

GENERAL ARTICLE

The Association of Physical Activity and Academic Behavior: A Systematic Review

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ABSTRACT

BACKGROUND: In this systematic review, we assessed the existing research describing the effects of physical activity (PA) on academic behavior, with a special focus on the effectiveness of the treatments applied, study designs, outcome measures, and results.

METHODS: We obtained data from various journal search engines and 218 journal articles were downloaded that were relevant to PA and academic performance topics. The abstracts of all the articles were independently peer reviewed to assess whether they met the inclusion criteria for further analysis. The literature search was ongoing. Of the reviewed articles, 9 were chosen on the topic of PA effects on academic behavior. Each article was analyzed and summarized using a standard summary template.

RESULTS: Overall, PA interventions commonly found positive effects on academic behavior, with few exceptions. There were additional unique findings regarding differences in outcome measures and PA treatments.

CONCLUSIONS: The findings from these studies are significant and support the implementation or continuation of PA in schools to improve academic behavior and associated performance. More research needs to be conducted using the effective aspects of the treatments from this review with consistent outcome measures.

Keywords: physical activity; academic behavior; academic performance; academic performance and health; systematic review.

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According to the National Health and Nutrition Examination Survey (NHNE), the prevalence of obese children and adolescents in 2012 in the United States was nearly 17%.¹ This figure has been a growing concern, as physical education (PE) programs have been reduced worldwide for various reasons, often to use the time and money for other academic programs.² This growing concern is 1 reason that substantial research has been conducted to investigate the effects of PA and fitness on academic performance. Academic performance refers to the outcome of students' education, often represented by grades and test scores. Some research has shown negative associations among academic performance and overweight or obese children and adolescents.³⁻⁵ Whereas this research is still controversial, it is generally accepted that PA

does not decrease levels of academic performance.⁶ The body of research on the topic of PA and fitness on academic performance is extensive and ongoing. However, there is less research on other effects that a lack of PA can cause among schoolchildren and adolescents, such as academic behavior. It is of value to investigate how PA programs impact all facets of academic life, as well as overall fitness, to assess the importance of PA programs in schools.

Academic behaviors, conceptually defined in a review by the US Centers for Disease Control and Prevention's Division of Adolescent School Health, include a range of behaviors that may have an impact on students' academic performance, including on-task behavior, organization, planning, attendance, scheduling, and impulse control.⁷ Academic behavior

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is an important contributing factor to academic performance; moreover, teacher ratings of attention, internalizing behavior, and externalizing problems at age 6 may predict math and reading achievement at age 17.⁸ To reduce poor ratings of academic behavior, it is necessary to explore interventions, such as PA, as a way to improve the scholastic experience.

There are various types of PA that can be integrated into students' lives. Choosing an effective option includes investigating the most efficient interventions in terms of duration and outcome measure. In this review, the outcome measure is academic behavior, consisting of attention and concentration, time-on-task (TOT) or on-task behaviors, and teacher reported behaviors. Highlighting the varying durations of PA is important to determine differential efficacies. When PA is efficient in schools, sufficient time can be spent on academics, without the cost of removing all PA throughout the day. The option of PA integrated into class lessons may be a novel idea for the school setting because it can be implemented more frequently because the students continue to be engaged in learning while performing PA. Further supporting this claim, there have been reports that the school setting is an effective environment for young people to perform regular PA.^{9,10} It is beneficial to compare treatments of different intensities and durations, including recess, PE classes, and after-school programs, in addition to in-class PA.

The entire school day can last up to 7 hours a day, which is a long duration for students to be sedentary and can have a harmful effect on behavior as all their energy is prevented from being released physically. Children may spend more than 60% of their waking day sedentary.^{11,12} In addition to improvements in academic performance, short and regular PA interventions have been reported to reduce clinical risks in children by interrupting 3 hours of sedentary behavior.¹³ We propose the risks of sedentary behavior and prevention by PA are not limited to clinical observations and test scores, but extend to the classroom environment, potentially affecting behavior.

