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Physical activity and academic achievement across the curriculum: Results from a 3-year cluster-randomized trial

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Abstract

We compared changes in academic achievement across 3 years between children in elementary schools receiving the Academic Achievement and Physical Activity Across the Curriculum intervention (A+PAAC), in which classroom teachers were trained to deliver academic lessons using moderate-to-vigorous physical activity (MVPA) compared to a non-intervention control. Elementary schools in eastern Kansas (n=17) were cluster randomized to A+PAAC (N=9, target ≥ 100 min/wk.) or control (N=8). Academic achievement (math, reading, spelling) was assessed using the Wechsler Individual Achievement Test-Third Edition (WIAT-III) in a sample of children (A+PAAC = 316, Control = 268) in grades 2 and 3 at baseline (Fall 2011) and repeated each

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spring across 3 years. On average 55 min/wk. of A+PACC lessons were delivered each week across the intervention. Baseline WIAT-III scores (math, reading, spelling) were significantly higher in students in A+PAAC compared with control schools and improved in both groups across 3 years. However, linear mixed modeling, accounting for baseline between group differences in WIAT-III scores, ethnicity, family income, and cardiovascular fitness, found no significant impact of A+PAAC on any of the academic achievement outcomes as determined by non-significant group by time interactions. A+PAAC neither diminished or improved academic achievement across 3-years in elementary school children compared with controls. Our target of 100 min./wk. of active lessons was not achieved; however, students attending A+PAAC schools received an additional 55 min./wk. of MVPA which may be associated with both physical and mental health benefits, without a reduction in time devoted to academic instruction.

Keywords

Physical activity; Children; Academic achievement; Cluster-randomized trial; Cognitive function; Cardiovascular fitness

Introduction

The majority of elementary school children in the US attend school for 5–7 hours/day, 5 days/wk. approximately 9 months/year (ECS, 2011). Thus, schools provide a potential site for interventions designed to increase moderate-to-vigorous physical activity (MVPA); although traditional classrooms encourage sedentary behavior to promote an environment thought to be conducive to learning. Traditionally, schools have relied on physical education/recess to provide MVPA for students (McKenzie et al., 1998; Morgan and Bourke, 2005; Morgan and Hansen, 2008). However, concerns regarding meeting academic goals mandated by government policies including the Every Student Succeeds Act of 2015 and Common Core State Standards Initiatives, has likely contributed to recent reductions in time allotted for physical education/recess (Association, 2010; Klein, 2015).

The 2010 Centers for Disease Control review on school-based physical activity and academic performance (CDC, 2010) and the recent American College of Sports Medicine (ACSM) Position Stand on physical activity and academic achievement in children (Donnelly et al., 2016) both suggest the potential for academic instruction incorporating physical activity to improve MVPA during the school day and academic achievement without reducing time devoted to classroom instruction; an approach which may be attractive to school administrators and teachers who are unlikely to adopt or sustain any intervention that reduces instruction time or requires significant additional resources. However, the ACSM Position Stand (Donnelly et al., 2016) indicates empirical support for the association between increased MVPA and improved academic achievement is derived from mostly inadequately powered, cross-sectional or observational studies which lack methodological rigor including failure to consider potentially important confounders including body mass index and socioeconomic status or to blind outcome assessments.

Our group previously completed a 3-year cluster randomized trial titled “Physical Activity Across the Curriculum” (PAAC, DK61489) to evaluate the impact academic lessons

delivered by classroom teachers using MVPA (goal 90 min/wk.) on changes in BMI between children who were in grade 2 at baseline attending schools randomized to PAAC versus non-PAAC control. A description of the design and results have been published (Donnelly et al., 2009; DuBose et al., 2008). As a non-powered exploratory aim we compared change in academic achievement over 3 years (Weschler Individual Achievement Test-Second Edition-WIAT-II) in a random sub-sample (n=167). We observed significantly greater improvement in composite academic achievement score, and reading, math and spelling scores in students in PAAC compared with control schools. Based on these results, we conducted a cluster-randomized trial titled “Academic Achievement and Physical Activity Across the Curriculum” (A+PAAC) that was powered to compare changes in academic achievement between children in elementary schools receiving academic lessons delivered by classroom teachers similar to our previous trial, and a non-intervention control. Project details regarding the design and methods and the results for cognitive function from this trial have been published (Donnelly et al., 2013; Scudder et al., Accepted). Results for our primary outcome, academic achievement, and secondary outcomes including BMI, waist circumference and cardiovascular fitness are presented herein. This study was approved by the Human Subjects Committee at the University of Kansas (HSCL #13460).

