



## Review

# The association between school-based physical activity, including physical education, and academic performance: A systematic review of the literature<sup>☆,☆☆</sup>

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## ABSTRACT

**Objective.** The purpose of this review is to synthesize the scientific literature that has examined the association between school-based physical activity (including physical education) and academic performance (including indicators of cognitive skills and attitudes, academic behaviors, and academic achievement).

**Method.** Relevant research was identified through a search of nine electronic databases using both physical activity and academic-related search terms. Forty-three articles (reporting a total of 50 unique studies) met the inclusion criteria and were read, abstracted, and coded for this synthesis. Findings of the 50 studies were then summarized.

**Results.** Across all the studies, there were a total of 251 associations between physical activity and academic performance, representing measures of academic achievement, academic behavior, and cognitive skills and attitudes. Slightly more than half (50.5%) of all associations examined were positive, 48% were not significant, and 1.5% were negative. Examination of the findings by each physical activity context provides insights regarding specific relationships.

**Conclusion.** Results suggest physical activity is either positively related to academic performance or that there is not a demonstrated relationship between physical activity and academic performance. Results have important implications for both policy and schools.

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## Introduction

When youth participate in at least 60 min of physical activity every day, health benefits accrue, such as healthy bones and muscles, improved muscular strength and endurance, reduced risk for developing chronic disease risk factors, improved self-esteem, and reduced stress and anxiety ([Physical Activity Guidelines Advisory Committee, 2008](#)). Most youth, however, are not engaging in the recommended level of physical activity. For example, in 2009, only 18.4% of U.S. high school students reported being physically active at least 60 min per day for the previous 7 days ([Centers for Disease Control and Prevention, 2010b](#)).

Schools provide a unique venue for youth to participate in physical activity, as they serve nearly 56 million youth ([National Center for Education Statistics, 2009](#)). At the same time, schools face increasing challenges in allocating time for physical education and other physical activity opportunities during the school day. Many schools are attempting to increase instructional time for mathematics, English, and science in an effort to improve standards-based test scores ([Wilkins et al., 2003](#)). As a result, physical education classes, recess, and other physical activity breaks often are decreased or eliminated during the school day. Outside of school-day opportunities, youth may participate in physical activities (e.g., school or community sports), which may be available through schools, communities, and/or after-school programs ([Coatsworth and Conroy, 2007](#)).

There is a growing body of research focused on the association between school-based physical activity, including physical education, and academic performance among school-aged youth ([Castelli et al., 2007](#); [Sibley and Etnier, 2003](#); [Strong et al., 2005](#); [Taras, 2005](#); [Tomprowski et al., 2008](#); [Trost, 2007](#); [Trudeau and Shephard, 2008, 2010](#)). This developing literature suggests physical activity may have an impact on academic performance through a variety of direct and indirect physiological, cognitive, emotional, and learning mechanisms ([Hillman et al., 2005](#); [Rosenbaum et al., 2001](#); [Sibley and Etnier, 2003](#)).

To extend the understanding of these connections, this review offers a broad examination of the literature on a range of physical activity contexts, including physical education class, recess, classroom-based physical activity breaks outside of physical education class and recess, and extracurricular physical activity, thereby providing a tool to inform program and policy efforts for education and health professionals. The purpose of this review is to synthesize the scientific literature that has examined the association between

four school-based physical activity contexts and indicators of academic performance, including cognitive skills and attitudes, academic behaviors, and academic achievement.

## Methods

### Conceptual definitions

The research on this topic suggests that physical activity can be related to many different aspects of academic performance (e.g., attention, on-task behavior, grade-point average (GPA)), and as a result, the existing literature examines a wide range of variables. In this review, those variables have been organized into three categories: cognitive skills and attitudes, academic behaviors, and academic achievement. The three categories, as well as other important terms, are defined in [Fig. 1](#).

### Inclusion criteria

The following criteria were used to identify published studies for inclusion in this review. Studies had to be published between 1985 and October 2008;<sup>1</sup> present original data; be published in English; focus on school-aged children between 5 and 18 years of age; include clear measures of school-based physical education and/or physical activity or extracurricular physical activities (including school sports); and measure academic performance (cognitive skills and attitudes, academic behaviors, and academic achievement) using one or more educational or behavioral outcomes (e.g., graduation or dropout rates, performance on standardized tests, academic grades/GPA, years of school completed, time on task, concentration or attentiveness in educational settings, attendance, disciplinary problems, school connectedness<sup>2</sup>).

Studies were excluded for not meeting the above criteria or if they focused solely on sedentary lifestyle variables, overweight status, or media use rather than physical activity. Studies also were excluded if they focused exclusively on the relationship between academic performance and fitness test scores rather than physical activity

<sup>1</sup> Articles published between October 2008 and the publication date that met the inclusion criteria and made a notable contribution to the field may have been included in the review based on expert recommendations.

<sup>2</sup> School connectedness refers to students' belief "that adults and peers in the school care about their learning as well as about them as individuals" ([Centers for Disease Control and Prevention, 2009](#)).

**Academic Performance:** In this review, academic performance is used broadly to describe different factors that may influence student success in school. These factors were grouped into three primary areas:

- **Cognitive Skills and Attitudes:** Cognitive skills and attitudes include both basic cognitive abilities, such as executive functioning, attention, memory, verbal comprehension, and information processing, as well as attitudes and beliefs that influence academic performance, such as motivation, self concept, satisfaction, and school connectedness. Studies used a range of measures to define and describe these constructs.
- **Academic Behaviors:** Academic behaviors include a range of behaviors that may have an impact on students' academic performance. Common indicators include on-task behavior, organization, planning, attendance, scheduling, and impulse control. Studies used a range of measures to define and describe these constructs.
- **Academic Achievement:** Academic achievement includes standardized test scores in subject areas such as reading, math, and language arts; GPAs; classroom test scores; or other formal assessments.

**Physical Education:** Physical education, as defined by the National Association for Sport and Physical Education (NASPE), is a curricular area offered in schools (K–12) that provides students with instruction on physical activity, health-related fitness, physical competence, and cognitive understanding about physical activity, thereby enabling students to adopt healthy and physically active lifestyles (National Association for Sport and Physical Education, 2008). A high-quality physical education program enables students to develop motor skills, understand movement concepts, participate in regular physical activity, maintain healthy fitness levels, develop responsible personal and social behavior, and value physical activity (National Association for Sport and Physical Education, 2008). This context category encompassed all studies that were explicitly set in physical education class or consisted of a school-based course or curriculum that addressed primary aspects of physical education. This category was inclusive of activities conducted in physical education class but did not exclude curricula with components that extended beyond formal physical education. Typically, studies in this category examined the impact of increasing the amount of time students spent in physical education class or manipulating the types of activities conducted with students.

**Recess:** Recess is a time during the school day that provides children with the opportunity for active, unstructured or structured, free play.

**Physical Activity:** Physical activity is defined as any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a resting level (Physical Activity Guidelines Advisory Committee, 2008). Physical activity can be repetitive, structured, and planned movement (e.g., a fitness class or recreational activity such as hiking); leisurely (e.g., gardening); sports-focused (e.g., basketball, volleyball); work-related (e.g., lifting and moving boxes); or transportation-related (e.g., walking to school). The studies in this review included a range of ways to capture the frequency, intensity, duration, and type of students' physical activity.

**Physiology:** In this report, physiology includes indicators of structural or functional changes in the brain and body. Studies most often reported measures of physical fitness, motor skills, and body composition from this construct.

