Sport Participation and Academic Performance in Children and Adolescents: A Systematic Review and Meta-analysis

KATHERINE B. OWEN[1], BRIDGET C. FOLEY[1], KATRINA WILHITE[2], BRIDGET BOOKER[2], CHRIS LONSDALE[2], and LINDSEY J. REECE[1]

[1]SPRINTER, Prevention Research Collaboration, Faculty of Medicine and Health, Charles Perkins Centre, School of Public Health, The University of Sydney, NSW, AUSTRALIA; and [2]Institute for Positive Psychology and Education, Australian Catholic University, NSW, AUSTRALIA

ABSTRACT

OWEN, K. B., B. C. FOLEY, K. WILHITE, B. BOOKER, C. LONSDALE, and L. J. REECE. Sport Participation and Academic Performance in Children and Adolescents: A Systematic Review and Meta-analysis. *Med. Sci. Sports Exerc.*, Vol. 54, No. 2, pp. 299–306, 2022. **Introduction:** Physical activity can improve academic performance; however, much less is known about the specific association between sport participation and academic performance, and this evidence has not been synthesized. Our aim was to systematically review and combine via meta-analyses evidence of the association between sport participation and academic performance in children and adolescents. **Methods:** We conducted searches of five electronic databases using sport and academic performance related terms. We combined evidence from eligible studies using a structural equation modeling approach to multilevel meta-analysis. **Results:** From 115 eligible studies, most of which had a high risk of bias ($k = 87$), we meta-analyzed 298 effect sizes. Overall, sport participation had a small positive effect on academic performance ($d = 0.26$, 95% confidence interval = 0.09, 0.42). Moderator analyses indicated that sports participation was most beneficial for academic performance when it was at a moderate dose (i.e., 1–2 $h \cdot wk^{-1}$), compared with no sport or a high dose of sport (3+ $h \cdot wk^{-1}$). **Conclusions:** Sports participation during school hours was more beneficial for academic performance compared with sport participation outside school hours. Based on mostly low-quality studies, we found some evidence that sport could positively affect academic performance in children and adolescents. It appears that sport participation of a moderate dose and at school could be used to promote academic performance. However, if this field were to inform policy, high-quality studies are needed that provide insight into the effect of dose and sport characteristics on academic performance. **Key Words:** EXERCISE, SCHOOL PERFORMANCE, ACADEMIC ACHIEVEMENT, YOUTH

Physical activity and academic performance. There is evidence that physical activity positively influences academic performance in children and adolescents (1). A recent systematic review of systematic reviews identified 12 reviews of experimental studies: 6 concluded physical activity had a positive effect on academic performance, and the other 6 reported a mixture of positive and null effects leading to inconclusive findings (1). A common hypothesis to explain this generally accepted positive association is improved cognitive function and brain structure and function (2,3). Donnelly et al. (4) systematically reviewed evidence of the effects of physical activity on cognitive function, brain structure, and function in children and concluded that physical activity was beneficial. More recently, Valkenborghs et al. (5) systematically reviewed experimental medical imaging studies investigating the effects of physical activity on children and adolescents brain structure and function. In terms of structural changes, physical activity can improve white matter integrity of the corpus callosum, a region in the brain important for cognitive processing. Physical activity can also result in changes in the frontal lobe, which is responsible for executive processes, cognition, attention, and information processing. These changes in the brain and improved cognitive function could explain how physical activity improves academic performance.

Address for correspondence: Katherine Owen, PhD, Charles Perkins Centre, The University of Sydney, NSW 2006, Australia; E-mail: Katherine.owen@sydney.edu.au.
Submitted for publication June 2021.
Accepted for publication August 2021.
Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.acsm-msse.org).