METHODS

Recruitment/Randomization-Schools

Schools were required to be within a 25-mile radius of Lawrence, KS, include grades 2 through 5, have at least 40 students in grades 2 and 3, not be participating in other classroom-based physical activity interventions, and agree to be randomized to intervention or control. Schools were recruited during in-person visits with school principals and teachers and were monetarily compensated for participation. Seventeen elementary schools (clusters) from 3 school districts agreed to participate. Schools were stratified by district (n=3) and computer randomized by the study statistician to A+PAAC (N = 9) or control (N = 8).

Recruitment-Students

Parents of students in grades 2 and 3 received a flyer describing the study. Only students in grades 2 and 3 at baseline were included as study participants, and they were followed as they progressed across the 3-year intervention to grades 4 and 5. Recruitment exceeded both our capacity to complete evaluations of our primary outcome in a timely manner and the number of students per school required to achieve adequate statistical power. Therefore, the first eligible 11 boys and 11 girls in each grade at each school, who returned a completed consent packet, were included in the study sample.

A+PAAC lessons: description

A+PAAC integrates activity with academic instruction in contrast to physical activity breaks (e.g. brain breaks), which are typically unrelated to academic lessons. The A+PAAC concept can be applied in a variety of academic disciplines including mathematics, language arts, geography spelling etc. and settings (e.g., classroom, hallways, cafeterias etc.) and is limited only by teacher creativity, and at times the configuration of the physical surroundings.

A+PAAC: classroom teacher training

Second and 3rd grade teachers in intervention schools were trained to provide A+PAAC lessons during a 1-day (6-hour) in-service prior to initiating the intervention with booster sessions (1-day, 4-hour) at the beginning of years 2 and 3. New teachers joining intervention schools during the intervention were trained individually. Teachers were provided with a written teacher's guide and access to the study website, both included a variety of sample lessons connected to the common core state standards. Teachers were asked to participate in A+PAAC lessons to model active behavior for their students and were also asked to log on to the study website to report the number of minutes of A+PAAC activities performed each day.

A+PAAC: prescribed amount/intensity

Classroom teachers were asked to deliver two, 10-minute lessons per day (~4–5 METs) in the subject of their choice; one in the morning and one in the afternoon, 5 days per week,100 min./wk. A+PAAC lessons (100 min/wk.) plus physical education (60 min/wk.) would provide ~160 min/wk. of physical activity each week. This amount of activity is less than the 300 min/wk./(60 min/day) recommended for health promotion in children (Services and Committe, 2008); however, feed-back obtained from focus groups with teachers and school administrators from the PAAC trial (Gibson et al., 2008), suggested higher levels of classroom physical activity were unacceptable.

Outcomes

Outcomes pertinent to this report, including academic achievement, cardiovascular fitness, waist circumference, and BMI were assessed during 2 month periods at baseline (Fall 2011) and at the end of the Spring semester in 2012, 2013 and 2014 in conjunction with the active intervention. Staff completing assessments, other than those obtained in the classroom, and staff performing data entry, were blinded to condition.

Research staff training

Staff training to review and practice standardized protocols for all assessments were conducted prior to baseline data collection and at the beginning of subsequent data collection periods. An inter-rater reliability of > 0.90 was required for all assessments prior to staff participation in data collection. Student and teacher MVPA during A+PAAC lessons was assessed by one group of research staff, while a second independent group completed outcome assessments (academic achievement, height/weight, waist circumference, cardiovascular fitness).

Academic achievement

Academic achievement was assessed with the Wechsler Individual Achievement Test-Third Edition (WIAT-III) an instrument with established reliability and validity (Wechsler, 2009). The WIAT-III measures improvements (or detriments) in academic achievement regardless of where students rank (high or low), assuming a normal range of intelligence (The Wechsler Individual Achievement Test-Third Edition, San Antonio: Pearson, 2009). All tests were checked for accuracy by a qualified investigator. Discrepancies between research staff and

the supervising investigator were resolved by another co-investigator. Subtest and composite scores were computed using the WIAT-III scoring assistant. Standardized composite scores for mathematics (math problem solving and numerical operations subtests), reading comprehension fluency (reading comprehension and oral reading fluency subtests) and the standardized subtest score for spelling were analyzed.

