

The Impact of Increased Physical Activity on Academic Achievement
A Synthesis of the Research Literature

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Abstract

The purpose of this synthesis was to examine the existing body of knowledge regarding the impact of physical activity on academic achievement. Previous research identified several factors that contribute to the increased academic achievement in school aged students as a result of fitness level and physical activity. The studies reviewed within the critical mass yielded themes that contributed to the understanding of how physical activity (PA) impacts academics. The types of PA interventions, who was impacted, and how they were impacted were noted as factors which affected academic achievement (AA). PA is being drastically undervalued in schools. It is important to find ways to increase PA within a student's academic day. While previous research notes that increased PA has positive impacts academics further research is needed to understand which types of PA directly result in positive AA. Future research should study the effects of intervention recommendations on AA in students.

Keywords: [Physical Activity, physical education, Academic achievement, Time on task, standardized tests]

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Chapter 1

Introduction

The war on Physical Education is real. Even in the state New York where Physical Education is a state mandated course, class sizes are rising and budgets are shrinking. The National Association for Sport and Physical Education (NASPE) recommends that the size of physical education classes be comparable to other subject areas (e.g. maximum 1:25 for Elementary School, 1:30 for Middle School, 1:35 for High School) for safe and healthy instruction (NASPE, 2006). According to the union contract for NYC the Physical education number for High School is maxed out at 50, and for younger grades there is currently no limit to how many students can be in the gym at one time (NYC Teacher contract, 2018). The median funding amount for physical education programs is \$764, and according to a study done by Roslow research group (2009), most programs have seen budgets remain the same or shrink. Forty five percent of physical education teachers say that their budgets have remained about the same since 2006, and 36% say that budgets have decreased (Roslow, 2009). All of this while programs promoting science, technology, engineering, and math (STEM) saw a jump, states like California for example, in recent budget contracts, for as much as \$400 million.

The evidence above can only lead to the conclusion that physical education, and physical activity as a whole, are being devalued in academic environments. There are only six states — Alabama, Georgia, Mississippi, North Carolina, Illinois and Iowa-- that adhere to standards from NASPE that school children participate in 150 minutes a week of physical education (Rochman 2011). In addition, just three states — Delaware, Virginia and Nebraska — have 20 minutes of mandatory elementary-school recess a day. As it stands, in New York, it is a state requirement for HS graduation that students have four credits of English, four of Social studies, three of

science, and three of math (one credit= one full year of daily participation), while physical education has a mandate of only two credits, but must be taken every semester (NYS DOE, 2019).

The emphasis on certain academic subjects is intended to help increase student test scores; however, this has not always been successful. According to a study done by the Pew Research Center (2017), the National Assessment of Educational Progress, a project of the federal Education Department stated that math scores fell for the first time in years, after trending water for several years prior. The average fourth-grade NAEP math score in 2015 was 240 (of a possible 500), the same level as in 2009 and down from 242 in 2013. The average eighth-grade score was 282 in 2015, compared with 285 in 2013; that score was the lowest since 2007 (Desilver, 2017). High school test scores had only been recorded 4 times, but in 2015 they were the same or lower than the previous 3 records taken from 2009-2013 (Desilver, 2017). To speak specifically about New York, The New York Times released statistics in a recent article that stated in 2009, 82 percent of test-takers in New York City passed the state wide standardized math exam. The next year, about half of city students failed it, and by 2013, about 70 percent of students were failing (Shapiro, 2018).

Physical activity is a critical component to any healthy lifestyle; this is not limited to physical health. Physical education and physical activity is a critical piece of our academic communities and the only way to prove this might be to successfully make the connection between physical activity and increasing student achievement in the classroom.

Statement of the Problem

The purpose of this synthesis is to explore the impact of physical activity on academic achievement. Specifically three components that might better help us to understand exactly how

to get the most out of increasing physical activity in schools. This synthesis intends to explore the different types of physical activity, amount and duration of physical activity, and what types of people can be impacted.