0195-9131/21/5402-0299/0
MEDICINE & SCIENCE IN SPORTS & EXERCISE®

DOI: 10.1249/MSS.0000000000002786

Sport and academic performance. Sport is a type of physical activity that is distinct from recreation (e.g., going to the gym or dancing), active transport (e.g., walking or biking to school or work), and other forms of physical activity (e.g., physically active employment or household chores). Sport is defined as physical exertion, skill, and/or hand–eye coordination as the focus of the activity, with elements of competition and rules set formally through organizations, and sport may be participated in either individually or as a team (6). Children can participate in organized sports during school time or leisure time, and on weekdays or weekends.

Sport could provide additional benefits, over and above those acquired from physical activity. Recent experimental studies have found that compared with moderate to vigorous physical activities with low cognitive engagement (e.g., running), sports provided additional cognitive benefits (7,8). These additional cognitive benefits are likely due to the increased cognitive load from performing moderate to vigorous physical activity and skills in a dynamic and changing environment during sports participation. It is also possible that the type of sport and skills involved in the sport could affect the cognitive benefits. Sports can involve either open skill (i.e., performed in a dynamic and changing environment such as tennis or basketball) or closed skill (predictable stable environment such as swimming or cycling) (9). Open skills have high cognitive demands and provide practice with cognitive functions such as visuospatial ability, information-processing speed, multitasking flexibility, working memory, and inhibitory control. Two recent systematic reviews have concluded that sports with open skills are more effective in improving cognitive function compared with sports with closed skills (10,11). Therefore, sports could provide additional cognitive benefits (e.g., academic performance) compared with more general physical activity (12). However, the evidence examining the specific association between sport participation and academic performance has not been systematically reviewed or combined in meta-analyses. The primary objective of this study was to examine the association between sports participation and academic performance, by reviewing and combining studies that examined the association between sport participation and academic performance in children and adolescents. The secondary objective was to explain the heterogeneity in the overall sport and academic performance effect size by testing potential moderators (13). Moderator analyses may explain some of the heterogeneity in effect sizes, provide direction for future research, and guide intervention efforts. We compared type of sport (i.e., different settings and doses), type of academic performance (i.e., different school subjects and types of measures), participant characteristics (i.e., different ages), and study quality (study design and risk of bias) to provide insights into the most effective way to use sport to promote academic performance for specific groups.

METHODS

This systematic review and meta-analysis was registered at PROSPERO (ID no. CRD42020185908) and guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement (14).

Eligibility criteria. Studies were required to

- include children or adolescents (i.e., school-age children enrolled in primary or secondary school or mean age between 5 and 18 yr)
- not exclusively examine special populations (e.g., children diagnosed with ADHD or obesity)
- assess sport participation either during school hours or outside school hours. Examples of acceptable measures include the number of sport sessions per week or the duration (min) of sport participation per weeks
- assess academic performance using performance outcomes measured within the school environment. Academic performance was defined as performance outcomes that indicate the extent to which an individual has accomplished specific goals within the school environment (15). For example, performance measures include class test scores and grades (class performance), grade point average (across class performance), and standardized test results (e.g., Woodcock–Johnson Tests of Achievement)
- quantitatively assess the association between sport participation and academic performance
- involve an experimental (randomized controlled trials and quasi-experimental), longitudinal, or cross-sectional study design
- have a full-text available in the English language
- be conducted between 1990 and March 2020.

Information sources. Searches were conducted in ERIC, PubMed, Psych Info, Scopus, and Sport Discus up to March 23, 2020. Search results were extracted into Endnote. Additional studies were identified by searching the reference lists of included studies and posting a message on electronic mailing lists (LISTSERVS), requesting that researchers provide information about unpublished studies that met the inclusion criteria.

Search. The search strategy combined the following terms: (a) sport* AND (b) academic performance OR academic outcome OR academic achievement OR academic success OR academic attainment OR academic grades OR school grades OR scholastic OR scholastic performance OR scholastic achievement OR grade point average OR standardized test score OR test scores OR reading OR math* OR learning OR grade OR literacy OR numeracy AND (c) child* OR adolescent* OR teen* OR school-age OR student* OR youth OR boy* OR girl* (for the full search strategy in PubMed, see Supplemental Digital Content 1, http://links.lww.com/MSS/C429).