Understanding how different ways of implementing PA into daily life through recess, PE programs, in-class activities, or after-school programs, can have effects on academic and fitness factors can help guide future research. Furthermore, knowing which types of PA and durations are most effective to improve fitness and academic behavior is vital in designing operational programs to be implemented. The purpose of this review is to investigate different types of PA interventions utilized in previous research, while differentiating the outcome measures, and evaluate how variations in duration and intensity affect academic behavior in school-aged children and adolescents.

METHODS

Information Sources and Searches

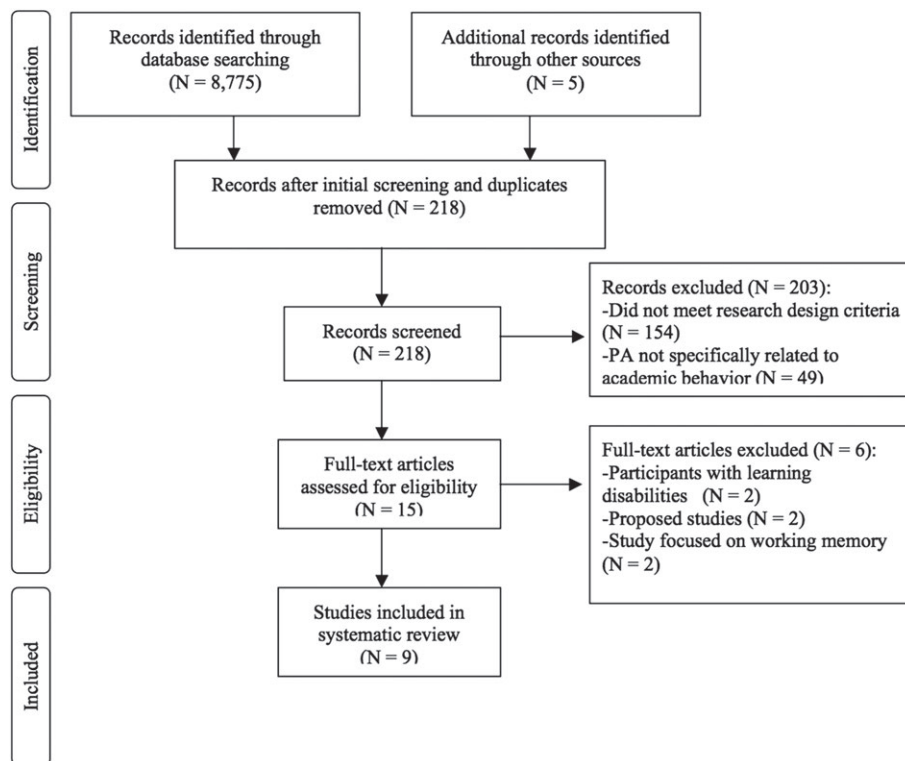
Five database engines were used in the original data collection to access literature concerning academic behaviors and PA that have been published since 1995 and filtered for school-aged children. The search engines included Education Resources Information Center (ERIC), Google Scholar, PsychINFO, PubMed, and SportDiscuss. The search strategy for each engine was as follows: terms related to PA were each combined with an academic-related term to yield a search result. For example, in each search engine, the term "exercise" from the PA-related list was combined with each term from the academic-related list, including terms such as academic performance, academic achievement, academic behavior, and so on. The list of PA-related terms consisted of 18 terms and the academic-related list consisted of 32 terms (Table 1). The variety of academic-related terms allowed for a holistic understanding of the current literature regarding academic interests.

During the search process, each set of search results was screened for relevance, as well as duplicates resulting from the same search engine. After each of the searches was completed, the articles were then assessed to remove duplicates from different search engines. This original search and screening process took place in the summer of 2014 and yielded 218 articles relevant to PA, academic performance, academic behavior, and cognition. In addition, literature and systematic reviews were utilized in an ongoing literature search to include any relevant articles that were missed in the