Operational Definitions

Physical Activity (PA)- Any bodily movement produced by skeletal muscles that requires energy expenditure. Will include physical education and in class exercise. (World Health Org, 2019)

Academic Achievement (AA)- Is represented by an increase in test scores, typically in math and science. AA is also considered when increasing time-on-task behaviors. (Mahar, 2011)

Scope of Synthesis

This synthesis looks to examine the benefits of increasing physical activity (PA) and its impact on students' academic achievement, as well as the importance of physical education. This synthesis will only take into consideration increasing physical activity in grades K-12, and college aged students. This synthesis does not look to factor in impacts on things outside of the standard school day. The study will focus on who is impacted by an increase in PA, what types of physical activity can be utilized, and what this increase in PA is impacting.

Chapter 2

Methods

Search Procedures

In order to find the critical mass of articles for my topic, I utilized the Brockport Online Library, as well as Google Scholar. I utilized a number of search terms to locate articles. The search terms I utilized to find the articles used were “academic achievement and physical activity” which returned 2,972 results, “importance of physical education” which yielded about

18,380 results, “physical education requirements” which gave about 9,765 results, and “physical activity and academic performance” which gave about 6,511 results. Results were then narrowed to include only original research studies and not literature review articles. With a wide variety of information centered on this topic, the search returned many results.

Criteria for Inclusion

The next step in my research was to choose articles that fit my synthesis question. Criteria for inclusion was centered around this idea, where the study and/or the articles needed to include information that addressed the question of how physical activity impacts academic achievement, specifically how it impacts time-on-task behaviors and increasing standardized test scores. The age groups effected were as a result of the searches conducted. The studies selected were made up of studies published in peer-reviewed journals or under the direction of government agencies (World Health Org.), and large institutions, which resulted in the 11 articles used for the critical mass.

Data Analysis

Articles chosen were then included in an article grid to more concisely summarize the main ideas and points behind the articles and their included studies. Studies were examined thoroughly to ensure all pertinent information regarding the synthesis question was extracted and included in this synthesis. Themes such as, types of exercise and who is most impacted, were chosen to more thoroughly show the impact of physical activity on students and their academic performance.

Chapter 3

Results

This section provides an overview of my findings in regards to the literature used for the critical mass. This consists of 11 articles that discuss physical activity and its impact on students' academic achievement, within the school community. The themes that emerged were as follows; what is impacted, who is impacted, and how it's impacted. They are discussed below.

What Is Impacted

Test scores and time on task (TOT) are the two biggest outcomes of interest when discussing academic achievement as a result of physical activity. Test scores are often used to determine the strength of a school as well as whether or not those students within that school are meeting the benchmarks they should be. TOT is extremely important in gauging academic achievement as it is described as time spent on academic related activities. These factors were most commonly measured by standardized tests as well as through researcher observation. Regardless of the data collection method positive results were seen in almost all cases.

Test scores. Test scores are one of the performance outcomes that is positively impacted by increasing PA. We see in the Chomitz et al, (2009) study that Math and English scores were tracked and the likelihood of passing the Massachusetts test in these areas was impacted based on fitness tests passed. These fitness tests consisted of an endurance cardiovascular test, an abdominal strength test, a flexibility test, an upper body strength test, and an agility test. So this is a good example of increasing PA, becoming more fit, and therefore scoring better on standardized tests. In the Donnelly et al., (2017) study teachers delivered academic activity lessons to see the impact on test scores. Math, reading, and spelling were assessed and an

average of 55 minutes per week of extra physical activity were used during the lessons. This type of intervention saw positive results on for the classroom teachers as test scores in these three areas increased during the intervention.

When discussing the impact on standardized tests it is important to mention where the biggest rise in scores came from. According to Resland et al. (2018) lower achieving students prior to interventions made more progress with standardized test scores. It stands to reason that students with more room for improvement would gain more. In the Resaland et al. study, it was researched how much scores were impacted as a result of physical activity breaks and active learning, after students were split into achievement categories (low, middle, high). Both boys (+10%) and girls (+18%) (Resland et al., 2018) in the low performing category had a similar beneficial trend, both gaining between 10 and 20% on the academic assessments administered, which evaluated skills in math, reading and english.