Two authors independently assessed the titles, abstracts, and full texts of articles for eligibility in two stages (Fig. 1). In the first stage, titles and abstracts were screened. In the second stage, relevant full texts were retrieved and assessed for eligibility. Any discrepancies were resolved by discussion with a third investigator.

Data extraction. Data extracted included the year of publication, authors, study design, sample size, age of participants,

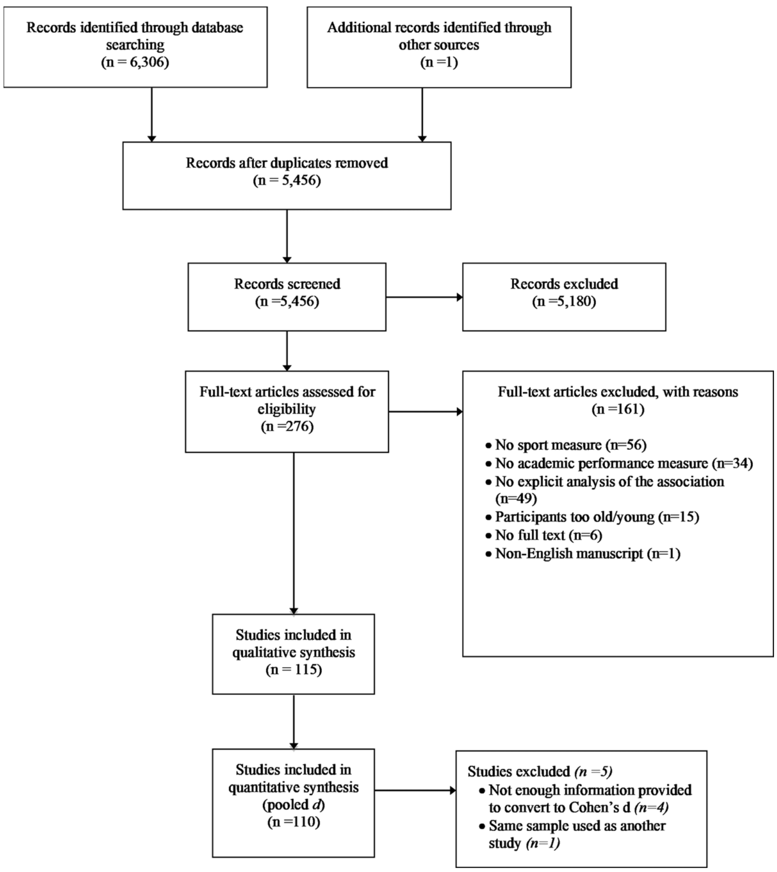

FIGURE 1—Flow diagram of search results and study inclusion and exclusion.

proportion of males and females, country, sport participation measure, academic performance measure, and the association between sport participation and academic performance.

Risk of bias in individual studies. Risk of bias in individual studies was assessed using a combination of items from the Strengthening the Reporting of Observational Studies in Epidemiology, the Consolidated Standards of Reporting Trials, and the Cochrane Handbook for Systematic Reviews. Criteria included: (a) description of participant eligibility criteria, (b) random selection of schools and/or participants (sampling procedures appropriate and adequately described), (c) valid assessment of participant sport participation (reliability and validity evidence reported in the article), (d) valid assessment of participant school academic performance (reliability and validity evidence reported in the article), (e) power calculation reported and study adequately powered to detect hypothesized association, (f) description of the completeness of academic performance data and how missing data was handled, and (g) covariates adjusted for in analyses (e.g., gender, age, weight status). Two researchers independently rated each study on each of these criteria, and any discrepancies were resolved by discussion with a third investigator. Studies that met less than half of the criteria were considered to have a high risk of bias, whereas studies that met more than half of the criteria were considered to have a low risk of bias.