**Classroom-based physical activity:** This context category included studies that were classroom-based but were not physical education class or recess. In general, these studies explored short physical activity breaks (5–20 minutes) or ways to introduce physical activity into learning activities that were either designed to promote learning through physical activity or provide students with a pure physical activity break. These interventions are relatively easy and inexpensive for a teacher to incorporate into the classroom.

**Extracurricular physical activity:** This context category encompassed studies that focused specifically on the relationships between activities organized through school that occur outside of the regular school day. This category included participation in school sports (interscholastic sports and other teams) as well as other after-school physical activity programs.

**Fig. 1.** Conceptual definitions.

itself. Review articles, meta-analyses, and unpublished studies were excluded from the coding and analysis portion of this review, although their reference lists were used to identify original research to be reviewed for inclusion.

#### *Identification of studies that met the inclusion criteria*

Studies were identified through a search of nine electronic databases (ERIC, Expanded Academic Index ASAP, Google Scholar, PsycNET, PubMed, ScienceDirect, Sociological Abstracts, SPORTDiscus and the Cumulative Index to Nursing and Allied Health Literature) using a pre-established set of search terms that included both physical activity and academic-related terms (see Table 1). Additional studies were located from reference lists of the identified articles.

#### *Classification of studies*

The search yielded 406 articles. Two trained researchers examined each article to determine its match with the inclusion criteria; it was then classified as “included for review” or “excluded from review.”

When the match was unclear, articles were temporarily classified as “possible inclusion” before being reviewed by two additional researchers for final classification. Additional details on classification are provided in the full report (Centers for Disease Control and Prevention, 2010a).

Overall, 43 articles (describing 50 unique studies) met the inclusion criteria and were read, abstracted, and coded for this synthesis (Fig. 2). Two articles in this review presented findings from more than one study that met inclusion criteria; one article described three studies (Pellegrini et al., 1995), and the other reported on six (Collingwood et al., 2000).

#### *Study coding process*

The coding method for this report is similar to that of several prominent literature reviews in the public health field (Kirby, 2007; Stone et al., 1998; Welk et al., 2000). A team of eight trained reviewers read and coded the 43 articles using a standard coding protocol. The following information was abstracted: purpose, research questions, study design, sampling, sample characteristics, setting, theory,

**Table 1**  
Article search terms and databases searched.

Physical activity search terms	Academic-related search terms	Databases searched
Physical activity	Academic achievement	PubMed
Exercise	Academic problems	SportDiscus
Physical education	Educational status (MESH)	The Cumulative Index to Nursing and Allied Health Literature (CINAHL)
		Expanded Academic Index ASAP
Fitness	Education measurement (MESH)	PsycNET
Sport	Graduation rates	Sociological Abstracts
Sport participation [searched in Cumulative Index to Nursing and Allied Health Literature (CINAHL) and SportDiscus only]	Academic grades	
Energy expenditure (searched in CINAHL and SportDiscus only)	Grade point average (GPA)	ERIC
	Standardized test scores	ScienceDirect
	Grade retention	Google Scholar
	Years of school completed	
	Time on task	
	Attentiveness	
	Concentration (searched in CINAHL and SportDiscus only)	
	Attendance	
	Tardiness	
	Discipline	
	Memory	
	Reading achievement	
	Reading performance	
	Mathematics achievement	
	Mathematics performance	
	Science achievement	
	Science performance	
	Educational indicators	
	Achievement scores	
	Educational testing	
	Educational assessment	
	Dropout	
	School refusal	
	Student motivation	
	Student engagement	
	Student learning	
	Information retrieval (searched in CINAHL and SportDiscus only)	
	Cognitive performance	
	Student assessment	
	Brain Development	
	School connectedness	

intervention, methods, analytic strategy, results, limitations, study focus, and additional comments. For this review, study designs were classified as experimental, quasi-experimental, descriptive, or case studies; data collection methods and time points were noted as described. Studies that lacked details regarding any field of interest were coded as “information not provided.”

To ensure consistency in coding, approximately 17% of all articles were double-coded by a reviewer and a senior coder. A team of article reviewers met regularly during the coding process to discuss and resolve issues associated with coding. Senior team members resolved and verified issues as they arose.

A brief summary profile of each study was then created, and summaries were e-mailed to the studies' corresponding authors for review and verification. Seventy-two percent of the authors (31 of 43) reviewed their summaries. Author edits were incorporated where applicable.

## Data analysis

Coded data from the articles were used to categorize and organize studies first by their physical activity context (i.e., school-based physical education, recess, classroom-based physical activity breaks outside of physical education class and recess, and extracurricular physical activity) and then by outcome, cohort, sampling groups, and date published. The individual studies were identified (in the instances where articles described more than one study), and treated equally, regardless of study characteristics or design. Results describe the types of associations or relationships reported in the studies. Positive or negative associations described in the results, refer to findings study authors reported reached statistical significance ( $p < 0.05$ ). Within each study, every association tested that was related to one of the four physical activity contexts and an academic performance outcome of interest was counted and included in the analysis. Studies included in this review tested between 1 and 32 different associations.

## Results

This review examines the findings of 43 articles (reflective of 50 studies total) that explored the relationship between four school-based physical activity contexts and academic performance.

The results are presented by physical activity context. Within each context, results are described by study focus (intervention or nonintervention) and by the type of results. Results with  $p$  values less than 0.05 were considered statistically significant in this report. Qualitative and descriptive studies that did not include significance testing are described in the text of this report, but not in outcome counts. Descriptions of study characteristics are provided in Table 2, and outcome counts are provided in Table 3. Associations are displayed by type of academic performance outcome measured: cognitive skills and attitudes, academic behavior, or academic achievement.

Across all the studies, there were a total of 251 associations between physical activity and academic performance, representing measures of academic achievement, academic behavior, and cognitive skills and attitudes. Slightly more than half (50.5%) of all associations examined were positive, 48% were not significant, and 1.5% were negative.

### School-based physical education studies

Fourteen studies (reported in 14 articles) examined the relationship between school-based physical education and academic performance. Most ( $n = 10$ ) described intervention studies and assessed the impact of an intervention on a range of outcomes. The remaining four were descriptive and examined relationships between physical education and academic measures.

### Intervention studies

In general, the 10 intervention studies examined how differences in physical education affected academic performance. Six studies (Bluehardt et al., 1995; Dwyer et al., 1996; Ericsson, 2008; McNaughten and Gabbard, 1993; Pollatschek and O'Hagan, 1989; Raviv and Low, 1990) examined increasing the amount of physical education or level of physical activity intensity in physical education class and comparing students' academic performance by intervention condition. Two studies examined strategies for improving the quality of physical education (Milosis and Papaioannou, 2007; Sallis et al., 1999). The remaining two studies examined the relationship between increasing the emphasis on different types of activities (i.e., aerobic exercise, coordinative exercise) and aspects of academic performance (Budde et al., 2008; Tuckman and Hinkle, 1986). Collectively, the studies were conducted across a broad range of grade levels, representing elementary, middle, and high schools. Seven studies employed an experimental design, and three reported data from