Time on task. Time on task is another outcome that has been shown to increase with PA. We see evidence of this in a study conducted by Webster, Wadsworth, and Robinson (2014) where 10 min activity breaks were implemented. Researchers used direct observation to record TOT, and found that most students gained an average of 18% points. Moreover, students deemed to be the most off task prior to the intervention gained an average of 30% on their TOT behaviors. Grieco, Jowers, Errisuriz, and Bartholomew (2009) found similar results when investigating TOT as a result of active lessons. Study habits, an activity closely related to TOT, has also been shown to increase as a result of PA (Caletine et al., 2017). Students who were more physically active demonstrated better ability to focus and study compared to those who were less physically active.

Who Is Impacted

Physical activity has been shown to produce positive impacts on academic achievement for a variety of school aged students. While elementary aged students are definitely the most widely impacted, there is evidence that secondary and college aged students are positively impacted as well.

Elementary students. It was found in numerous studies that increasing PA helped to positively impact academic achievement in pre-k and elementary aged students both in standardized test scores as well as TOT behaviors. In a study by Donnelly et al., (2017) researchers compared changes in academic achievement across three years between children in elementary schools. Math, reading, and spelling were assessed after classroom teachers delivered the extra PA. It was found that baseline scores (math, reading, spelling) were significantly higher in students who participated in the intervention compared with control schools.

Aerobic only breaks are one way in which studies were conducted to find the impact of PA on academic achievement. In a study executed by Fedewa, et al (2018), elementary students were tested at four different schools to find the impact of “aerobic only” breaks in the classroom, as opposed to active lessons. It was found that the activity only breaks were more effective than allowing the breaks to include some movement, but with a more academic focus (Fedewa et al., 2018). It was found that not only did the students involved in the “aerobic only” breaks see larger gains academically, but also saw larger gains in steps in their overall daily activity.

Gender can be another contributing factor to the effectiveness of PA on academics. Resaland et al. also researched impact of PA on AA within elementary aged students using gender as a potential factor on how much PA impacts academic achievement. Academic performance in math, reading, and English was measured and a composite score was calculated. The students participating in the study were divided into three academic categories (Low

achieving, middle and high) to better understand where the benefits can most accurately be attributed. While benefits in the high academic achievement category were present, they were much more prevalent in the lowest academic category. Both boys (+10%) and girls (+18%) (Resland et al., 2018) in the low performing category had a similar beneficial trend, both gaining between 10 and 20% on the academic assessments administered. While the girls saw the largest gain in the low category, the boys had larger returns in the other two categories (+4 % middle, and + 2 %, high) (Resland et al., 2018),

Time on Task (TOT) is another important barometer to be used when discussing elementary aged students and their academics. After studying students from one particular pre-k school researchers deemed that after the teacher implemented only 10 min activity breaks into the student's daily routine TOT improved (Webster, Wadsworth, and Robinson, 2014).

Academic activity lessons have also shown to increase TOT in students. Grieco, Jowers, Errisuriz, and Bartholomew (2009) investigated this idea with elementary aged students. It was found that TOT increased following academic games in contrast to the sedentary standard lesson (Grieco et al., 2016).

Classroom activity breaks has been found to improve TOT in students throughout their academic day. Schmidt, M., Benzing, V., & Kamer, M. (2016) investigated the effects of short physical activity breaks on attention-to-task in elementary school students. The particular focus here is on the idea that improving on-task behavior in elementary students using PA in the classroom setting. Schmidt et al. (2016) mentions that research in this particular area is sparse. The study found that students who participated in classroom-based physical activities that incorporate academic concepts demonstrated significantly better improvements (+8.3%) in attention-to-task behaviors than control group participants (-3.1%).

A study by Grieco, Jowers, and Bartholomew (2009), also inquires about how classroom PA breaks impact time-on-task (TOT) behavior while also increasing the activity time to 15 minutes. From early in the school day to later the tendency is for TOT behaviors to struggle, especially in elementary aged students “(Grieco et al., 2009), the authors stated that physically active classroom lessons provide a buffer to prevent the steep reduction in TOT experienced after a period of inactivity in all children” (Grieco et al, 2009, p.1921),

Secondary and College age

Most of the research has focused on elementary students, there is also some evidence that PA has a positive effect on the academic achievement of secondary and college students.