Summary measures and synthesis of results. Summary measures included standardized mean differences, correlation coefficients, *t* values, log odds ratios, and *F* values. We converted the most adjusted summary measure within each individual study to Cohen's *d* (16,17). We corrected Cohen's *d* for sample size, so that effect sizes for smaller studies were reduced to control for different sample sizes across studies (18). These corrected Cohen's *d* values were then conservatively interpreted as small (0.2), medium (0.5), or large (0.8) (19).

We combined effect sizes using a structural equation modeling approach to multilevel meta-analysis. The main advantage of this approach is that it is not limited by the assumption of independence and multiple effect sizes can be included from each study (i.e., effect sizes are nested within studies). Unconditional mixed-effects models using maximum likelihood estimation were conducted to calculate the overall pooled effect size (pooled Cohen's *d*). For each pooled effect size, 95% likelihood-based confidence intervals were calculated. All analyses were conducted using the metaSEM package (20) in R Version 4.0.2 (21).

The I^2 statistic measures variability in the effect sizes (i.e., heterogeneity) (22). An I^2 statistic between 0% and 40% might not be important, 30% to 60% might represent moderate heterogeneity, 50% to 90% might represent substantial heterogeneity, and 75% to 100% considerable heterogeneity (23). Heterogeneity can be explored and explained using moderator analyses.

The first moderator we tested was the sport context. To provide direction for future research and guide intervention efforts,

APPLIED SCIENCES

we compared the association between sport in the school setting (i.e., during school hours) and outside school (i.e., outside school hours) with academic performance. If sport participation could not be differentiated from physical activity participation, such as activity during physical education lessons or lunch breaks, these studies were excluded. Second, as there is some evidence for a dose–response association between physical activity and academic performance (24), we compared a low (1 sport or <1 h·wk^{-1} or <1 session per week), medium (2 sports or 2 h·wk^{-1} or 2 sessions per week), and high (3+ sports or 3+ h·wk^{-1} or 3+ sessions per week) dose of sport. Next, we compared the association between sport and academic performance in different school subjects (i.e., mathematics, science, English, and language). There is some evidence that physical activity is most beneficial for mathematics as physical activity improves executive function, working memory, and cognitive flexibility, which are important components in mathematics (25). Fourth, to ensure that the overall effect size was not inflated due to methodological artifact, we compared the academic performance measures (i.e., self-reported grades vs school reported grades vs standardized tests). Next, as sport dropout peaks during adolescence, we compared the association between sport and academic performance in children (younger than 13 yr) and adolescents (13 yr or older) (26). Finally, to examine risk of bias within studies, we compared studies with a high and low risk of bias, and to assess publication bias, we compared published and unpublished studies (27). For each moderator analysis, we calculated the proportion of explained variance by the inclusion of the potential moderator variable (R^2).

Risk of bias across studies. We assessed risk of bias across studies (publication bias) using funnel plots (28) and Egger's regression asymmetry tests (29). First, we constructed funnel plots by plotting the effect sizes against the standard errors and inspected the symmetry. Next, we conducted Eggers' regression asymmetry tests by regressing the normalized effect estimate (effect size divided by its standard error) against precision (reciprocal of the standard error of the effect size). The regression line will run through the origin when the funnel plot is symmetrical (i.e., no bias).

RESULTS

Study Selection

Searches of electronic databases identified 5456 nonduplicate records (Fig. 1). After reviewing titles and abstracts, 276 full-text articles were retrieved and screened. Of these, 115 met the inclusion criteria and 110 provided sufficient information to be included in the meta-analysis.

Study Characteristics

Study characteristics are displayed in Supplemental Table 1 (Supplemental Digital Content 2, http://links.lww.com/MSS/C430). Publication dates ranged from 1991 to 2020. The majority of studies were published in the United States (k = 87), followed by Canada (k = 5), Turkey (k = 4), Finland (k = 3), and Australia (k = 2). Study designs were mostly cross-sectional (k = 62) or longitudinal (k = 46), with six quasi-experimental study designs, and no randomized controlled trials. The experimental studies involved sports programs during school hours (k = 3) and outside school hours (k = 3).