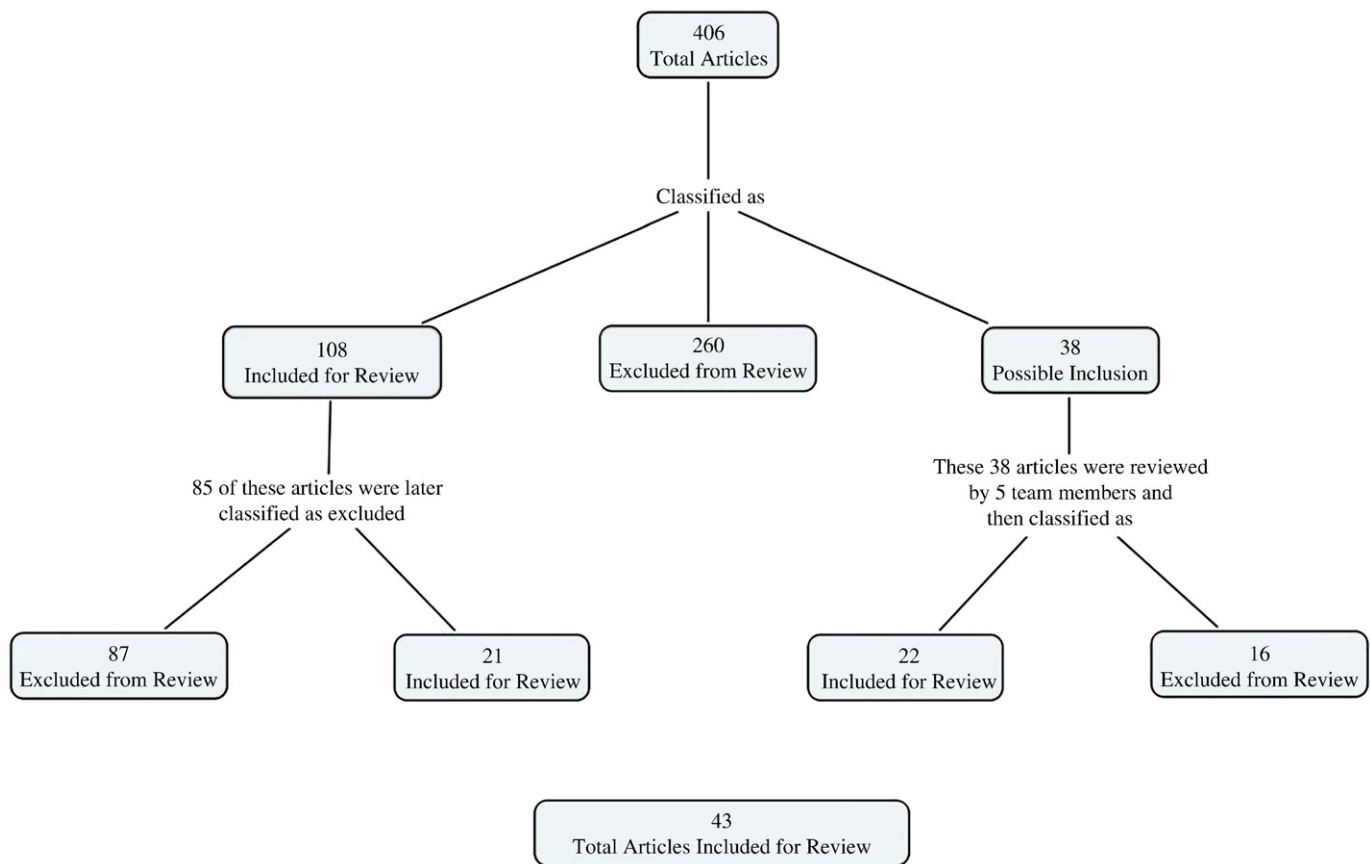


Fig. 2. Article classification system.

quasi-experimental designs. Most studies involved short-term follow-up (e.g., immediate or 3-month delay). Finally, the studies assessed a range of indicators of academic performance including cognitive skills (e.g., concentration and creativity), attitudes (e.g., self-esteem and motivation), academic behaviors (e.g., conduct), and/or academic achievement (e.g., standardized test scores and GPA).

Results varied across the 10 intervention studies, with most (8 of 10 studies) showing one or more positive associations. Two studies showed all or mostly positive associations between physical education and cognitive skills and attitudes or academic achievement (Budde et al., 2008; Ericsson, 2008). As an example, Ericsson (2008) found that extending physical education (from 2 days per week to daily) was associated positively with math, reading, and writing test scores. This study also noted positive associations for attention, but the relationships dissipated over time.

Six studies reported more mixed conclusions. Five found a mixture of positive and nonsignificant associations (Bluehardt et al., 1995; Dwyer et al., 1996; McNaughten and Gabbard, 1993; Milosis and Papaioannou, 2007; Tuckman and Hinkle, 1986). For example, Dwyer et al. (1996) compared academic achievement and classroom behavior across three intervention conditions (fitness group—75 min of activity daily, with an emphasis on intensity of activities; skill group—75 min of activity daily with no focus on intensity; and control group—three 30-min periods of physical education per week). They found no differences in academic achievement across the three intervention conditions, despite the fact that students in the fitness and skill groups actually had less classroom teaching time to accommodate the increase in time for physical education. They also found that classroom behavior improved for students in the skill and fitness intervention conditions. The sixth study, by Sallis et al. (1999), examined an intensive 2-year health-related physical education

program taught by trained classroom teachers or physical education specialists and designed to increase students' physical activity levels. They found the program taught by trained teachers had a positive impact on reading, language, and basic battery standardized test scores, but no significant impact on math. When taught by physical education specialists, students in the program scored better than students not enrolled in the program on reading, but lower on language and about the same in math.

Finally, two studies found no associations between physical education and indicators of academic performance. These studies examined the relationship between the frequency of physical education and either cognitive skills and attitudes (Raviv and Low, 1990) or academic achievement (Pollatschek and O'Hagan, 1989).

#### Nonintervention studies

The four nonintervention studies examined associations between physical education and academic performance using cross-sectional designs ( $n=3$ ) or secondary analyses of an existing longitudinal dataset ( $n=1$ ). Three of the four studies were conducted at the elementary or middle school level; the fourth study was completed with high school students. All studies used standardized tests to assess academic achievement. Results were either positive or neutral. Three of the studies found positive associations between time spent in physical education or skills learned in physical education and indicators of academic achievement (Carlson et al., 2008; Dexter, 1999; Tremarcke et al., 2007). As an example, one study (Tremarcke et al., 2007) noted a positive association between standardized English language arts test scores and time spent in physical education, but no such association for math scores. The remaining study found no significant associations between physical education and academic performance on state literacy and numeracy tests (Dollman et al.,

**Table 2**  
Summary characteristics of reviewed studies.

Characteristics of studies	Number of studies (n = 50)	Number of studies that included academic performance measure <sup>a</sup>		
		Academic achievement	Academic behavior	Cognitive skills and attitudes
Physical activity context				
Physical education class	14	10	3	7
Recess	8	0	3	5
Classroom based	9	6	1	5
Extracurricular physical activity	19	16	9	14
Study design				
Experimental	11	8	3	6
Quasi-experimental	17	6	4	12
Descriptive	22	17	11	11
Data collection design				
Cross-sectional	12	8	3	5
Longitudinal	38	27	15	26
Intervention				
Intervention	32	20	12	23
Nonintervention	18	15	6	8
Setting <sup>b</sup>				
School day	40	26	12	22
After school	6	5	2	5
Community	3	3	3	3
Household	2	2	1	2
Student sample educational level				
Primary	22	12	6	11
Secondary	27	23	11	19
Cross level	1	0	1	1
Country				
United States	34	23	16	21
International	16	12	2	10

<sup>a</sup> Studies often included more than one type of measure; thus, the number of studies that include these different academic performance measures may exceed the total number of studies in any given category.