Anthropometrics (Height/weight/waist circumference)

Weight was measured (± 0.1 kg) on a calibrated digital scale (Model #PS6600, Befour, Saukville, WI) while standing height was measured with a portable stadiometer (Model #IP0955, Invicta Plastics Ltd., Leicester, UK). BMI (kg/m^2) percentile was calculated using CDC growth charts (Kuczmarski et al., 2002). Waist circumference was assessed using the procedures of Lohman et al. (Lohman et al., 1988).

Cardiovascular fitness

Cardiovascular fitness was assessed using the Progressive Aerobic Cardiovascular Endurance Run (PACER)(Leger and Lambert, 1982; Leger et al., 1988; Welk and Meredith, 2008). The reliability and validity of PACER are both moderately high and acceptable (Welk and Meredith, 2008). Participants ran a 20-meter shuttle course with 1- minute stages, paced by an audible beep. The number of laps completed constituted the PACER score.

Process evaluation

We evaluated the degree to which the intervention was implemented as designed (i.e., fidelity via teacher self-reports), and the level of engagement in A+PAAC lessons by both teachers and students (i.e., dose via direct observation). The System for Observing Fitness Instruction Time (SOFIT) (Heath et al., 2006; Honas et al., 2008; McKenzie et al., 1992) was used to document both student and teacher level of physical activity and the subject matter (reading, math, spelling etc.) of the A+PAAC lessons. The SOFIT is a time-moment, repeated sampling technique that rates the level of physical activity on a 5-point Likert scale: 1= lying, 2= sitting, 3 = standing, 4= walking/moderate, 5= vigorous. Observations were completed over 20-second intervals on selected participants over the duration of the A +PAAC lesson in intervention classrooms and over a 10-minute interval, consistent with the duration of the scheduled A+PAAC lessons, in control classrooms. Observations were completed in both intervention and control schools every other week across the school year. Prior to a school visit research staff contacted classroom teachers to confirm the visit. During the first classroom visit observations were completed on the teacher and on the first 3 students on a random list of participants. Subsequent observations were completed on the teacher and the next 3 students on the list. If a student was absent, the next student on the list was assessed. We attempted to observe the missing student during the next scheduled classroom visit. This cycle continued across the 3-year intervention.

The energy expenditure of A+PAAC activities was assessed in a volunteer sample of students (17 boys, 15 girls) using a portable indirect calorimeter (COSMED $K4b^2$, Rome, Italy (Honas et al., 2016). Principals/vice principals from both intervention and control schools completed a 5-item survey at the end of each school year to assess external or competing factors that may have influenced the objectives of the A+PAAC intervention

including changes in the time allocated to physical education/recess or the adoption of new course content intended to increase student physical activity.

Sample size

Based on our previous PAAC trial we expected an average increase in standardized composite scores for mathematics, reading comprehension fluency, and spelling of 5 points in the A+PAAC group, no change in the control group, with a common standard deviation of 9 points. Power analysis indicated randomizing 14 schools with a minimum of 40 participants would provide > 80% power to detect the hypothesized between group differences with a type I error rate of 5% with intra-class correlations (ICC) as high as 0.10.

Statistical analysis

Baseline demographics were summarized by means and standard deviations or percentages, as appropriate. Two-sample t-tests for quantitative variables and the chi-square test for categorical variables were used to determine the significance of differences in baseline participant characteristics. Change (year 3 minus baseline) in academic achievement between intervention and control was compared using Donner's t-test to account for the clustering (ICC) within schools with a type I error rate of 5% for each test. Multiple imputation (k=5), using age and minority status, was used to impute change in academic achievement for students missing scores at year 3. Similar analyses, without imputation, were completed using students with data on secondary outcomes (waist circumference, BMI and cardiovascular fitness) at both baseline and year 3. Between group differences in SOFIT scores were evaluated using the Wilcoxon Rank-Sum test and the association between teacher and student SOFIT scores was evaluated using a Spearman correlation. Linear mixed models, controlling for baseline WIAT-III scores, household income, and cardiovascular fitness were used to assess the longitudinal impact of the intervention and any potential intervention by time interaction on WIAT-III scores.