There was a total of 1,184,664 participants included. Sample sizes ranged from 13 (30) to 139,349 (31), and mean ages ranged from 9.1 to 17.7 yr with the majority sampling adolescents (i.e., 13+ yr old) (k = 86).

Academic performance was measured using school grades (k = 68), standardized tests (k = 24), and self-reported grades (k = 18). Most studies examined an overall composite grade (k = 79), with some studies specifically assessing mathematics (k = 37), English (k = 23), science (k = 10) and other subjects (k = 13).

Risk of bias within studies. Risk of bias assessments are detailed in Supplemental Table 2 (Supplemental Digital Content 3, http://links.lww.com/MSS/C431). Initial interrater agreement for risk of bias ratings was 97% (Cohen's kappa = 0.94), but all discrepancies were resolved after discussion. Most studies had a high risk of bias (79%; k = 87), and 23 studies (21%) had a low risk of bias.

Synthesis of results. Overall, sport had a small positive effect on academic performance (d = 0.26, 95% confidence interval [CI] = 0.09–0.42) (Table 1). A moderate proportion of the variation within this pooled effect was attributable to differences within studies (I^2 = 0.58) and differences between studies (I^2 = 0.42).

Moderator Analyses

Sport. Sport context moderated the association between sport participation and academic performance (R^2 = 0.02). Sports participation during school time had a small to moderate positive association with academic performance (d = 0.36, 95% CI = 0.12–0.61), whereas sport participation outside school time had a small positive association with academic performance (d = 0.22, 95% CI = −0.34 to 0.58), but the confidence intervals crossed zero.

Weekly sport dose accounted for a portion of the heterogeneity between studies that examined the association between sport participation and academic performance (R^2 = 0.12). A medium dose of sport had a small positive association with academic performance (d = 0.20, 95% CI = −0.02 to 0.43), whereas a low and high dose had negligible effects (d = 0.06, 95% CI = −0.20 to 0.32 and d = 0.13, 95% CI = −0.11 to 0.40).

Academic performance. The academic performance measure moderated the association between sport participation and academic performance (R^2 = 0.02). Studies that used school reported grades reported a small positive association between sport and school grades (d = 0.33, 95% CI = 0.11–0.55), whereas studies that used self-reported grades and standardized tests reported negligible effects (d = 0.18, 95% CI = −0.23 to 0.60, and d = 0.12, 95% CI = −0.23 to 0.46).

TABLE 1. Results of academic performance meta-analyses and moderator analyses.