<sup>b</sup> Some studies included more than one setting; therefore, the total number of studies by setting exceeds 50.

2006). There were no negative associations between physical education and indicators of academic performance across these four studies.

#### Strengths and limitations of methods

This collection of studies has a number of strengths as well as limitations. The studies were conducted across a range of grade levels and used a range of indicators related to cognitive skills, attitudes, and academic achievement. Furthermore, nearly half featured experimental designs and half explored associations by gender. Several limitations were noted, including small samples or samples with potential biases that may affect the generalizability of the results (e.g., university research/laboratory school populations). Several authors acknowledged measurement issues, such as limited follow-up; not assessing precursors of academic achievement (e.g., concentration, memory, or classroom behavior); or failing to collect data on socioeconomic status (SES) and other background variables. Finally, authors of intervention studies also noted implementation limits, such as unequal participation in the intervention or lack of data on implementation quality.

#### Recess studies

Eight studies (reported in six articles) examined the relationship between school recess, cognitive skills, attitudes, and/or academic behavior. Six of the studies tested interventions to examine how recess impacts academic performance. The other two descriptive, nonintervention studies explored relationships between recess and school adjustment or classroom behavior.

#### Intervention studies

The six intervention studies examined the relationship between recess, or increased physical activity during recess, and cognitive skills

(attention or concentration) and academic behavior (on-task behavior). All of these studies were conducted in elementary schools with students in kindergarten through fourth grade, and all six employed an experimental or quasi-experimental design (Caterino and Polak, 1999; Jarrett et al., 1998; Pellegrini and Davis, 1993; Pellegrini et al., 1995). Most used trained observers to collect data on classroom and recess behaviors, with multiple observation points. The data collection follow-up period ranged from 0 to 4 months following baseline. The interventions involved the introduction of recess into the daily school schedule or manipulating timing of recess (e.g., holding recess after varying lengths of class time).

Results across these six studies showed positive associations or no association. Three studies reported all positive associations between more physical activity at recess and classroom behaviors (Caterino and Polak, 1999; Jarrett et al., 1998; Pellegrini and Davis, 1993). For example, Jarrett et al. (1998) observed that children were less fidgety, less listless, more focused, and more on task when they had recess compared to when they did not have recess.

The three intervention studies by Pellegrini et al. (1995) reported both positive and nonsignificant associations. Investigators found that students' attention was lower after longer periods of classroom work without a break than after shorter periods. They also found that, in general, students' attention was better after recess than before. Finally, they found the type of behavior during recess (physical activity or social interaction) did not affect classroom attention after recess for any grade or gender groups.

#### Nonintervention studies

One of the two nonintervention recess studies (Barros et al., 2009) explored the impact of the frequency of recess on teacher reports of classroom behavior in a very large sample (n = 11,529) and found overall classroom behavior was significantly better for students who had recess every day for at least 15 min than for those who did not.

**Table 3**  
Summaries of the outcomes of cognitive skills and attitudes, academic behaviors, and academic achievement, grouped by context area.

Context area	Total # of performance outcomes	Type of relationship observed between physical activity variable and academic performance		
		Positive	None	Negative
<i>Intervention or nonintervention studies</i>				
<i>Variables of interest</i>				
<b>Physical education</b>				
<i>Intervention studies</i>				
Cognitive skills and attitudes (N = 7 studies)	24	12	12	0
Academic behavior (N = 3 studies)	7	2	5	0
Academic achievement (N = 6 studies)	21	11	9	1
<i>Nonintervention studies</i>				
Academic achievement (N = 4 studies)	27	14	13	0
<b>Recess</b>				
<i>Intervention studies</i>				
Cognitive skills and attitudes (N = 4 studies)	10	4	6	0
Academic behavior (N = 2 studies)	4	4	0	0
<i>Nonintervention studies</i>				
Cognitive skills and attitudes (N = 1 study)	2	1	1	0
Academic behavior (N = 1 study)	1	1	0	0
<b>Classroom physical activity</b>				
<i>Intervention studies</i>				
Cognitive skills and attitudes (N = 5 studies)	11	2	9	0
Academic behavior (N = 1 study)	1	1	0	0
Academic achievement (N = 6 studies)	8	5	3	0
<b>Extracurricular physical activity</b>				
<i>Intervention studies</i>				
Cognitive skills and attitudes (N = 7 studies)	17	12	5	0
Academic behavior (N = 6 studies)	6	1	5	0
Academic achievement (N = 6 studies)	6	1	5	0
<i>Nonintervention studies</i>				
Cognitive skills and attitudes (N = 7 studies)	48	28	18	2
Academic behavior (N = 3 studies)	34	15	19	0
Academic achievement (N = 10 studies)	24	13	10	1

The other study explored the impact of recess on observations of individual students' cognitive and emotional adjustment to school within one school ( $n = 77$ ) and found a positive association between recess and end-of-year social competence and perceptions of school adjustment for boys, but not for girls (Pellegrini et al., 2002).

#### Strengths and limitations of methods

These studies feature several strengths as well as some limitations. Six of the eight studies used experimental or quasi-experimental designs, and most involved observations of student behaviors with multiple observation points (e.g., 6, 12, or 32 observations). Study authors reported a number of limitations including small sample sizes (range of 23–77 students in seven of the eight studies), and the inability in most studies to analyze data by SES, race/ethnicity, or other subgroups. In addition, the authors noted classroom-level ratings of student behavior by classroom teachers could be influenced by teachers' perceptions of the benefits of recess.

#### Classroom physical activity studies

Nine studies (reported in nine articles) examined the relationship between classroom-based physical activity and academic performance. All nine of the studies were interventions.

These studies examined how the introduction of brief physical activities in a classroom setting affected cognitive skills (e.g., aptitude, attention, memory); attitudes (e.g., mood); academic behaviors (e.g., on-task behavior, concentration); and academic achievement (e.g., standardized test scores, reading literacy scores, and math fluency scores). The interventions involved the introduction of physical activities by trained teachers or facilitators into the classroom setting, with activities lasting between 5 and 20 min per session. Physical activity sessions or breaks typically were delivered on a daily or regular basis. Intervention implementation periods spanned from 1 day to 16 months, with most lasting between 2 and 3 months.

All but two of these studies were conducted with elementary school students in first through fifth grade; the others were conducted in a primary and secondary school in Sweden (Norlander et al., 2005) and an urban middle school in the United States (Della Valle et al., 1986). Five studies employed quasi-experimental designs (Della Valle et al., 1986; Maeda and Randall, 2003; Mahar et al., 2006; Molloy, 1989; Norlander et al., 2005), three used experimental designs (Ahamed et al., 2007; Fredericks et al., 2006; Uhrich and Swalm, 2007), and one used a qualitative, case-study design (Lowden et al., 2001). The data collection follow-up period ranged from 0 to 12 months after the intervention. Outcome measures most often included standardized aptitude and achievement tests and teacher or trained observer ratings of classroom behavior.

Results across the nine intervention studies showed positive outcomes or no association. Four studies reported all positive associations between classroom physical activity and classroom behaviors and academic achievement (Della Valle et al., 1986; Maeda and Randall, 2003; Mahar et al., 2006; Norlander et al., 2005). For example, Maeda and Randall (2003) reported that second-grade students exhibited greater concentration and demonstrated higher math fluency after engaging in brief movement breaks consisting of 5 min of vigorous exercise 1 h after lunch.