Table 1. Search Terms Used in Systematic Review

PA-related terms	Physical Activity, Exercise, Fitness, Motor skills, Motor ability, Movement skills, Sports, Sport Participation, Energy Expenditure, Physical Education, Recess, Physical activity breaks, Class-room based physical activity, After school physical activity, After school sports, Extracurricular physical activity, PPAC intervention, Physically active classroom
Academic-related terms	Academic performance, Academic achievement, Academic behaviors, Classroom behaviors, Academic skills, Cognitive performance, Cognitive skills, Cognitive function, Cognitive behaviors, Grade point average (GPA), Executive function, Attention, Concentration, Attention span, Memory, Information process, Time on task, Student Motivation, Student engagement, Student learning, Standardized test scores, Math achievement, Reading achievement, Science achievement, Achievement scores, Brain cognition, Brain health, Brain development, Brain function, Mental abilities, Cognitive processes, Executive function

Figure 1. Search Methods Used in Systematic Review



original search. The selection process is illustrated in Figure 1.¹⁴

Eligibility Criteria and Study Selection

Two investigators were trained in the exclusion and inclusion requirements of the review and identifying types of research designs, and then reviewed each abstract individually. The exclusion criteria included review articles, theoretical articles, and correlation/cross-sectional studies. Inclusion criteria were: (1) intervention studies consisting of pre-post research design, quasi experimental research design, or randomized controlled trial research design published in peer-reviewed journals between 1995 and present; (2) participant population of children and adolescents aged between 5 and 16 years without learning disabilities; and (3) research outcomes including the combination of PA as an independent outcome and academic performance, academic behavior, and/or cognition as dependent variables.

Once the articles were cross-checked to ensure there were no correlation/cross-sectional studies, theoretical, or review articles included, 64 articles remained from the original dataset. Further screening, extraction, and sorting based on study content resulted in 15 intervention studies regarding PA and academic behaviors. Upon further review and analysis, 9 studies

were ultimately included in this review. The data from the 9 studies were extracted using a standard data extraction template. The template included year of publication, research purpose, study setting, sample size and characteristics, research design and intervention strategies, outcome measures, and key results with significant levels. Table 2 presents the extracted data.

RESULTS

Each of the 9 studies under review included reports of improvement in academic behaviors after implementing a PA intervention. However, 2 of the studies also included contradicting findings.^{16,19} Researchers from 3 of the studies measured attention and concentration acutely, applying a one-time PA intervention during the school day, followed immediately by a test of concentration.^{15,16,19} The 6 remaining studies were ongoing for different durations. Two studies utilized in-class PA programs, Texas I-CAN and Energizers, which integrated PA into academic lessons.^{17,21} Two studies used in-class PA programs that were not combined with an academic lesson.^{20,22} Other interventions included recess or an after-school program.^{18,23} Two studies included measurements of physical fitness changes in addition to academic behavior outcomes.^{21,23}