RESULTS

Sample description

Descriptive characteristics of participating schools and students are presented in Tables 1 and 2, respectively. Schools were located primarily in urban areas (~70%), included ~ 25% minorities with ~39% of students qualifying for free and reduced lunch. A total of 698 2nd and 3rd grade students (A+PAAC = 374, 2nd grade = 48.1%); control = 324, 2nd grade = 49.3%), which represented 36.7% of those eligible, provided parental consent, student ascent, and completed baseline testing. There was a significantly greater percentage of students from households with higher income, and a lower percentage of students of Hispanic/Latino ethnicity and students qualifying for free or reduce lunch in A+PAAC compared with control schools. The CONSORT diagram (Figure 1) describes schools/student flow across the 3-year intervention. Two schools withdrew during year 1 citing time constraints and competition for instruction time with reference to the pressures of achieving the academic standards set forth by the Common Core State Initiative. Six schools (A+PAAC = 3, Control = 3) did not participate in any secondary outcome assessments in year 2, citing the same concerns. However, these six schools participated in all outcome

assessments in year 3. Year 3 assessments were completed in 77.2% and 76.1% of the baseline sample in the intervention and control groups, respectively. Student attrition was primarily due to the withdrawal of the 2 schools with additional attrition resulting from students moving from A+PAAC control schools or vice versa, or moving out of participating districts.

Intervention delivery

Schools were in academic session approximately 4 days/wk. during the intervention. Academic session denotes regular classroom instruction where A+PAAC lessons were feasible and not for example, field trips, assemblies, teacher/parent meetings, etc. Based on teacher reports, A+PACC lessons were delivered ~ 3 days/wk. for an average of ~ 55 minutes/wk. across the 3-year intervention. A+PACC delivery (min/wk.) was highest in year 1 (60.8±32.3) and deceased in both years 2 (54.6±34.4) and 3 (49.2±33.6). MVPA was incorporated primarily in math (~2 days/wk.) and language arts (~ 1 day/wk.) and less frequently in science or social studies (< 1 day/wk.). Student SOFIT scores were higher in A +PAAC compared with control schools in years 1 (INT = 3.6±0.5, CON= 2.1±0.2), 2 (INT = 3.8±0.5, CON = 2.2±0.3) and 3 (INT=3.8±0.5, CON= 2.1±0.3). SOFIT scores for teachers in A+PAAC schools were 3.4±0.5, in year 1, 3.6±0.6 in year 2 and 3.4±0.6 in year 3 compared with teachers in control schools of 2.7±0.5, 2.9±0.5, 2.8±0.5 for years 1–3, respectively. There was a modest, (r=0.27) but significant association ($p < 0.05$) between teacher and student SOFIT scores. The average intensity of student classroom activity, assessed by indirect calorimetry, was 4.2 ±0.9 METs in A+PAAC schools compared with 1.9 ± 0.4 METs in control schools ($p<0.0001$). Results from principal/vice principal surveys indicated that time devoted to physical education (2 days/wk., ~33 min/day) was similar in A +PAAC and control schools. Both A+PAAC and control schools had running/walking clubs designed to promote student physical activity.

Primary Outcome- Academic Achievement (Table 3)

Baseline WIAT-III scores for all 3 measures of academic achievement (reading comprehension fluency ($p=.010$), mathematics ($p=.005$) and spelling ($p<.01$)) were significantly higher in A+PAAC compared with control schools. Academic achievement improved from baseline to year 3; however, there were no significant between group differences for change (year 3 minus baseline) in any of the 3 academic achievement outcomes. ICC's ranged from 0.013 for spelling to 0.036 for reading comprehension fluency. A linear mixed modeling analysis, accounting for baseline between group differences in WIAT-III scores, ethnicity, income, and cardiovascular fitness, also found no significant impact of A+PAAC and no significant intervention by time interaction on any of the academic achievement outcomes.

Secondary Outcomes- BMI Percentile, Waist Circumference, and Fitness

There were no significant between group differences for change in BMI percentile (A +PAAC = −1.3±12.2; control = +1.0 ±14.1, $p = 0.08$), waist circumference (A+PAAC = 9.4 ± 5.3 cm; control = 10.3 ± 5.6 cm, $p = 0.32$ or cardiovascular fitness (PACER laps) (A +PAAC = 8.2 ±10.2; control = 6.9± 8.8, $p = 0.27$) for students in A+PAAC compared with

control schools. The results for BMI percentile and waist circumference were unchanged when accounting for change in cardiovascular fitness and ethnicity.