Four intervention studies reported positive and nonsignificant associations (Fredericks et al., 2006; Lowden et al., 2001; Molloy, 1989; Uhrich and Swalm, 2007). As an example, Fredericks et al. (2006) described improvements in spatial aptitude, reading skills, and math skills among first-grade students exposed to daily classroom exercises focused on the development of perceptual and sensory motor skills. However, there were no associations with other indicators of aptitude such as perception, reasoning, memory, and verbal comprehension or emotional indicators.

The ninth intervention study found no relationship between an additional 15 min of daily classroom-based physical activity, in the context of a school-wide physical activity program, and standardized

achievement tests (Ahamed et al., 2007). Collectively, eight of the nine studies reviewed suggest classroom-based physical activities may have favorable associations with indicators of cognitive functioning, academic behaviors, and/or academic achievement. No negative associations were found.

#### *Strengths and limitations of methods*

Eight of the nine studies employed either experimental or quasi-experimental designs, and most used standardized measures of cognitive functioning and academic achievement and standardized protocols for classroom observations. Several studies collected data at multiple follow-up dates. When reported, study populations represented an array of racial and ethnic backgrounds. Limitations reported by study authors include small sample sizes, with all but two studies having fewer than 100 students, and the inability to analyze data by SES, race/ethnicity, or other subgroups. Some authors noted that classroom observers typically were not blinded to study condition. Authors also noted concerns about group comparability at baseline and its potential impact on determining an intervention effect.

#### *Extracurricular physical activity studies*

Nineteen studies (reported in 14 articles) examined the relationship between involvement in extracurricular physical activity (such as interscholastic sports or other physical activities outside of the regular school day) and academic performance. Nine studies focused on involvement in school interscholastic sport teams; the other 10 focused on other school-related extracurricular physical activities.

#### *Interscholastic school sports*

All nine of the studies assessing the relationship between school sports team participation and academic performance were descriptive in nature and focused on secondary school students (Crosnoe, 2002; Fredricks and Eccles, 2008; Fredricks and Eccles, 2006; Hawkins and Mulkey, 2005; McNeal, 1995; Schumaker et al., 1986; Spence and Poon, 1997; Stephens and Schaben, 2002; Yin and Moore, 2004). Eight of the nine studies examined how students' participation on sports teams was related to test scores, grades, or teacher ratings of academic achievement; two (McNeal, 1995; Yin and Moore, 2004) measured dropout rates.

Three of the nine studies were cross-sectional, collecting data at one time point; six were longitudinal, and involved a secondary analysis of data collected at baseline and 3–5 years later. Two of the nine studies had small samples ( $n = 85$ – $136$ ); the remaining studies had larger sample sizes ( $n = 883$ – $14,249$ ).

These studies varied in measurement of academic performance and participation in sports. Some used school records (test scores, GPAs, or dropout rates) (McNeal, 1995; Schumaker et al., 1986; Stephens and Schaben, 2002; Yin and Moore, 2004), and one used a teacher rating of student academic ability (Hawkins and Mulkey, 2005) for students who participated in interscholastic sports. Others examined the relationship between student report of participation on sports teams (type of team was not specified) and students' self-reported grades (Crosnoe, 2002; Darling, 2005; Fredricks and Eccles, 2006; Spence and Poon, 1997).

The studies that explored the relationship between school records of academic achievement and student participation in interscholastic sports found mostly positive and neutral results. For example, one study (Stephens and Schaben, 2002) of 8th-grade students found participation in interscholastic sports was associated with higher math grades, higher math standardized test scores, and higher overall GPA; however, another study (Schumaker et al., 1986) of 12th-grade students found no relationship between varsity sports participation and grades. Two studies (McNeal, 1995; Yin and Moore, 2004) examined the impact of sports on high school dropout rates and found

participants were significantly less likely to drop out of school compared to nonparticipants.

Two studies (Fredricks and Eccles, 2008; Yin and Moore, 2004) found the relationship between academic achievement and varsity sports participation was inconsistent, showing positive, negative, and no associations, depending on the outcome measured and the grade level of the students. As an example, Yin and Moore (2004) found students who reported participation in interscholastic sports in eighth grade showed significantly lower test scores for that year compared to students who did not participate. However, as these same students moved through high school, these differences disappeared, showing no differences in test scores between sport participants and nonparticipants in the 10th or 12th grades.

Three of the four studies that examined the relationship between student report of participation in sports teams and self-report of grades showed positive relationships (Crosnoe, 2002; Darling, 2005; Fredricks and Eccles, 2006; Spence and Poon, 1997). Fredricks and Eccles (2006) also found a positive relationship between sports participation and students' educational expectations and school completion rates.

Seven of the nine studies examined gender effects (Crosnoe, 2002; Fredricks and Eccles, 2008; Fredricks and Eccles, 2006; Hawkins and Mulkey, 2005; Schumaker et al., 1986; Stephens and Schaben, 2002; Yin and Moore, 2004) on academic performance; five of the seven studies found at least one significant difference by gender; however, overall, 68% of the associations by gender showed no relationship. One study (Fredricks and Eccles, 2008) also examined results by race and SES. No other subgroup or demographic analyses were reported in the other studies.

#### *Other school-related extracurricular physical activity*

Ten studies focused on other extracurricular physical activities organized through the school, but conducted outside the regular school day (e.g., after-school physical activity or exercise programs). Seven studies examined the effects of an intervention (Collingwood et al., 2000; Reynolds and Nicolson, 2007), and the other three were descriptive (Darling, 2005; Darling et al., 2005; Harrison and Narayan, 2003) with sample sizes ranging from 35 to 4264 students. Measures of academic performance included grades, math scores, homework completion, and attendance.

#### *Intervention studies*

One intervention article (Collingwood et al., 2000) focused on physical activity opportunities after school using six different studies. This article assessed the impact of a life skills program with a focus on improving physical fitness on students' self-reported grades, school attendance, and self-concept. The program was taught after school in a sample of middle schools, high schools, and community centers. As part of the program, students completed an individual exercise program as well as instruction on self-assessment, goal setting, fitness, and exercise planning. Program impact was evaluated at six sites immediately after the program. Results showed positive associations between program participation and academic performance (grades and attendance) or no significant relationships. The positive findings (for self-concept, school attendance, and self-reported grades) were concentrated in the community site, which had the largest sample size. Across all sites (middle schools, high schools, and community centers), self-concept improved significantly for program participants.

The other intervention study examined participation in a school-organized, year-long exercise program that was completed at home and its relationship with cognitive skills and math outcomes of 7- to 10-year-old children diagnosed with, or at risk of, dyslexia or dyspraxia (Reynolds and Nicolson, 2007). This study used a quasi-experimental design with immediate and long-term (3-year) follow-



up. Children showed improved verbal and cognitive skills following the individualized physical activity intervention, although there were no math improvements (Reynolds and Nicolson, 2007).

#### *Nonintervention studies*

The three nonintervention studies (conducted with secondary students) examined associations between participation in after-school physical activities and academic performance using existing datasets (one cross-sectional and two longitudinal). Two studies (Darling, 2005; Darling et al., 2005) found consistently positive associations between extracurricular activity participation and self-reported grades as well as positive academic attitudes and higher academic aspirations. Harrison and Narayan (2003) showed physical activity participation was positively related to homework completion and class attendance.

