOFIT

B. Percent of time spend in on-task behavior before classroom PA bout

C. Percent of time spent in on task behavior following classroom PA bout

Table 1

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	χ^2	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%				

Variable	Total (N = 633)			A+PAAC Intervention (N = 319)			Control (N = 314)			Group difference		
	n	M / %	SD	n	M / %	SD	n	M / %	SD	t / χ^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
PACER 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)

On-task behavior

Table 2

Variable	Total (N = 633)			A+PAAC Intervention (N = 319)			Control (N = 314)			Group difference		
	n	M	SD	n	M	SD	n	M	SD	t	df	p
% time in SOFIT MVPA												
Year 1	569	25.66	31.62	268	52.73	26.60	301	1.55	5.11	30.99	284.56	0.00
Year 2	625	25.46	33.04	248	58.70	27.91	377	3.60	9.58	29.95	285.61	0.00
Year 3	524	19.37	30.39	155	60.05	26.06	369	2.29	6.23	27.27	161.45	0.00
% time in on-task behavior: pre-SOFIT												
Year 1	557	84.86	15.52	256	83.68	16.88	301	85.87	14.22	-1.64	501	0.10
Year 2	588	88.91	14.11	211	87.36	15.99	377	89.78	12.88	-1.88	363.47	0.06
Year 3	525	91.98	13.72	156	88.89	16.70	369	93.29	12.04	-2.98	226	<0.01
% time in on-task behavior: post-SOFIT												
Year 1	544	86.84	15.45	263	88.46	14.51	281	85.32	16.16	2.38	542.00	0.02
Year 2	591	88.86	14.26	232	89.77	15.41	359	88.26	13.46	1.22	445.26	0.22
Year 3	525	91.35	16.14	156	91.58	15.19	369	91.26	16.54	0.21	523.00	0.83

Values are presented as Mean (M) and standard deviation (SD)

Table 3
Percent of time-on-task behavior pre-SOFIT evaluation with demographic, anthropometric and fitness covariates

Fixed effect	Estimate	SE	z	p	F	p
Intercept	87.26	7.28	11.99			
Year (linear change)	4.18	0.83	5.02	0.000	43.77	0.000
Group					6.70	0.010
<i>Intervention</i>	-1.69	1.44	-1.17	0.242		
<i>Control (reference)</i>	-	-	-	-		
Year * Group (group difference in change)					0.00	0.975
<i>Intervention</i>	0.04	1.26	0.03	0.975		
<i>Control (reference)</i>	-	-	-	-		
Age	-0.50	0.74	-0.67	0.501	0.45	0.501
Gender					14.56	0.000
<i>Male</i>	-3.14	0.82	-3.82	0.000		
<i>Female (reference)</i>	-	-	-	-		
Race					1.19	0.314
<i>White</i>	4.65	4.75	0.98	0.329		
<i>Black/African American</i>	4.74	5.04	0.94	0.347		
<i>Asian</i>	8.10	5.75	1.41	0.160		
<i>American Indian /Alaska Native</i>	10.14	5.77	1.76	0.079		
<i>Two or more races</i>	6.17	4.85	1.27	0.205		
<i>Unknown (reference)</i>	-	-	-	-		
Free/reduced meals					1.50	0.221
<i>Yes</i>	-1.14	0.93	-1.23	0.221		
<i>No (reference)</i>	-	-	-	-		
BMI Percentile	-0.02	0.01	-1.65	0.099	2.73	0.099
PACER Laps	0.03	0.05	.68	0.497	0.46	0.497
Random effect	Estimate	SE	z	p		
Student	8.27	8.93	0.93	0.177		
Teacher	16.52	5.31	3.11	0.001		

	Estimate	SE	z	p	F	p
Fixed effect	177.91	10.73	16.58	0.000		
Residual						

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Percent of time-on-task behavior post-SOFIT evaluation with demographic, anthropometric and fitness covariates

Table 4

Fixed effect	Estimate	SE	z	p	F	p
Intercept	91.62	7.29	12.57			
Year (linear change)	3.79	0.84	4.49	0.000	21.90	0.000
Group					6.50	0.011
<i>Intervention</i>	3.68	1.44	2.55	0.011		
<i>Control (reference)</i>	-	-	-	-		
Year * Group (group difference in change)					1.64	0.02
<i>Intervention</i>	-1.62	1.26	-1.28	0.202		
<i>Control (reference)</i>	-	-	-	-		
Age	-0.16	0.76	-0.21	0.835	0.04	0.835
Gender					13.95	0.000
<i>Male</i>	-43.17	0.85	-3.73	0.000		
<i>Female (reference)</i>	-	-	-	-		
Race					0.66	0.652
<i>White</i>	-3.68	4.59	-1.80	0.423		
<i>Black/African American</i>	-3.94	4.90	-0.80	0.422		
<i>Asian</i>	0.59	5.73	0.10	0.918		
<i>American Indian /Alaska Native</i>	-0.84	5.76	-0.15	0.885		
<i>Two or more races</i>	-4.49	4.71	-0.95	0.341		
<i>Unknown (reference)</i>	-	-	-	-		
Free/reduced meals					0.67	0.415
<i>Yes</i>	0.78	0.96	0.82	0.415		
<i>No(reference)</i>	-	-	-	-		
BMI Percentile	-0.01	0.02	-0.49	0.623	0.24	0.623
PACER Laps	-0.01	0.05	-0.15	0.880	0.02	0.880
Random effect	Estimate	SE	z	p		
Student	0.00	-	-	-		
Teacher	14.46	4.65	3.11	0.001		

	Estimate	SE	z	p	F	p
Fixed effect	204.08	8.37	24.39	0.000		
Residual						

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Percent of time on-task behavior post-SOFIT based on time spent in MVPA with demographic, anthropometric and fitness covariates

Table 5

Fixed effect	Estimate	SE	z	p	F	p
Intercept	91.59	7.26	12.62			
Year (linear change)	3.12	0.79	3.97	0.000	15.77	0.000
% time in Sofit MVPA	0.06	0.02	2.75	0.006	7.55	0.006
Year * % time in Sofit MVPA	-0.01	0.02	-0.30	0.766	0.09	0.766
Age	-0.11	0.76	-0.15	0.882	0.02	0.882
Gender					13.33	0.000
Male	-3.08	0.84	-3.65	0.000		
Female (reference)	-	-	-	-		
Race					0.70	0.626
White	-3.83	4.58	-0.84	0.404		
Black/African American	-3.86	4.89	-0.79	0.430		
Asian	0.82	5.72	0.14	0.886		
American Indian /Alaska Native	-1.50	5.74	-0.26	0.794		
Two or more races	-4.66	4.69	-0.99	0.322		
Unknown (reference)	-	-	-	-		
Free/reduced meals					0.47	0.493
Yes	0.66	0.95	0.69	0.493		
No(reference)	-	-	-	-		
BMI Percentile	-0.01	0.02	-0.46	0.644	0.21	0.644
PACER Laps	-0.01	0.05	-0.15	0.879	0.02	0.879
Random effect	Estimate	SE	z	p		
Student	4.79	8.55	0.56	0.288		
Teacher	14.73	4.36	3.38	0.000		
Residual	208.56	11.05	18.87	0.000		