According to a mostly correlational study that was conducted across fourth through eighth grade classes at a school in Massachusetts by Chomitz et al, (2009), it was found that by increasing the number of fitness tests passed students were also increasing their standardized test scores. For each additional fitness test passed the percentage chance of passing both math and English tests went up, 38% for math and 25% for English. TOT was also a factor for college aged students.

There is a clear decline in PA and an increase in sedentary behavior amongst college aged students (Caestine et al., 2017). College students have increased academic demands on their time so finding a correlation between adequate PA and better study habits would be a large contribution to the discussion. Students were assessed based on cardiovascular endurance, muscular endurance, flexibility and body composition, as well as their academic diligence. Time spent studying was positively correlated with days per week of strength training for females and with minutes per week of exercise for both males and females (Caestine et al., 2017).

How it's Impacted

Within the critical mass there were several ways in which PA was utilized in the studies to investigate the influence on academic achievement. These include physical fitness measures and classroom interventions.

Physical fitness. Some studies discussed the relationship between physical fitness and academic achievement. For example Chomitz et al, (2009) found a correlation between fitness tests passed in physical education class and passing Math and English tests in the classroom. Another correlational study investigated the relationship between student self-esteem, PA and academic achievement (McAuley & Rudolph, 1995). The authors found that increased physical activity showed evidence of reducing depressive symptoms and anxiety while improving their academic habits in both test scores as well as study habits. Based on this idea Batista, Cubo, Honorio, and Martins (2016) investigated the influence of physical activity on self-concept, self-esteem and academic performance and also found a positive correlation. Students who participated actively in either individual sports, team sports, both individual and team sports, or physical education were considered to be more self-confident and self-assured and scored better on standardized tests.

Classroom interventions

There were also studies that had demonstrated a more direct connection between PA interventions and either test scores or TOT in students. In one study teachers were trained to give academic lessons within the classroom (Donnelly et al., 2017). Students who received these lessons scored higher on math, reading and spelling tests given after the lessons than did students under control conditions. Grieco, Jowers, Errisuriz, and Bartholomew (2009) also investigated the effect of physically active lessons and found positive results on student TOT following academic based movement games.

Fedewa et al. (2018) took a slightly different approach by investigating the effectiveness of purely aerobic-based movement breaks within the classroom *and* the impact of academic-based breaks, similar to Donnelly et al (2017). Fedewa et al. found that the aerobic only breaks were more effective in increasing test scores as well as increasing activity for the day as step counts for those students were found to be significantly higher on average per day.

Summary

As a result of the numerous studies investigated, we find that PA has both an indirect and direct impact on academic achievement. These findings are consistent across different ages and result from increased physical fitness levels as well as classroom PA interventions. In the next section I will discuss possible solutions and how to implement strategies to increase student participation in physical activity.

Chapter 4

Discussion

This synthesis examined the impact that physical activity has on academic achievement. After careful data analysis, and organization of themes, it appears that the most important factors are the types of PA interventions that are used, what the PA is impacting, as well as who is the target audience for the PA interventions. When examining the results it was clear that PA has a positive impact on both standardized test scores and time-on-task behaviors. Also found during the critical mass was evidence of PA improving study habits, specifically on college aged students. The information within the critical mass of articles yields recommendations for teachers and administrators to improve their students PA, and how administrators need to consider what implications further cuts to athletic departments might cost in the long run to students' academic progress.

Connection Made

Evidence was abundant throughout the synthesis that PA impacted student's academics in a positive way. With rising class sizes and decreased PE budgets as discussed in the introduction, principals and administrators should be weary of continuing to make this issue more and more prevalent. It is crucial to student success to have adequate access to materials and time to be physically active. The focus of schools and administrators should be investigating how to keep class sizes manageable and investing in newer better equipment. With smaller class sizes students can increase activity during their PE sessions and therefore become more PA.