#### *Strengths and limitations of methods*

Most studies of extracurricular physical activity (including interscholastic sports and/or other extracurricular activities) had relatively large sample sizes. Sixteen of the studies focused on measures of academic achievement, such as standardized test scores or grades (record data or self-reported data). Of the studies that examined sports participation compared to nonparticipation, more than half ( $n=6$ ) specified the level of competitiveness of team participation. More than three-fourths of the studies were longitudinal in nature ( $n=15$ ), allowing for an exploration of causality; the cross-sectional nature of the remaining studies ( $n=4$ ) limits the ability to establish the temporal relationship between the variables. Relatively few studies examined data by race/ethnicity, and only two explored physical activity interventions. Reports were unclear whether sport participation required a minimal level of academic achievement, a requirement that could bias the samples. Several authors also acknowledged limitations such as the need to include measures of social influence (e.g., parental support) in future research; the need to look more closely at how level of participation or competitiveness in sport might affect academic achievement; and the fact that some of the associations found were relatively weak.

## **Discussion**

This report identified 50 peer-reviewed studies and published reports addressing the association between four school-based physical activity contexts and indicators of academic performance (cognitive skills and attitudes, academic behaviors, and academic achievement).

#### *Relationship between physical activity and academics*

Collectively, the results suggest physical activity is either positively related to academic performance (50.5% of the associations summarized) or that there is not a demonstrated relationship between physical activity and academic performance (48% of the associations summarized). This pattern of having positive relationships or no relationships, along with the lack of negative relationships, was consistent throughout the results, despite the heterogeneous nature of the included studies, and is consistent with other published reviews (Shephard, 1997; Trost, 2007).

Very few of the findings in the studies reviewed were negative (only 1.5% of the associations examined). This pattern of results is consistent with other reports (Trost, 2007; Trudeau and Shephard, 2008) that suggest adding physical activity to the school day does not detract from academic performance.

There are a number of possible explanations for the relatively even split between finding positive relationships and no significant relationships between physical activity and academic performance. Some of the studies had relatively small samples, which can make it

more difficult to find statistically significant results. Other studies measured a broad range of student attitudes and behaviors to try to understand which factors may be related and *which are not*. Other issues, such as variation in questionnaires used in the studies, may account for some of the differences. Finally, differences that may not have been discussed in the studies—such as the intensity or duration of the physical activity, the context in which the physical activity took place, individual student differences (e.g., in motivation), and levels and quality of implementation for intervention studies—may help explain the different results among the studies.

#### *School-based physical education and academic performance*

The study results suggest school-based physical education either leads to a positive result or is associated with no change in academic performance. Overall, 11 of 14 studies found one or more positive associations between physical education and indicators of cognitive skills and attitudes, academic behavior, and/or academic achievement. Nearly half the associations (49.5%) between physical education and academic performance were positive; nearly all remaining associations showed no relationship.

The studies also suggest that increased time spent in physical education is not likely to detract from academic performance even when there is less time devoted to subjects other than physical education. Across the nine studies that examined the relationship between time spent in physical education and academic performance, 16 outcomes were positive, and 31 showed no association. No negative associations were found.

#### *Recess and academic performance*

Eight studies meeting the criteria of this review looked at the impact of physical activity during recess on academic performance. Of all outcomes measured in this context area, 59% were positive. In addition, all eight studies found one or more positive findings for cognitive functioning and academic behavior suggesting recess was associated with improvements in attention, concentration, and/or on-task classroom behavior. None of the studies looked directly at the association between recess and measures of academic achievement (e.g., test scores or grades). None of the studies reported negative relationships, which means recess does not appear to detract from students' focus in the classroom.

#### *Classroom physical activity and academic performance*

Nearly all studies (eight of nine) in this category found that offering physical activity breaks during standard classroom instruction may have favorable associations with some indicators of cognitive functioning (e.g., attention/concentration); academic behaviors (e.g., classroom conduct); and/or academic achievement (e.g., test scores). When looking at individual outcomes studied, 40% of associations between physical activity breaks and academic performance were positive and 60% showed no relationship. Furthermore, none of the studies found negative associations. Classroom physical activity breaks do not appear to have a negative relationship with academic performance.

#### *Extracurricular physical activities and academic performance*

More than half of the associations examined in these studies were positive (52% overall), and almost none were negative (2%). Of note, GPA was positively associated with extracurricular physical activity 12 out of the 22 times it was measured. Two studies also examined the association between extracurricular activities and dropout rates and found participation was linked to decreased high school dropout rates.

### Findings by subgroups

There were several interesting points noted when examining the findings by subgroups. First, very few studies examined the relationships between physical activity and academic performance by race or ethnicity. In addition, relatively few studies examined differences in associations by gender, and in those that did, there were no distinct patterns. Second, studies of recess and classroom-based physical activity tended to be from elementary school settings, and studies of extracurricular physical activity tended to be from secondary school settings. Third, the pattern of results appeared slightly more positive in the secondary school setting.

Finally, little variation in results by research design was noted. Although many factors influence a study's quality, experimental or quasi-experimental research designs are generally regarded as more rigorous. The pattern of associations in studies with either of these types of design had very similar results. In the 29 studies using experimental or quasi-experimental designs, 50% (55 of 109) of associations were positive, and 49% (53 of 109) were not significant. Less than 1% (1 of 109) of the associations was negative.

### Strengths and limitations

This review covers 23 years of research; it involved a systematic process for locating, reviewing, and coding the studies; articles were obtained using an extensive array of search terms and international databases; articles were reviewed by multiple trained coders; and the articles cover a broad array of contexts in which youth participate in school-based physical activities.

This review summarizes all studies that met the established review criteria, regardless of study characteristics. Studies were not ranked, weighted, or grouped according to their strengths and limitations; as a result, findings from studies with more rigorous research designs and larger sample sizes were given no more influence than findings from studies with weaker designs and smaller sample sizes. Instead, results were based on counts of statistical findings, and this, in essence, had the effect of allowing individual studies containing multiple comparisons to have a greater influence on the findings as a whole. In addition, the breadth of the review, while revealing a variety of study designs, measures, and populations, often made comparisons and summaries difficult. For example, similar constructs were often defined and/or measured differently across studies. Furthermore, there were not enough studies analyzing the same variables in any given category to make summary statements about the magnitude of associations between physical activity and academic performance variables. As a result, conclusions do not summarize magnitudes of effect sizes and are intentionally broad.

### Implications for policy

There are a number of policy implications stemming from this review. First, there is substantial evidence that physical activity can help improve academic achievement (including grades and standardized test scores). Second, the articles in this review suggest that physical activity can have an impact on cognitive skills and attitudes and academic behavior, all of which are important components of improved academic performance. These include enhanced concentration and attention as well as improved classroom behavior. Third, increasing or maintaining time dedicated to physical education may help, and does not appear to adversely impact, academic performance.

### Implications for schools

The results of this review support several strategies that schools can use to help students meet national physical activity recommendations without detracting from academic performance. To maximize

potential benefits of student participation in physical education class, schools and physical education teachers can consider increasing the amount of time students spend in physical education or adding components to increase the quality of physical education class (National Association for Sport and Physical Education, 2008). Classroom teachers can incorporate movement activities and physical activity breaks into the classroom setting that may improve student performance and the classroom environment. In addition, school personnel can feel confident that providing recess to students on a regular basis may benefit academic behaviors, while also facilitating social development (National Association for Sport and Physical Education, 2006) and contributing to overall physical activity (Ridgers et al., 2006) and its associated health benefits. Furthermore, the evidence suggests school staff can develop or continue school-based sports programs without concern that these activities have a detrimental impact on students' academic performance, and administrators and teachers can encourage after-school organizations, clubs, student groups, and parent groups to incorporate physical activities into their programs and events.