DISCUSSION

Academic achievement improved across 3 years in reading, math and spelling in children in both A+PAAC and control schools, with no significant between group differences. Baseline academic achievement, assessed by the WIAT III, was significantly higher in children in A+PAAC compared with control schools. There is no ceiling on WIAT III scores and children who achieve higher at baseline can improve scores just as children who do not perform as well at baseline. Thus, our observation of no between group differences in academic achievement across 3 years is unlikely attributed to the inability of children in A+PAAC schools to improve on baseline WIAT III scores. Furthermore, a linear mixed modeling analysis, accounting for baseline between group differences in WIAT-III scores, ethnicity, income, and cardiovascular fitness, also found no significant impact of A+PAAC and no significant intervention by time interaction on any of the academic achievement outcomes. Although uncertain, it is reasonable to suggest that baseline differences are not responsible for the non-significant differences for academic achievement between A+PAAC and control schools.

Our finding of no impact of physically active academic lessons on academic achievement in elementary school children is in agreement with some, but not all of the available literature. The recent ACSM Position Stand on Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children (Donnelly et al., 2016) identified 5 studies that evaluated the effect of physically active academic lessons on academic achievement in elementary school children. Three studies reported improvements in mathematics scores (Donnelly et al., 2009; Erwin et al., 2012; Hollar et al., 2010) over interventions ranging from 20 weeks to 3 years, one 4-month study reported no change in mathematics or language arts score, but improvements in social studies (Reed et al., 2010), and a 1-year study reported improvements in math and reading scores for children initially in third, but not second grade (Mullender-Wijnsma et al., 2015). Results from trials published subsequent to those included in the ACSM Position Stand (post May 1, 2015) are also inconsistent with trials in elementary school students reporting both no effect of physically active lessons on performance on a mathematics achievement test (Riley et al., 2016) and significantly greater improvements in test scores for mathematics speed, general mathematics and spelling achievement in children in the intervention compared with the control groups (Mullender-Wijnsma et al., 2016).

Weekly A+PAAC activity ranged from ~60 min./wk. in year 1 to ~49 min/wk. in year 3. This is less than the ~75 min./wk. observed in the original PAAC trial (Donnelly et al., 2009). Several factors contributed to the inability to reach our target of 100min./wk. of A+PAAC lessons. First, as reported by teachers, schools were in academic session on average only 4 days/wk. over the 3-year intervention due to a variety of special events (e.g., parent/teacher meetings) that reduced the potential to deliver A+PAAC lessons. Second, changes in classroom structures from the traditional (i.e., 1 teacher/class) to alternative structures, including open and blended classrooms, team teaching, etc., and limited classroom space

due to the increased use of computer technology, may have impacted the ability of teachers to deliver physically active lessons on a consistent basis. Perhaps most importantly, the intervention was implemented during the emergence of several academic initiatives and requirements in the state of Kansas which emphasized core subjects, and based school and teacher accountability on student performance. Although designed specifically to preserve academic instruction time, some teachers expressed anxiety and perceived A+PAAC as incongruent with academics, and were reluctant to deliver the intervention as designed. However, 60% of teachers in A+PAAC schools delivered ~55 min./wk. of physical activity across the 3-year intervention, an amount of activity similar to that obtained from physical education (~60 min./wk.). The average intensity of A+PAAC activities (4.2 METs) met our intensity goal (4–5 METs) and exceeded that of the original PAAC (3.4 METs.) (Honas et al., 2016). However, this level of intensity did not produce significant improvements in cardiovascular fitness over the 3-year intervention. Increased cardiovascular fitness has been associated with improved cognitive function, brain structure and function and academic achievement (Chaddock et al., 2012; Donnelly et al., 2016; Hansen et al., 2014; Hillman et al., 2014; Scudder et al., 2014). For example, analyses completed using baseline data from this trial have demonstrated a significant positive association between cardiovascular fitness and inhibitory control assessed by the flanker task (Scudder et al., 2014), working memory assessed by the n-back task and academic achievement in mathematics and spelling assessed by the WIAT-III (Hansen et al., 2014).