Increasing PA Opportunities

Studies to find out which students were most largely impacted were somewhat dispersed but the common trend definitely seemed to be on elementary aged students. Elementary students saw the greatest results from PA interventions and in many cases have the least access to adequate time to increase their PA. As it stands in the state of New York, most elementary schools have PE scheduled just twice a week for elementary students (grades K-5), citing recess as time for PA (Rochman, 2011). However due to the unstructured nature of recess many students are not taking advantage of this allotted time. SHAPE America recommends at least 20 minutes of recess a day and does not recommend recess be used as a substitute for PE (SHAPE, 2017), but we are seeing schools fall short of that number regularly and are constantly using recess as a substitute for structured PA. If schools are insistent on including recess as part of students PE experience than SHAPE America recommends properly training recess staff to lead structured PA interventions. It is discussed in the Donnelly (2017) study, which teachers were trained to provide stronger PA breaks in the classroom, and the results were extremely positive. Schools need to invest more time and money into adequately training staff to effectively

moderate PA breaks throughout the school day. This can even be accomplished internally by working more collaboratively with PE teachers already in the district.

We are currently involved in a time where women's sports are on the rise, both in their ability to enter the public eye, as well as overall participation so it was important to note if increased PA had positive impacts for both male and female students. Resland (2018) mentioned that all involved in the study both male and female saw positive effects of the increased physical activity. So it is important going forward that PA opportunities be available to all students. Budgets for men's sports are typically larger than that of women's sports. The Seattle times released a report citing that schools spent twice as much on men's sports in 2017 than they did on their female counterparts (Meredith, 2017). With the concern being on raising test scores across the population the spending gap on PA opportunities needs to close.

When discussing the research for pre-k students the focus is less on standardized test scores but on TOT behavior. It is more than evident to most that student in this age range could use some help to increase focus and Webster (2014) found that regular PA breaks increased student TOT significantly. It was discussed in the study that the PA breaks were in addition to, not instead of, PE and recess. It is recommended that schools supply training to all pre-k educators to include these PA breaks into their lesson plans, to add to (not be in place of) students already scheduled PA. Physical educators or outside athletic trainers are useful tools that could be helpful to allowing classroom teachers to be more effective with their PA intervention plans.

The evidence continues to mount regardless of the age of students, and this continues with the evidence of PA aiding in college students academic rigor. The goal of increasing PA can at times shift but it is all academic in nature, from TOT, to standardized test scores, and in the

case of college students study habits (TOT). When the study by Calestine (2017) was conducted it was with the goal of finding out how PA impacted college student study habits, finding that the more active the more students studied and the more productive they became. This can be attributed to the amount of focus and energy students who are active typically have. It is recommended that as adults we get 75 minutes of vigorous activity a week (Laskowski, 2019), however college aged students typically do not get this much as their academic demands increase. PE used to be a requirement for college students, however this is no longer the case, as of 2016 only 39% of colleges required PE (Hirniese, 2016). By re-instituting college PE you would increase student PA exponentially and therefore increase student productivity. Classroom activity breaks as mentioned at the other levels would be great solutions as well, however, as discussed they were always recommended in addition to PE and recess, not in place of, college students have neither.

Additionally there are other methods that might be more practical and frankly more feasible in this day and age. These would include more active lessons in the classroom as Grieco, Jowers, Errisuriz, and Bartholomew investigated in 2016. This same group also looked in to the effectiveness of PA breaks in between lessons, but again still inside the classroom as to keep the rooms flow academically, skipping the transition to a secondary location. Both studies found the results to be positive both academically for students but also to the students overall PA throughout the day. This type of PA intervention is effective and might be easier to implement as it does not require more equipment or decreasing PE class sizes. This type of intervention to be as effective as possible would require proper training for classroom teachers, this includes CPR, AED, and first aid training. However any type of increased PA opportunities should be welcomed by any district.

Limitations

The critical mass on the topic is pretty widespread, however, much of the research done leaves questions to those who doubt its validity. When academic breaks are taken in class, there is little evidence that the PA breaks are the reason for the increased time-on-task, in other words, was it just the presence of a break in general.

There needs to be a more wide range of age demographics. As it stands most research is limited to the elementary age, with very little research done to explore the impacts on older students, namely middle, high school, and college age students.