### Implications for future research

In the course of conducting this review, several important characteristics of the studies were noted. Within the contexts reviewed, there were relatively few studies of the impact of recess and classroom physical activity on academic achievement. There were no studies reviewed that examined the relationship of sports and academic achievement within the primary grades or the relationship of physically active breaks/recess and academic achievement within the secondary grades, and few studies reported subgroup analyses beyond gender comparisons. Additionally, less than half of the studies described effect sizes or magnitudes of the associations observed, and although nearly all of the reviewed studies described a practical framework for the research, few of the studies articulated a theoretical basis for the work or explicitly described how the findings informed theory development.

These characteristics highlight important implications for future research. Future research should further examine the relationship between school-based physical activity and academic performance in subpopulations of students (e.g., based on gender, race/ethnicity, or SES); such subgroup analyses are important to report even when associations or interactions are found to be non-significant. Studies should be developed in consultation with educators (e.g., school administrators and staff) and informed by research across disciplines, such as neurobiology, cognitive science, social psychology, and kinesiology. In addition, the field would benefit from identifying uniform ways to measure key outcomes, including both physical activity and academic performance outcomes, and future studies with larger sample sizes and stronger research designs that include longitudinal follow-up, as appropriate, would strengthen the existing body of literature.

### Conclusion

Results suggest physical activity is either positively related to academic performance or that there is not a demonstrated relationship between physical activity and academic performance. The pattern of having positive relationships or no relationships, along with the lack of negative relationships, is consistent throughout the results and suggests that adding physical activity to the school day may enhance and does not detract from academic performance.

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**Conflict of interest statement**

The authors declare that there are no conflicts of interest.