Variable	k	Number of Effect Sizes	Effect Size (Cohen's d)	Lower 95% CI	Upper 95% CI	τ_2	τ_3	R^2_2	R^2_3
Overall academic performance	110	298	0.26	0.09	0.42	0.65	0.46		
Moderator analyses									
Sport									
Type of sport						0.65	0.46	0.00	0.02
In school	51	158	0.36	0.12	0.61				
Outside school	26	51	0.22	−0.13	0.58				
Both	17	47	0.10	−0.34	0.54				
Sport dose						0.04	0.04	0.12	0.11
Low	5	6	0.06	−0.20	0.32				
Medium	8	9	0.20	−0.02	0.43				
High	6	6	0.13	−0.11	0.40				
Academic performance									
Type of academic performance						0.65	0.46	0.00	0.02
Self-reported grades	18	52	0.18	−0.23	0.60				
School grades	68	161	0.33	0.11	0.55				
Standardized test	24	85	0.12	−0.23	0.46				
School subject						0.64	0.44	0.02	0.06
Combined grades	79	162	0.21	0.02	0.41				
Mathematics	37	59	0.29	0.00	0.57				
English	25	43	0.20	−0.13	0.53				
Science	11	14	0.83	0.33	1.33				
Language	5	8	0.36	−0.32	1.04				
Other	8	11	0.70	0.13	1.27				
Participation characteristics									
Age						0.65	0.46	0.00	0.00
Children	16	38	0.26	−0.18	0.69				
Adolescents	86	243	0.27	0.07	0.46				
Study quality									
Study design						0.65	0.46	0.00	0.03
Cross-sectional	60	156	0.37	0.14	0.60				
Longitudinal	44	125	0.12	−0.14	0.38				
Experimental	6	17	0.23	−0.47	0.93				
Publication status						0.65	0.46	0.00	0.00
Published	77	211	0.28	0.08	0.48				
Unpublished	33	87	0.19	−0.11	0.50				
Risk of bias within studies									
Overall						0.65	0.46	0.00	0.01
Low risk of bias	23	61	0.11	−0.26	0.48				
High risk of bias	87	237	0.29	0.10	0.48				
Description of participant eligibility criteria						0.65	0.47	0.00	0.03
Yes			0.14	−0.10	0.38				
No			0.37	0.13	0.61				
Sampling procedures appropriate and adequately described						0.65	0.47	0.00	0.01
Yes			0.15	−0.13	0.44				
No			0.31	0.10	0.52				
Power calculation reported and study adequately powered to detect hypothesized relationships						0.65	0.47	0.00	0.00
Yes			0.23	−0.46	0.93				
No			0.26	0.08	0.43				
Description of the completeness of outcomes data and how missing data was handled						0.65	0.47	0.00	0.02
Yes			0.14	−0.12	0.40				
No			0.34	0.11	0.56				
Covariates adjusted for in analyses						0.65	0.47	0.00	0.04
Yes			0.12	−0.11	0.35				
No			0.41	0.16	0.65				

School subject was also an important moderating factor in the association between sport participation and academic performance ($R^2 = 0.06$). Sport participation had a strong positive association with science grades ($d = 0.83$, 95% CI = 0.33–1.33), a small positive association with mathematics grades ($d = 0.29$, 95% CI = 0.00–0.57) and overall grades ($d = 0.21$, 95% CI = 0.02–0.41), and a small positive but nonsignificant association with English ($d = 0.20$, 95% CI = −0.13 to 0.53) and language ($d = 0.36$, 95% CI = −0.32 to 1.04).

Study Design

Study design moderated the association between sport participation and academic performance ($R^2 = 0.03$). In cross-sectional studies, sport had a small to moderate positive association with academic performance ($d = 0.37$, 95% CI = 0.14–0.60), whereas longitudinal and experimental studies had negligible ($d = 0.12$, 95% CI = −0.14 to 0.38) to small effects ($d = 0.23$, 95% CI = −0.47 to 0.93).

Risk of bias within studies. Risk of bias explained a very small portion of the heterogeneity between studies examining the association between sport participation and academic performance ($R^2 = 0.01$). Studies with a high risk of bias reported a small positive effect ($d = 0.29$, 95% CI = 0.10–0.48), whereas studies with a low risk of bias reported a negligible effect ($d = 0.11$, 95% CI = −0.26 to 0.48).

Age and publication status explained negligible variation in the association between sport participation and academic performance ($R^2 = 0.00$).

Risk of bias across studies. Published studies reported a small positive effect of sport on academic performance (d = 0.28, 95% CI = 0.08–0.48), whereas unpublished studies found a nonsignificant small positive effect (d = 0.19, 95% CI = −0.11 to 0.50). Asymmetry of effect sizes in the funnel plot (Fig. 2), and a significant Egger's regression test (t = −2.54, P = 0.01) indicated that there was publication bias.

DISCUSSION

This systematic review and meta-analysis were the first to assess the specific association between sport participation and academic performance in children and adolescents. The results showed that sports participation had a small to moderate positive association with academic performance. However, most studies were of low quality, and there was high heterogeneity between studies.

The majority of studies had a high risk of bias. In particular, studies often did not use appropriate sampling procedures, use a valid measure of sport participation, conduct a power calculation and adequately power the study, describe the proportion and handling of missing data, or adjust for covariates. Only one study used a validated sport measure (32); however, this measure is only available in German. To accurately assess the association between sport participation and academic performance, studies need to accurately measure sport participation. We recommend a consensus surrounding the availability or development of a validated sport measure in English and other languages. Further, addressing missing data and adjusting for covariates are important statistical considerations that could bias the result. If conclusions are to be drawn regarding specific sport effects on academic performance, high-quality studies with low risk of bias are required.