Table 2. A Summary of Studies Used in Systematic Review

Study Citation	Research Purpose	Research Setting Sample Characteristics	Study Design and Intervention Condition	Outcome Measures	Key Results
Budde et al ¹⁵	Investigate the impact of short bouts of bilateral coordinative exercise (CE) on the cognitive performance of attention of adolescent students	99 adolescents - Ages: 13-16 years - 80 male/19 female - BMI: <25	Randomized control trial with pre- and post-tests - 2 conditions: - 10-minute CE lesson - 10-minute normal sport lesson control Experimental conditions: - Acute measures - Pre-test: all groups under normal conditions - Post-test: 1 intervention followed by test session	- Attention and concentration by d2 test scores - GZ = total number of responses - SKL = standardized number of correct responses minus errors of confusion - F% = number of all errors related to the total number of responses - Heart rate	d2 scores: - PE lessons > control (p < .05) - CE lesson > normal sport lesson (p < .05) - Heart rate: no significant difference among groups
Caterino and Polak ¹⁶	Compare passive and directed physical education activities on the concentration of second-, third-, and fourth-grade children	71 students - Grades: 2-4	Randomized control trial - 2 conditions: - Classroom activity: grade-appropriate classroom activity that followed teachers' lesson plans - Physical activity: 15 minutes of stretching and aerobic walking followed immediately by going to the library to take the concentration test Experimental conditions: - Acute measures - During school day Pre- and post-tests 2 conditions: - Physically active classroom group - Inactive control group Experimental conditions - Texas I-CAN lesson - 10-15 minutes of moderate-to-vigorous physical activity at least once a day - 91.5% of school days implemented a lesson - 15-minute classroom observations before and after the physically active academic lesson and the inactive control lesson	Woodcock-Johnson test of concentration	Grade 2: - PA group > CA group (p > .05) not significant difference Grade 3: - PA group > CA group (p > .05) not significant difference Grade 4: - PA group > CA group (p = .05)
Grieco et al ¹⁷	Examine the effects of a physically active classroom lesson on BMI, TOT (time on-task) in a sample of elementary school children	97 students - Age: 8.7 ± 0.41 - Grade: 3 - 43% male/57% female Location: central Texas Ethnicity: 69.3% white; 13.9% Hispanic; 10.9% African American; 5.8% Asian/Pacific Islander	Pre- and post-tests - Physically active classroom group - Inactive control group Experimental conditions - Texas I-CAN lesson - 10-15 minutes of moderate-to-vigorous physical activity at least once a day - 91.5% of school days implemented a lesson - 15-minute classroom observations before and after the physically active academic lesson and the inactive control lesson	- Time on task (TOT) - BMI - Step counts measured 1 week	Physical activity: - Number of steps: normal weight > overweight (p < .05) - TOT scores: - Physically active classes > control classes (p > .05)

Table 2. Continued

Study Citation	Research Purpose	Research Setting Sample Characteristics	Study Design and Intervention Condition	Outcome Measures	Key Results
Jarret et al ¹⁸	Examine the effects of a recess break on classroom behavior, specifically working, fidgeting, and listlessness in fourth-grade children	43 students - Grade: 4 - 18 male/25 female - 70% Caucasian; 30% African American	Pre- and post-tests 2 conditions: - 20-minute recess break - No recess Experimental conditions: - 6 recess breaks - 5 month duration - During the school day on non-PE days The children were not aware which day they would receive recess	- Work on-task behavior, doing assigned work, looking at the teacher, etc - Fidgety: excessive movement, tapping, swinging limbs, partly out of chair - Listless: head on desk, staring out window, slumping, eyes closed	- Time on task (work): - Recess > no recess (p < .05) - Fidgety behavior: - Recess < no recess (p < .05) - Listless behavior: - No difference; low on both recess/non-recess days
Kubesch et al ¹⁹	Examine the effects of a single 30-minute physical education program or a 5-minute movement break on executive functions in seventh-grade students	81 students - Age: 13-14 years - Grade: 7 - 41 male/40 female - Location: Germany	Randomized within-subject cross-over 3 conditions: - Physical education (PE) program - 30-minute aerobic endurance exercise - Movement break (MB) program - 5-minute aerobic endurance exercise - Control: no exercise Experimental conditions: - January-May 2007 - EFs measured pre/post condition and after math lesson - Measured in 2-week intervals on same day of the week	Neuropsychological tests: - Flanker (attention) - Dots	Flanker test-reaction times differences: - Incongruent task PE > control (p < .05) - Congruent task: no significant difference - Movement break: no significant differences in flanker or dots tasks - Dots test: No significant interaction effects of treatment and time for any parts of the test for both treatments
Maeda and Randall ²⁰	Investigate the effects of a implementing a 5-minute bout of physical activity on academic performance and behavior	19 students - Grade: 2 - 7 males/12 females - Location: Hawaii	Multiple treatment reversal design Experimental conditions: - 5-minute moderate-to-vigorous physical activity - 4 days/week - 61 sessions	- Math fluency - Teacher reports of student behavior	Behavior improvements based on teacher reports that students were able to get more work done after physical activity