**References**

- Ahamed, Y., MacDonald, H., Reed, K., Naylor, P.-J., Liu-Ambrose, T., McKay, H., 2007. School-based physical activity does not compromise children's academic performance. *Med. Sci. Sports Exerc.* 39, 371–376.
- Barros, R.M., Silver, E.J., Stein, R.E., 2009. School recess and group classroom behavior. *Pediatrics* 123, 431–436.
- Bluehardt, M.H., Wiener, J., Shephard, R.J., 1995. Exercise programmes in the treatment of children with learning disabilities. *Sports Med.* 19, 55–72.
- Budde, H., Voelcker-Rehage, C., Pietraszky-Kendziorra, S., Ribeiro, P., Tidow, G., 2008. Acute coordinative exercise improves attentional performance in adolescents. *Neurosci. Lett.* 441, 219–223.
- Carlson, S.A., Fulton, J.E., Lee, S.M., Maynard, L.M., Brown, D.R., Kohl III, H.W., et al., 2008. Physical education and academic achievement in elementary school: data from the Early Childhood Longitudinal Study. *Am. J. Public Health* 98, 721–727.
- Castelli, D.M., Hillman, C.H., Buck, S.M., Erwin, H.E., 2007. Physical fitness and academic achievement in third- and fifth-grade students. *J. Sport Exerc. Psychol.* 29, 239–252.
- Caterino, M.C., Polak, E.D., 1999. Effects of two types of activity on the performance of second-, third-, and fourth-grade students on a test of concentration. *Percept. Mot. Skills* 89, 245–248.
- Centers for Disease Control and Prevention, 2009. School connectedness: Strategies for increasing protective factors among youth. Atlanta, GA.
- Centers for Disease Control and Prevention, 2010a. The association between school-based physical activity, including physical education, and academic performance. Atlanta, GA.
- Centers for Disease Control and Prevention, 2010b. Youth risk behavior surveillance—United States, 2009. *MMWR CDC Surveill. Summ.* 59 (SS-5), 1–142.
- Coatsworth, J.D., Conroy, D.E., 2007. Youth sport as a component of organized afterschool programs. *New Dir. Youth Dev.* 115 (57–74), 57–58.
- Collingwood, T.R., Sunderlin, J., Reynolds, R., Kohl, H.W., 2000. Physical training as a substance abuse prevention intervention for youth. *J. Drug Ed.* 30, 435–451.
- Crosnoe, R., 2002. Academic and health-related trajectories in adolescence: the intersection of gender and athletics. *J. Health Soc. Behav.* 43, 317–335.
- Darling, N., 2005. Participation in extracurricular activities and adolescent adjustment: cross-sectional and longitudinal findings. *J. Youth Adolesc.* 34, 493–505.
- Darling, N., Caldwell, L.L., Smith, R., 2005. Participation in school-based extracurricular activities and adolescent adjustment. *J. Leis. Res.* 37, 51–76.
- Della Valle, J., Dunn, R., Geisert, G., Sinatra, R., Zenhausern, R., 1986. The effects of matching and mismatching students' mobility preferences on recognition and memory tasks. *J. Educ. Res.* 79, 267–272.
- Dexter, T., 1999. Relationships between sport knowledge, sport performance and academic ability: empirical evidence from GCSE Physical Education. *J. Sports Sci.* 17, 283–295.
- Dollman, J., Boshoff, K., Dodd, G., 2006. The relationship between curriculum time for physical education and literacy and numeracy standards in South Australian primary schools. *Eur. Phys. Educ. Rev.* 12, 151–163.
- Dwyer, T., Blizzard, L., Dean, K., 1996. Physical activity and performance in children. *Nutr. Rev.* 54, S27–S31.
- Ericsson, I., 2008. Motor skills, attention and academic achievements: an intervention study in school years 1–3. *Br. Educ. Res. J.* 34, 301–313.
- Fredericks, C.R., Kokot, S.J., Krog, S., 2006. Using a developmental movement programme to enhance academic skills in grade 1 learners. *S. Afr. J. Res. Sport Phys. Educ. Recr.* 28, 29–42.
- Fredericks, J., Eccles, J.S., 2008. Participation in extracurricular activities in the middle school years: are there developmental benefits for African American and European American youth? *J. Youth Adolesc.* 37, 1029–1043.
- Fredericks, J.A., Eccles, J.S., 2006. Is extracurricular participation associated with beneficial outcomes? Concurrent and longitudinal relations. *Dev. Psychol.* 42, 698–713.
- Harrison, P.A., Narayan, G., 2003. Differences in behavior, psychological factors, and environmental factors associated with participation in school sports and other activities in adolescence. *J. Sch. Health* 73, 113–120.
- Hawkins, R., Mulkey, L.M., 2005. Athletic investment and academic resilience in a national sample of African American females and males in the middle grades. *Educ. Urban Soc.* 38, 62–88.
- Hillman, C.H., Castelli, D.M., Buck, S.M., 2005. Aerobic fitness and neurocognitive function in healthy preadolescent children. *Med. Sci. Sports Exerc.* 37, 1967–1974.
- Jarrett, O.S., Maxwell, D.M., Dickerson, C., Hoge, P., Davies, G., Yetley, A., 1998. Impact of recess on classroom behavior: group effects and individual differences. *J. Educ. Res.* 92, 121–126.
- Kirby, D.B., 2007. Emerging Answers 2007: Research Findings on Programs to Reduce Teen Pregnancy and Sexually Transmitted Diseases. National Campaign to Prevent Teen and Unwanted Pregnancy, Washington, DC.
- Lowden, K., Powney, J., Davidson, J., James, C., 2001. The Class Moves! Pilot in Scotland and Wales: An Evaluation. Scottish Council for Research in Education, Edinburgh.
- Maeda, J.K., Randall, L.M., 2003. Can academic success come from five minutes of physical activity? *Brock Educ. J.* 13, 14–22.
- Mahar, M.T., Murphy, S.K., Rowe, D.A., Golden, J., Shields, A.T., Raedeke, T.D., 2006. Effects of a classroom-based program on physical activity and on-task behavior. *Med. Sci. Sports Exerc.* 38, 2086–2094.
- McNaughten, D., Gabbard, C., 1993. Physical exertion and immediate mental performance of sixth-grade children. *Percept. Mot. Skills* 77, 1155–1159.
- McNeal, R.B., 1995. Extracurricular activities and high school dropouts. *Sociol. Educ.* 68, 62–81.
- Milosic, D., Papaioannou, A.G., 2007. Interdisciplinary teaching, multiple goals and self-concept. In: Liukkonen, J., Vanden Auweele, Y., Vereijken, B., Alfermann, D., Theodorakis, Y. (Eds.), *Psychology for Physical Educators: Student in Focus*, 2nd ed. Human Kinetics, Champaign, IL, pp. 175–198.
- Molloy, G.N., 1989. Chemicals, exercise and hyperactivity: a short report. *Int. J. Disabil. Dev. Educ.* 36, 57–61.
- National Association for Sport and Physical Education, 2006. Recess for elementary school students [position paper]. Reston, VA.
- National Association for Sport and Physical Education, 2008. Comprehensive School Physical Activity Programs Available from [http://www.aahperd.org/naspe/pdf\\_files/CSPAP\\_Online.pdf](http://www.aahperd.org/naspe/pdf_files/CSPAP_Online.pdf).
- National Center for Education Statistics, 2009. Digest of Education Statistics: 2008. Washington, DC.
- Norlander, T., Moas, L., Archer, T., 2005. Noise and stress in primary and secondary school children: noise reduction and increased concentration ability through a short but regular exercise and relaxation program. *Sch. Eff. Sch. Improv.* 16, 91–99.
- Pellegrini, A.D., Davis, P.D., 1993. Relations between children's playground and classroom behaviour. *Br. J. Educ. Psychol.* 63, 88–95.
- Pellegrini, A.D., Huberty, P.D., Jones, I., 1995. The effects of recess timing on children's playground and classroom behaviors. *Am. Educ. Res. J.* 32, 845–864.
- Pellegrini, A.D., Kato, K., Blatchford, P., Baines, E., 2002. A short-term longitudinal study of children's playground games across the first year of school: implications for social competence and adjustment to school. *Am. Educ. Res. J.* 39, 991–1015.
- Physical Activity Guidelines Advisory Committee, 2008. Physical Activity Guidelines Advisory Committee Report, 2008. U.S. Department of Health and Human Services, Washington, DC.
- Pollatschek, J.L., O'Hagan, F.J., 1989. An investigation of the psycho-physical influences of a quality daily physical education programme. *Health Educ. Res.* 4, 341–350.
- Raviv, S., Low, M., 1990. Influence of physical activity on concentration among junior high-school students. *Percept. Mot. Skills* 70, 67–74.
- Reynolds, D., Nicolson, R.I., 2007. Follow-up of an exercise-based treatment for children with reading difficulties. *Dyslexia* 13, 78–96.
- Ridgers, N.D., Stratton, G., Fairclough, S.J., 2006. Physical activity levels of children during school playtime. *Sports Med.* 36, 359–371.
- Rosenbaum, D.A., Carlson, R.A., Gilmore, R.O., 2001. Acquisition of intellectual and perceptual-motor skills. *Annu. Rev. Psychol.* 52, 453–470.
- Sallis, J.F., McKenzie, T.L., Kolody, B., Lewis, M., Marshall, S., Rosengard, P., 1999. Effects of health-related physical education on academic achievement: Project SPARK. *Res. Q. Exerc. Sport* 70, 127–134.
- Schumaker, J.F., Small, L., Wood, J., 1986. Self-concept, academic achievement, and athletic participation. *Percept. Mot. Skills* 62, 387–390.
- Shephard, R.J., 1997. Curricular physical activity and academic performance. *Pediatr. Exerc. Sci.* 9, 113–126.
- Sibley, B.A., Etnier, J.L., 2003. The relationship between physical activity and cognition in children: a meta-analysis. *Pediatr. Exerc. Sci.* 15, 243–256.
- Spence, J. C., & Poon, P., 1997. Results from the Alberta Schools' Athletic Association Survey. Res. Update, 5. Retrieved from [http://www.centre4activeliving.ca/publications/research\\_update/1997/WellBeingSept.htm](http://www.centre4activeliving.ca/publications/research_update/1997/WellBeingSept.htm).
- Stephens, L.J., Schaben, L.A., 2002. The effect of interscholastic sports participation on academic achievement of middle level school students. *NASSP Bull.* 86, 34–41.
- Stone, E.J., McKenzie, T.L., Welk, G.J., Booth, M.L., 1998. Effects of physical activity interventions in youth: review and synthesis. *Am. J. Prev. Med.* 15, 298–315.
- Strong, W.B., Malina, R.M., Blimkie, C.J.R., Daniels, S.R., Dishman, R.K., Gutin, B., et al., 2005. Evidence based physical activity for school-age youth. *J. Pediatr.* 146, 732–737.
- Taras, H., 2005. Physical activity and student performance at school. *J. Sch. Health* 75, 214–218.
- Tomprowski, P.D., Davis, C.L., Miller, P.H., Naglieri, J.A., 2008. Exercise and children's intelligence, cognition, and academic achievement. *Educ. Psychol. Rev.* 20, 111–131.
- Tremarche, P.V., Robinson, E.M., Graham, L.B., 2007. Physical education and its effect on elementary testing results. *Phys. Educ.* 64, 58–64.
- Trost, S., 2007. Active Education: Physical Education, Physical Activity and Academic Performance. Active Living Research, San Diego, CA.
- Trudeau, F., Shephard, R.J., 2008. Physical education, school physical activity, school sports and academic performance. *Int. J. Behav. Nutr. Phys. Act.* 5 (10) Retrieved from <http://www.ijbnpa.org/content/5/1/10>. doi:10.1186/1479-5868-5-10.
- Trudeau, F., Shephard, R.J., 2010. Relationships of physical activity to brain health and the academic performance of schoolchildren. *Am. J. Lifestyle Med.* 4, 138–150.
- Tuckman, B.W., Hinkle, J.S., 1986. An experimental study of the physical and psychological effects of aerobic exercise on schoolchildren. *Health Psychol.* 5, 197–207.
- Uhrich, T.A., Swalm, R.L., 2007. A pilot study of a possible effect from a motor task on reading performance. *Percept. Mot. Skills* 104, 1035–1041.
- Welk, G.J., Corbin, C.B., Dale, D., 2000. Measurement issues in the assessment of physical activity in children. *Res. Q. Exerc. Sport* 71, S59–S73.
- Wilkins, J.L.M., Graham, G., Parker, S., Westfall, S., Fraser, R.G., Tembo, M., 2003. Time in the arts and physical education and school achievement. *J. Curric. Stud.* 35, 721–734.
- Yin, Z., Moore, J.B., 2004. Re-examining the role of interscholastic sport participation in education. *Psychol. Rep.* 94, 1447–1454.