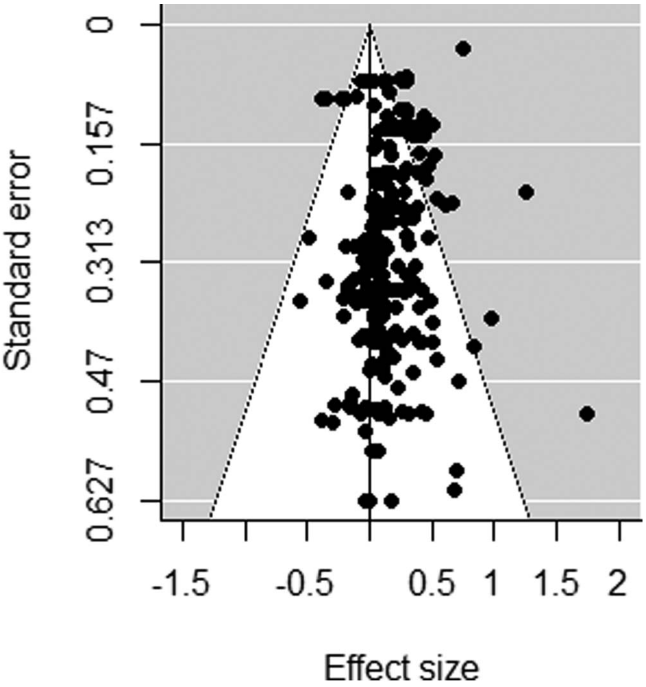

FIGURE 2—Funnel plot.

Study design influenced the association between sport participation and academic performance. Although effects for all study designs were in the positive direction, cross-sectional studies were the only study design to report a significant positive effect. It could be that sport participation is positively correlated with academic performance but does not cause increased academic performance. Selection bias could explain why children who participate in sport also have higher academic performance. Participation in sports is self-selected, and it is likely that children who choose to participate in sport differ systematically from those who do not. Children who choose to participate in sport could differ in terms of intrapersonal psychological processes such as motivation, interpersonal factors such as parental support, or environmental factors such as socioeconomic status (33). An alternate explanation is a third unmeasured factor such as mental health that has a causal effect on both sport participation (34) and academic performance (35). Vella etal. (34) found bidirectional relationships between time involved in organized sport and overall mental health (measured by Strengths and Difficulties Questionnaire), but mental health was a somewhat stronger predictor of later sports participation than *vice versa*. Before causal inferences can be made, further high-quality longitudinal or experimental studies are needed.

Sports participation during school hours was the most beneficial for academic performance. Sport at school is likely immediately before academic lessons and therefore could have an immediate effect on children's attention and time on task (36), which may facilitate academic learning and performance. Educators perceive pressures to increase academic performance outcomes and often think that time spent sitting in the classroom is more beneficial to academic performance than time spent being physically active (37,38). However, the results of this study suggest that this is not the case and that school-based sport interventions could be a cost-effective strategy to influence almost all children and adolescents' physical activity and, subsequently, academic performance. There is also evidence that suggests exposure to physical activity opportunities in the education setting can help children develop active behaviors that track into adult life (39). Results of this study suggest that promoting sport participation in school could increase academic performance as well as provide additional opportunities to promote health and well-being outcomes through physical activity promotion.