Table 2. Continued

Study Citation	Research Purpose	Research Setting Sample Characteristics	Study Design and Intervention Condition	Outcome Measures	Key Results
Mahar et al ²¹	Evaluate the effects of a classroom-based physical activity program on children's in-school physical activity levels and on-task behavior during academic instruction	62 students - Ages: 8-11 - Grades: 3-4	Multiple-baseline across-classrooms design with pre- and post-tests - 2 conditions: - Start Energizers classroom-based PA after 4 weeks of baseline - Start Energizers after 8 weeks of baseline Experimental conditions: - One 10-minute activity per day during intervention period - 12 weeks total including baseline measures - Third-grade observation in afternoon - Fourth-grade observation in morning	- On-task behavior observation 30 minutes during academic instruction time immediately before and after intervention: - On-task verbal or motor behavior that followed the class rules and was appropriate - Off-task any behavior that was not on talk and coded as motor off-task, noise off-task, or passive/other off-task	- On-task behavior: - Intervention period > baseline period (p < .05) - Pre-baseline and post-baseline: no significant difference
Norlander et al ²²	Examine whether a simple and regularly applied program of relaxation can increase primary and secondary school students' ability to concentrate as measured by teachers' estimates	88 students - Ages: 11.31 ± 1.09 - Grades: 4, 5, 6 - 40 male, 48 female - Location: Sweden - 7 teachers - Ages: 42.14 ± 13.91 - 2 male, 5 female - Location: Sweden	Pre-/post-test study design with randomized controls - 2 conditions: - Relaxation program group - Control group Experimental conditions: - Intervention included 3 different groups of stretch exercises that were performed repeatedly in short series. Primarily focusing on upper body muscle groups. - Duration: 5-10 minutes, twice daily for 4 weeks - 5 groups receive relaxation treatment and 1 group serves as	Teacher questionnaires before and after treatment	Teachers reported increased ability to concentrate following treatment
TKacz et al ²³	Examine the effect of a structured aerobic exercise program on anger expression in healthy, overweight children	208 students - Ages: 7-11 years - 57% female/43% male - Ethnicity: 59% African American - BMI: ≥ 85th percentile	Randomized controlled experiment with pre/post-test study design - 3 conditions - Low dose exercise: 20 minutes/day - High dose exercise: 40 minutes/day - Control: no exercise Experimental conditions: - After-school program - Duration: 12.8 (± 1.6) weeks - Activity examples: running games, jump rope, basketball, soccer - 20-minute bouts of intermittent vigorous exercise with short bursts of intense PA with intermixed low intense activity. 1 session for low dose, 2 for high	- Pediatric Anger Expression Scale (PAES): - Anger In - Anger Out - Anger Expression - Anger Control - Aerobic fitness - Percent body fat	- PAES - Anger In: no significant difference - Anger Out: exercise group < control (p < .05) - Anger Expression: exercise < control (p > .05) - Anger Control: exercise > control (p < .05) - Aerobic fitness: exercise > control - Percent body fat: exercise < control

Quantitative Measures

Four studies used quantitative tests to measure components of academic behaviors including attention, concentration, or anger expression. In a study, researchers found that seventh graders reacted faster on a Flanker test immediately after a 30-minute aerobic endurance PE program in comparison to both the control group and students participating in a 5-minute, in-class, aerobic movement break. The PE program consisted of running exercises, bench work, and abdominal and back extension exercises. They concluded that a single PE program of 30 minutes duration leads to an improvement in the maintenance of on-task attention in the face of distraction, whereas a 5-minute aerobic movement break does not.¹⁹ The study was a randomized within-participant crossover design.

In a different study, researchers compared the attention and concentration of 2 intervention groups and a control group using the d2 test of concentration.¹⁵ The greatest improvement in attention and concentration among the groups of adolescents, ages 13 to 16, was seen following the 1-time, 10-minute PA intervention utilizing bilateral coordinative movements, such as bouncing basketballs with both hands at the same time. There was also an improvement in concentration after the one-time, 10-minute normal PA intervention, with no use of bilateral coordinative movements.¹⁵ The results from another study indicated better performance on The Woodcock-Johnson test of concentration among fourth-grade students after participating in a one-time, 15-minute stretching and aerobic walking intervention compared with control students.¹⁶ However, in the same study there was not a significant difference in concentration level among second and third-grade students under the same intervention conditions.