The majority of laboratory based randomized trials demonstrate a positive effect of physical activity and/or cardiovascular fitness on cognitive function (Donnelly et al., 2016). However, translating results from laboratory trials to the classroom setting, with the goal of improving academic achievement has provided mixed results (Donnelly et al., 2009; Erwin et al., 2012; CDC; Reed et al., 2010). Our experience with the current trial identified several areas which may need to be addressed to improve results from classroom based interventions designed to improve academic achievement. Many teachers found it difficult to incorporate physical activity into their academic lessons, as this approach is contrary to the traditional sedentary classroom. Although we provided extensive teacher training, resource materials, etc., teachers frequently expressed a level of stress associated with extra time devoted to developing active lessons, and maintained the perception that active lessons diminished instruction time. Innovative strategies to provide additional teacher training and support or alternatives to individual teacher delivery may improve the quality and quantity of physically active lessons. For example, teacher training delivered remotely using computer technology (e.g. video conferencing), the use of electronic motion sensors (e.g. Fitbit) to monitor activity and provide feedback, or the delivery of active academic lessons by a single classroom teacher, experienced with this approach, to groups of classes simultaneously using technology all warrant investigation. Finally, it may important to develop higher intensity (≥ 5 METs) active lessons that can be performed safely in the classroom setting. Higher intensity lessons may be more likely to improve cardiovascular fitness, cognitive function and academic achievement and increased intensity may be more acceptable to teachers/ school administrators than increased duration.

Strengths of this trial include the use of a cluster-randomized design, a sample size powered to evaluate changes in the primary aim (academic achievement), and evaluation of academic

achievement using a well-established instrument by research staff blinded to intervention group, over a period of 3 academic years. Despite randomization we observed significant baseline differences between the intervention and control groups in academic achievement, cardiovascular fitness, parental education and income, and ethnicity which may be considered a potential weakness. However, accounting for baseline differences using mixed modeling did not alter our results. Additional potential weaknesses include: variability between teachers in the amount of time spent in active lessons directed to specific subject areas (reading, math, spelling), and variability in the time between completion of an active lesson and academic achievement testing. It is also impossible to know if the withdrawal of 2 schools (1 intervention, 1 control) during year 1 of the intervention impacted our results. However, the 8 intervention and 7 control schools that completed the intervention exceeded the number of schools (7 intervention, 7 control) required to provide adequate statistical power for the evaluation of our primary aim; i.e., between group differences in change in academic achievement.

CONCLUSION

The A+PAAC intervention did not improve or diminish academic achievement across 3-years in a sample of children, initially in second and third grade attending public schools in eastern Kansas. Although our target of 100 min./wk. of active lessons was not achieved, students attending A+PAAC schools received an additional 55 min./wk. of physical activity which may be associated with both physical and mental health benefits, without a reduction in time devoted to academic instruction.

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Abbreviations

A+PAAC	Academic Achievement and Physical Activity Across the Curriculum
METs	Metabolic equivalents
MVPA	moderate-to-vigorous physical activity
PACER	Progressive Aerobic Cardiovascular Endurance Run
SOFIT	System for Observing Fitness Instruction Time
WIAT-III	Wechsler Individual Achievement Test-Third Edition