Most of these studies also show students active participation in the state required amounts in a small window. There would need to be more longitudinal studies to truly see the long term affects academically for students.

Implications for Future Research

Based on the analysis and the limitations of the critical mass, more research must be conducted to effectively examine this topic. As new strategies are being developed to improve the current situation regarding in school physical activity opportunities, more research is needed to determine whether the strategies are effective when those strategies are implemented.

More research into middle, high school and college, aged students' needs to be conducted. Most research at this time for those age groups points to academic productivity rather than academic achievement.

It was recommended that classroom teachers have access to training so they might include more movement breaks, or active lessons in their lesson plans. This would need further research to see the long term effectiveness of these changes.

It should also be noted that student's participation in most studies is voluntary, should the PA breaks and increased PE become a long term reality the voluntary participation rate would need to be considered when investigating the results. Students who voluntarily increase PA are not always the ones who need it the most.

Conclusions

Studies show that as it stands many schools fall short of the necessary PA requirements as recommended either by independent organizations like SHAPE, or even by their own governing body's such as the state of New York. The research examined in this synthesis appears to point very clearly that should schools meet these requirements students may see the results in the academic arena as well as in the physical well beings. Recommendations include decreasing class sizes, increasing school budgets, incorporating in class activity breaks, and including active lessons. While the evidence is prevalent that PA does indeed equal increased academic ability more research is needed to examine how the long term application of these suggestions would impact students.

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Appendix A, Article grid

Author	Title	Source	Purpose	Methods & Procedures	Analysis	Findings	Recommendations
Basch, Charles E	Physical Activity and the Achievement Gap Among Urban Minority Youth	Journal of School Health.	This article is designed to show disparities of physical activity among school-aged urban minority youth, ways in which low levels of physical activity and fitness adversely affects academic achievement, and approaches for schools to increase physical activity and physical fitness	Literature review.	Literature review.	A large proportion of youth is insufficiently physically active. Estimates of population-wide levels of physical activity indicate that Black and Hispanic youth are less physically active than White youth, with disparities particularly evident for females.	Increasing students' physical activity and physical fitness can best be achieved through a comprehensive approach that includes physical education, wise use of recess and after-school times, co-curricular physical activity opportunities, and bicycling or walking to and from school.

			among youth.				
Chomitz, V. Meghan M. Slining MS, MPH Robert J. McGowan EdD Suzanne E. Mitchell MD, MS Glen F. Dawson MA Karen A. Hacker MD,	Is There a Relationship Between Physical Fitness and Academic Achievement? Positive Results From Public School Children in the Northeastern United States	Journal of School Health	To determine relationships between physical fitness and academic achievement in diverse, urban public school children.	Academic achievement was assessed as a passing score on Massachusetts Comprehensive Assessment System achievement tests in Mathematics and in English Fitness achievement was assessed as the number of physical fitness tests passed during physical education (PE).	Multivariate logistic regression analyses were conducted to assess the probability of passing the MCAS tests, controlling for students' weight status (BMI z score), ethnicity, gender, grade, and socioeconomic status (school lunch enrollment).	The odds of passing both the MCAS Mathematics test and the MCAS English test increased as the number of fitness tests passed increased ($p < .0001$ and $p < .05$, respectively).	Results show statistically significant relationships between fitness and academic achievement, though the direction of causation is not known. While more research is required, promoting fitness by increasing opportunities for physical activity during PE, recess, and out of school time may support academic achievement.
Donnelly, Joseph E., Hillman, Charles H.,	Physical activity and academic achievement	Preventive Medicine	This study compared changes in academic	Elementary schools in eastern Kansas were cluster	On average 55 min/week of A + PACC lessons were delivered	Baseline WIAT-III scores (math, reading,	Students attending A + PAAC schools received an additional 55