Anger expression was measured using the Pediatric Anger Expression Scale (PAES), which utilizes 4 subscales including, Anger In, Anger Out, Anger Expression, and Anger Control. The intervention was an after-school PA program with a 20-minute, low-dose exercise group and a 40-minute, high-dose exercise group.²³ Both groups consisted of students with ages ranging from 7 to 11 years that were compared with a control group. The after-school program occurred after each school day, lasted about 12 weeks, and included activities such as running games, jumping rope, basketball, and soccer. In both the high- and low-dose groups there were reduced levels of the overall Anger Expression Scale of the PAES. There were significant reductions for the treatment group ratings on the subscale of Anger Out compared to the control group ratings, which increased on the Anger Out scale. The subscales, Anger In and Anger Control, were not significantly different in changes between the treatment and control groups. It was reported that increased time on the treadmill

and decreased percent body fat among the school-aged children who participated in the aerobic exercise indicated improved their fitness levels due to the after-school PA program. This improved fitness was significantly related to lower posttest Anger Expression scores.²³

Observation Measures

In 3 of the studies under review, researchers used trained observers to measure in-class behaviors. In one of these studies, there were significant increases in on-task behaviors from pre-Energizers treatment to post-Energizers treatment.²¹ Observers saw an average of 8.3 more on-task behaviors among third and fourth graders after the Energizers treatment, which consisted of 10-minute, classroom-based PA, occurring each school day for 12 weeks. On-task behaviors included appropriate verbal or motor behaviors that followed the class rules. Researchers described off-task behaviors as any behaviors that were not on-task and they were coded as motor off-task, noise off-task, or passive/other off-task. Additionally, students in the treatment group had significantly greater pedometer steps compared to the control group.²¹

In another study, there was an intervention consisting of a 15-minute, in-class, moderate-to-vigorous PA lesson implemented each day for 91.5% of school days. The in-class PA, called Texas I-CAN, was applied in third-grade classrooms. The researchers compared the TOT of treatment group students against that of control group students, finding that control group students' TOT decreased significantly after the inactive lesson.¹⁷ However, after the active lesson treatment researchers observed a small increase in TOT.

Following a 20-minute recess intervention, which occurred 6 times over a 5-month duration on non-PE days, fourth graders were more consistent in spending time on schoolwork and showed significantly less signs of fidgeting than before the recess break. During the recess break, observers described that students spent their time running and chasing one another.¹⁸ The observers used measures including work (on-task behavior, doing assigned work, looking at the teacher), fidgety behavior (excessive movement, tapping, swinging limbs, partly out of chair), and listless behavior (head on desk, staring out window, slumping, eyes closed) to assess academic behaviors in the classroom on recess and non-recess days.¹⁸

Teacher Reports

Teacher reports were used to measure academic behavior in the 2 remaining studies. In 1 study, second-grade students participated in a 5-minute, moderate-vigorous activity of walking and running during the school day, 4 days a week. After this treatment,

teachers reported improved student concentration and behavior leading to a greater ability to get work done.²⁰ In another study, teachers indicated increases in primary and secondary school students' ability to concentrate after 5 to 10 minutes of a stretching intervention that occurred twice daily for 4 weeks.²²

DISCUSSION

This review highlights unique findings that PA can have a positive effect on academic behaviors, including better attention and on-task behaviors in the classroom. This is further supported by reports from a correlational study that 8- to 9-year-old children who have 1 or more daily recess periods of more than 15 minutes are associated with better teacher ratings of academic behaviors.²⁴ In addition, repetitive engagement in PA leads to higher fitness, which has been positively related to better academic behaviors.²⁵ This review adds to the growing body of literature that promotes the positive effects of PA on school-aged children and adolescents.