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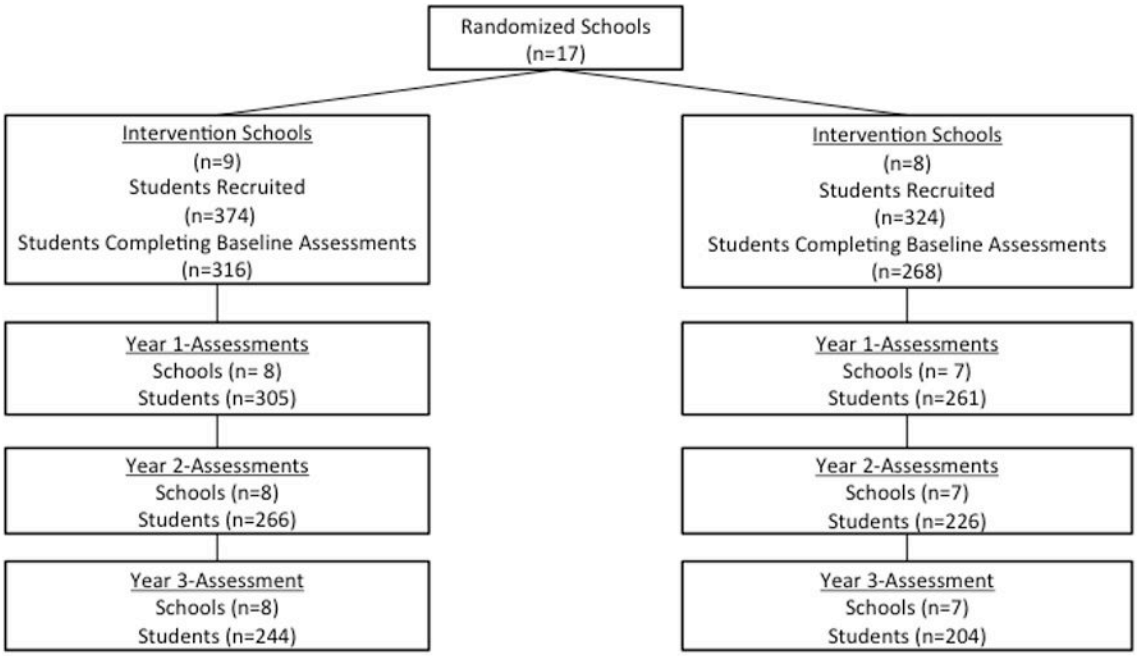

Figure 1.

Table 1

Descriptive characteristics of participating schools

	Intervention (n = 9)	**Control (n = 8)**
Total enrollment 2nd and 3rd grade	978	924
Average 2nd and 3rd grade class size	22.5 ± 5.3	20.4 ± 2.6
Urban/rural schools (n/n)	6/3	6/2
Minority[a] (%)	23.8	30.2
Free/reduced lunch (%)	35.3	42.5

Values are n's, percentages or mean ± standard deviation.

[a]Non-white

Table 2

Student baseline descriptive characteristics

	Intervention (n = 316)	Control (n = 268)	*p* between groups
Age (yrs.)	8.1 ± 0.6	8.1 ± 0.6	0.375
Height (cm)	129.7 ± 6.6	129.6 ± 6.8	0.793
Weight (kg)	29.8 ± 7.2	29.8 ±7.8	0.995
Waist circumference (cm)	57.6 ± 7.5	57.4± 7.8	0.640
BMI (kg/m^2)	17.5 ± 3.1	17.5 ± 3.2	0.984
BMI percentile	62.8 ± 29.0	61.9 ± 29.9	0.708
Cardiovascular fitness (PACER laps)	17.3 ± 9.4	15.8 ± 8.4	0.043
Girls (%)	49.1	54.1	0.223
Free/reduced lunch (%)	27.2	34.0	0.046
Hispanic/Latino (%)	6.3	14.6	0.003
Annual household income (%)			< 0.001
≤ $20,000	13.6	9.3	
$21,000–$50,000	22.5	32.1	
$51,000–$70,000	12.3	16.8	
$71,00–$100,000	21.8	23.1	
>$100,000	26.9	13.1	
Missing/unknown	2.8	5.6	

Values are mean ± standard deviation or percentage.

[a]Non-white

Table 3

Academic achievement across 3 years

	Baseline			**Year 1**		**Year 2**		**Year 3**		**Change (Year 3 – baseline)**		
	I	**C**	***p***	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	***p***
Reading	101.8 (13.5)	98.8 (13.9)	0.010	107.5 (15.2)	105.2 (14.8)	108.0 (13.4)	105.9 (14.4)	105.2 (13.2)	104.8 (13.5)	2.6 (9.5)	4.8 (10.5)	0.056
Math	104.5 (12.1)	101.6 (11.7)	0.005	107.9 (12.5)	105.9 (12.5)	107.2 (12.0)	105.7 (12.2)	107.6 (13.3)	105.7 (14.0)	2.8 (10.0)	3.6 (11.2)	0.082
Spelling	102.1 (10.9)	98.6 (11.8)	0.002	106.5 (12.1)	101.5 (12.4)	104.4 (13.1)	102.9 (13.7)	103.8 (13.7)	103.0 (14.5)	1.3 (9.0)	4.1 (9.4)	0.366

Values and mean (SD). I = Intervention (A+PAAC), C = Control