<p>Greene, Jerry L., Hansen, David M., Gibson, Cheryl A., Sullivan, Poggio, D., John., Mayo, Matthew S., Lambourne, Kate., Szabo-Reed, Amanda N., Herrmann, Stephen D., Honas, Jeffery J., Scudder, Mark R., Betts, Jessica L., Henley, Katherine, Hunt, Suzanne L., Washburn, Richard A.</p>	<p>across the curriculum: Results from a 3-year cluster-randomized trial</p>		<p>achievement across 3years between children in elementary schools receiving the “Academic Achievement and Physical Activity Across the Curriculum” intervention</p>	<p>randomized to A + PAAC or control. Academic achievement (math, reading, spelling) was assessed using the Wechsler Individual Achievement Test-Third Edition (WIAT-III) in a sample of in grades 2 and 3 at baseline (Fall 2011) and repeated each spring across 3 years.</p>	<p>each week across the intervention</p>	<p>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</p>	<p>min/week of MVPA which may be associated with both physical and mental health benefits, without a reduction in time devoted to academic instruction. So the amount of time spent on interventions should be increased in the future across all samples.</p>
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						non-significant group by time interactions	
Fedewa, Alicia L., Fettrow, Elizabeth., Erwin, Heather., Ahn, Soyeon., Farook, Minnah	Academic-Based and Aerobic-Only Movement Breaks: Are There Differential Effects on Physical Activity and Achievement? (Research Quarterly for Exercise & Sport,	This study discusses different types of activity breaks being implemented in elementary school classrooms and their impact on both physical activity and academic performance.	Schools were randomly assigned at the school level to implement either aerobic movement breaks with academic content infused within the breaks ("academic-based breaks") or aerobic-only movement breaks without the addition of academic material ("aerobic-only breaks") for approximately 10 min of activity per day.	A mixed-effects (multilevel-growth) model, in which the repeated measures of individuals nested within a classroom are analyzed, was used to answer all posited research questions.	Small to moderate effect sizes (ES) indicating gains in reading achievement (ES = .13) and steps (ES = .33) were found for classrooms that used aerobic-only movement breaks compared with those that used academic-based breaks.	Results from the present study indicate that children who were given aerobic-only movement breaks had slightly larger gains in reading achievement and physical activity levels than children who were given academic-based breaks.
Grieco, Lauren A., Jowers, Esbelle M.,	Physically Active Academic Lessons and	Medicine & Science in Sports & Exercise	This article focuses on a study which looks at the	Behavior was assessed through direct observations	TOT was calculated through momentary time	TOT decreased significantly from before	Physically active classroom lessons provide a buffer to prevent the steep

Bartholomew, John B	Time on Task: The Moderating Effect of Body Mass Index.		effects of a lesson that includes physical activity on body mass index (BMI) and on time on task (TOT) among children of third grade classrooms in Texas.	before and after a physically active classroom lesson and before and after a traditional inactive classroom lesson.	sampling for each student by dividing the number of on-task observations by the total number of observations per student (interrater reliability = 94%).	to after the lesson for all BMI categories in the inactive control condition, with no change for the active condition. Post hoc analyses found a significant linear effect for the reduction in TOT with each level of BMI in the inactive condition, with the greatest magnitude of effect for the overweight group.	reduction in TOT experienced after a period of inactivity in all children, especially those who are overweight.
Grieco, Lauren A., Jowers, Esbelle M., Errisuriz,	Physically active vs. sedentary academic lessons: A	Preventive Medicine	this study is designed to find the answer to the question do	Participants were 320 children (7–9 years) recruited from school		Mixed-method RMANOVA indicated TOT	While the sedentary, academic game prevented the reduction in TOT

Vanessa L., Bartholomew, John B	dose response study for elementary student time on task.		lessons involving physical activity help elementary students increase time-on-task versus sedentary lessons	districts in Central Texas in 2012. They were assigned by classroom (n = 20) to one of four conditions: 1) sedentary, standard lesson (n = 72); 2) sedentary academic game (n = 87); 3) low to moderate intensity PA (LMPA), academic game (n = 81); and 4) moderate to vigorous intensity PA (MVPA), academic game (n = 76). Measures included PA via accelerometer and TOT		decreased following the standard lesson ($p < 0.001$), showed no change following the sedentary academic game ($p = 0.68$), and increased following the LMPA ($p < 0.01$) and MVPA ($p < 0.001$) academic games.	observed in the standard lesson, PA resulted in increased TOT. Future research should be designed to examine the potential academic benefits of the change in TOT.
Mahar, Matthew T	Impact of short bouts of physical	Preventive Medicine	The point of this study was to	The study's objective was to describe the	Published studies that measured	The limited evidence suggests a	Because of the positive effects of physical activity on