Most research in this paper supports PA associations with academic behaviors, but it is of value to address unique findings and inconsistencies. This does not devalue the positive results, but can be a part of the assessment for future intervention implementation and outcome methods. Between the 2 different studies with 5-minute interventions, 1 set of researchers found this short duration was sufficient PA to improve academic behaviors, while the others did not find it effective.^{19,20} One explanation is that the measurement outcomes varied by qualitative or quantitative results, which was obtained by computerized tests.¹⁹ The other study used the subjective measure of a teacher report.²⁰ Teacher perceptions of students' behaviors are valuable to a classroom setting, but are not an objective evaluation of the true academic behavior, as bias influences cannot be ruled out. Owing to the inconsistent results from these 2 studies, it cannot be confidently stated that 5-minute PA interventions result in improvements of academic behavior.

Another inconsistency is that fourth graders' concentration performance improved after a 15-minute stretching and aerobic walking treatment, but the second and third graders' concentration performances did not significantly improve.¹⁶ This addresses the limitation of age effects on academic behaviors. A possible explanation for these results is that younger students may have shorter attention spans compared with older students, because basic attention increases with age until around 11-12 years, when it becomes more stable.²⁶ Age could be a factor influencing the results reviewed in this paper. To avoid this confounding effect, it is important to include a large age range and test for these effects.

Long and short duration exercise is directly compared in 2 of the studies, but yield different results. Researchers found no difference between 20 and 40 minutes of aerobic activity in the results of Anger Expression.²³ However, in another study, improvements in attention were seen after a 30-minute PE lesson, but not after a 5-minute movement break.¹⁹ The differences in durations are similar, 20 and 25 minutes, but because 5 minutes is shorter than 20 minutes, this may suggest that there is a certain duration in which the effects of PA on academic behaviors are comparable after a specific amount of time. This is supported by the fact that there were few significant differences in results among the studies under review, which utilized various time durations ranging from 10 to 40 minutes. It would be of interest to further investigate the concept of a plateau effect for planning PA time in schools.

Further considerations may attribute the inconsistency between the 2 studies to the repetitive nature of an after-school program versus a one-time PA intervention. Consistent PA over a substantial duration can have greater effects in other areas like fitness, which may positively affect academic behaviors independently.^{23,25} Another possible explanation may be differences among the outcome measures, since 1 study is an investigation of Anger Expression and the other of maintenance of on-task attention. The aspect of varying outcome measures plays a role in all the comparison of all the studies under review.

With respect to physical fitness 2 of the studies included examinations of the effects of long duration PA on physical fitness, both reporting improvements in physical fitness.^{21,23} Both studies lasted 12 weeks. The other studies under review were shorter in duration or implemented less frequent interventions, which may explain why they did not test for changes in fitness. Physical fitness results are notable because some research has shown positive correlations of fitness and PA with academic achievements and cognitive outcomes.^{25,27}

Furthermore, strong academic and cognitive performances can be associated with academic behaviors. One longitudinal study reports that high externalizing problems in grades 1 and 2 are linked with low academic performance in following years through increased task-avoidant behaviors. In addition, they reported an association between low academic performance in grades 1 and 2 with high externalizing problems and task-avoidant behaviors in following years.²⁸ This demonstrates the connection between behavior and academic performance in school-aged children.

Moving forward, it is valuable to assess which academic behavior outcome measures provide strong results and could therefore be used in future studies. It may be useful to combine qualitative and quantitative

data measurements. Using tests and scales is a good way to obtain numerical data, which provides the opportunity for clear differences in results. Studies from this review used tests such as the Woodcock-Johnson test of concentration, computerized flanker tests, and d2 tests. These tests should be assessed among others to confirm their validity, such as the validity evaluation done for the d2 test.²⁹ Continuing to monitor and compare validities of existing tests and more recently developed tests will allow for understanding which test is the best to use consistently for easier meta-analyses.

Qualitative data from teachers is also valuable in gauging changes. However, it is difficult to remove biases and placebo effects in this setting. Existence of various teacher biases have been recorded, including literature on racial and ethnic bias using behavior rating scales.³⁰ In addition, 1 study showed teachers indicating anti-fatness bias toward obese students.³¹ Using objective observers is an option that could serve as a solution to teacher bias and there has been thorough description of the process for training observers in the current literature.³² Whether using teachers or observers, it is best to train against rating with various biases that may exist against the participant demographic.

In assessing academic behaviors, utilizing consistent measures for concentration, attention, and TOT is important for future research. We propose the best way to make academic behavior assessments involves a holistic approach to data collection by using quantitative and qualitative measures. Utilizing both measures can validate the results or provide unique findings. It is valuable to understand of the classroom atmosphere using observational data. The possibility of having additional quantitative data can serve to support observational data, ruling out potential bias effects, strengthening the results.

Limitations

The main limitations among the studies under review are the inconsistent methodologies used throughout the studies being compared. Different measurements of academic behaviors include the use of subjective reports, trained observers, or structured concentration or attention tests. Each of the measurements account for the definition of academic behaviors in this review, but the differences may have led to the few slight inconsistencies between studies. In a recent review, it was concluded that the evidence for the effects of acute bouts of PA on attention is weak.³³ Whereas our review finds this association to be stronger, there is agreement that it is difficult to compare studies that have different methodologies and outcome measures.

The populations involved in the studies under review represented a wide range of children across

the world, which may have led to differences based on different lifestyle habits in different settings. There are many outside, social factors including socioeconomic status, home-life and family situations, and other environmental effects that can affect child behavior.^{34,35} Although these factors vary individually, there can be higher concentrations of certain factors in particular geographic areas, which may lead to differences in results. It is important to include sufficient information about the participants involved in the study. Analysis and review could have been stronger had this information been reported adequately throughout all the studies.

In addition to increasing reports of participant information, it is important to account for the individual effects of students and school systems that can cause confounding variables. For example, additional PA and participation in sports outside of the experimental PA intervention can affect the data collected. Not all studies addressed whether the school offered a PE class in addition to the PA interventions. Furthermore, many students are involved in extracurricular activities that contribute to the frequency and duration of PA they participate in. It is more difficult to control for this in terms of improvements for further research studies. One option could be to have participants report PA levels outside of the treatment setting.

To ensure that the PA implemented is controlled, it can be useful to use heart rate monitors to see if there are differences among students who apply more intense PA or to encourage students to stay around a particular rate for consistency. This method was only used in one of the studies under review.¹⁵ It would also be of value to record heart rates to include intensity of the PA in data analysis, especially because the PA interventions varied so greatly, from stretching to aerobic exercises. Applying small changes to the methods of some of these studies would add substantial value to the research presented and to the strength of this review.

IMPLICATIONS FOR SCHOOL HEALTH

Academic behaviors in terms of paying attention, concentrating, and performing on-task behavior is a vital aspect of the learning experience because it directly affects academic performance and learning abilities. As demonstrated in this paper, PA has positive effects on academic behaviors in school-aged youth, with few exceptions. With as little as 5 minutes of PA, positive results in academic behaviors have been observed, but it is more likely to be effective with at least 10-30 minutes of PA performed regularly. However, these statements are made with caution due to the low number of studies on this topic and inconsistent methodologies between studies. Schools

can use the information provided by this systematic review in the following ways:

- Implement a form of PA appropriate for the school and its resources.
- Be creative in the ways PA can be implemented.
- Research new ways to implement PA in schools if traditional methods are not feasible.
- Standardize the definition of academic behaviors at the school district level.
- Record academic behaviors because of PA implemented.
- Compile records and best practices among classrooms and schools.
- Adjust PA practices as needed to be most effective for improving academic behaviors.

Overall, the results demonstrated by the 9 studies reviewed call for more research to be conducted on the effects of PA on academic behaviors, especially because these results have strong potential. The data represented on this topic is lacking, particularly compared with the data existing on PA effects on grades and test scores. By following the suggested outline, there is room for further small- and large-scale research to be conducted on this topic. In addition, it is important school personnel are aware of the benefits of PA and different ways it can be implemented. Existing research can guide PA implementation and can contain helpful compilation of resources.³⁶ Continuing to make connections between PA and different aspects of academic life will add to the existing literature supporting PA in schools, which can lead to school personnel implementing PA that improves the classroom environment and ultimately, the academic lives of school-aged children.

Human Subjects Approval Statement

Preparation of this article did not involve original research with human subjects.

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