	activity on attention-to-task in elementary school children.		research the effects of short physical activity breaks on attention-to-task in elementary school students	measurement of on-task behavior and review the research on the effects of short physical activity breaks on attention-to-task in elementary school students, with a particular focus on a promising approach to improving on-task behavior with short bouts of physical activity in the classroom	attention-to-task in elementary school students following physical activity breaks were reviewed.	small to moderate improvement on attention-to-task following physical activity breaks.	attention-to-task, it is recommended that elementary school teachers consider implementing physical activity sessions throughout the school day in the form of recess and classroom-based physical activities.
Resaland, G.K., Moe, V.F., Bartholomew, J.B., Andersen, L.B., McKay, H.A., Anderssen,	Gender-specific effects of physical activity on children's academic performance: The Active Smarter Kids	Preventive Medicine	This study discusses active learning (AL), which combines academic content with physical activity, and	Academic performance in numeracy, reading, and English was measured and a composite score was calculated. Children were	3-way-interactions for group (intervention, control)*gender (boys, girls)*academic performance (tertiles) were investigated	There was a significant, 3-way-interaction ($p=0.044$). Both boys ($ES=0.11$) and girls ($ES=0.18$) in the low	It is likely that active learning benefited children most in need of adapted education but it may have a null or negative effect for those girls who are already performing

S.A., Aadland, E.	cluster randomized controlled trial.		its ability to improve academic performance	split into low, middle and high academic performing tertiles.	using mixed model regression	performing tertile had a similar beneficial trend. In contrast, middle (ES=0.03) and high performing boys (ES=0.09) responded with small beneficial trends, while middle (ES=- 0.11) and high performing girls (ES=- 0.06) responded with negative trends.	well in the sedentary classroom. Differences in gendered responses are discussed as a possible explanation for these results
Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D.	Effect of classroom- based physical activity interventions on academic and physical activity outcomes: A	International Journal of Behavioral Nutrition and Physical Activity	The primary aim of this systematic review and meta-analysis was to evaluate the impact of	A systematic search of electronic databases (PubMed, ERIC, SPORTDiscus, PsycINFO)	Meta-analyses were conducted in Review Manager, with effect sizes calculated separately for	Results of the meta-analyses showed classroom- based physical activity had a positive effect on improving	Results suggest classroom-based physical activity may have a positive impact on academic-related outcomes. However, it is not

	systematic review and meta-analysis.		classroom-based physical activity interventions on academic-related outcomes. A secondary aim was to evaluate the impact of these lessons on physical activity levels over the study duration.	was performed in January 2016 and updated in January 2017. Studies that investigated the association between classroom-based physical activity interventions and academic-related outcomes in primary (elementary) school-aged children were included.	each outcome assessed.	on-task and reducing off-task classroom behaviour (standardised mean difference = 0.60 (95% CI: 0.20,1.00)), and led to improvements in academic achievement when a progress monitoring tool was used (standardised mean difference = 1.03 (95% CI: 0.22,1.84)). However, no effect was found for cognitive functions (standardised mean difference = 0.33 (95% CI: -0.11,0.77)) or	possible to draw definitive conclusions due to the level of heterogeneity in intervention components and academic-related outcomes assessed. Future studies should consider the intervention period when selecting academic-related outcome measures, and use an objective measure of physical activity to determine intervention fidelity and effects on overall physical activity levels.
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Webster, E. Kipling, Wadsworth, Danielle D., Robinson, Leah E	Preschoolers' Time On-Task and Physical Activity During a Classroom Activity Break	Pediatric Exercise Science	This study looks at the effects of a 10-min teacher-implemented, classroom-based, activity break (AB) on physical activity participation and time on-task in preschoolers.	The experiment took place over 4 days, 2 with the intervention and 2 without.		Results showed that AB led to a higher percent of physical activity during the AB. Breaks also promoted more on-task behavior immediately following the AB.	