The dose of sport influenced the association between sport participation and academic performance. Children who played sport for 1–2 $h \cdot wk^{-1}$ had higher academic performance outcomes compared with children who played no sport or 3+ $h \cdot wk^{-1}$. This finding suggests that an inverted-U shape association could exist between sport participation and academic performance (i.e., physical fatigue could lead to decreased cognition and academic performance) (40). Practically, it could also be that children who played sport for 1–2 $h \cdot wk^{-1}$ still have time for recreation, sleep, homework, and study, whereas children who spend more time playing sport do not have time. Alternatively, it could be that children who have or perceive low

APPLIED SCIENCES

academic abilities (i.e., low academic self-concept) spend more time participating in sports (41). However, it is important to note that only 19 studies examined the dose–response association, and of these 18 had a high risk of bias. More high-quality studies are needed on the dose–response association between sport participation and academic performance.

Sport participation was more beneficial for mathematics and science grades compared with English and language grades. This finding is consistent with a recent systematic review that examined the association between physical activity and school grades and found that physical activity was beneficial for mathematics, but not for language (42). Skills developed through sport, such as problem solving (43), can be transferred to classroom learning and possibly more so to mathematics and science learning where problem solving is more commonly used. This result could also be explained by sex differences in sport participation (44) and science, technology, engineering, and mathematics (STEM) subject performance (45). Boys tend to participate in higher levels of sport and are more likely to continue participating into adolescence and adulthood. Boys also achieve higher grades in mathematics and science (45). Future high-quality longitudinal studies are needed that examine the relationship between sport and STEM subjects before sport can be used to promote academic performance in these subjects, which are core subjects that provide children with the critical skills they need for informed personal decision making and effective community, national, and global citizenship (46).

Strengths and limitations. This is the first systematic review and meta-analysis of the association between sport participation and academic performance to the author's knowledge. Some limitations to this study must be acknowledged. First, there was moderate unexplained heterogeneity in the overall effect size, and therefore, the results should be interpreted with caution. This heterogeneity could be attributed to the wide variety of sports (e.g., basketball, gymnastics, and football) and academic performance measures (e.g., standardized mathematics test, self-reported Arabic language grade), but some heterogeneity was explained by moderator analyses. It is likely that other factors are responsible for the unexplained variation, and further research is needed to understand the source of this variation. Second, publication bias was found in our study. However, we systematically searched the gray literature and identified 33 unpublished studies with 87 unpublished effect sizes. This is an unusually high number of unpublished studies, and even with these studies included in the meta-analysis, the overall effect remained significant. Third, although we did explore the dose–response, due to the low number of studies that measured sport duration, we used a combination of number of sports and hours of sports per week to examine duration of participation. We could not examine whether the intensity of the sport (low-intensity sports such as golf or high-intensity sports such as football), type of sport (individual vs team), or type of skills within a sport (open vs closed) moderated the association between sport participation and academic performance as few studies provided sufficient details to classify studies into these categories. Future high-quality studies are needed that compare the duration and intensity of the sport, individual and team sports, and open skill sports with closed skill sports. Fourth, to examine age as a moderator, we categorized studies with a mean age less than 13 yr as children and studies with a mean age of 13 yr or more as adolescents. Although many children and adolescents in each study were correctly classified, it is likely that there will be some children who are misclassified as adolescents and *vice versa*.

CONCLUSIONS

Based on mostly low-quality studies, we found some evidence that sport could positively affect academic performance in children and adolescents. It appears that sport participation within the school environment and of a moderate dose could improve school-age children's academic performance, particularly in mathematics and science. However, if this field were to inform policy, high-quality studies are needed that provide insight into the effect of dose and sport characteristics on academic performance.

No financial disclosures were reported by the authors of this article. The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. Results of the present study do not constitute endorsement by the American College of Sports Medicine.

All authors declare that they have no conflicts of interest relevant to the content of this review.

REFERENCES

1. Wassenaar TM, Williamson W, Johansen-Berg H, et al. A critical evaluation of systematic reviews assessing the effect of chronic physical activity on academic achievement, cognition and the brain in children and adolescents: a systematic review. *Int J Behav Nutr Phys Act*. 2020;17(1):79.
2. Biddle SJ, Ciaccioni S, Thomas G, Vergeer I. Physical activity and mental health in children and adolescents: an updated review of reviews and an analysis of causality. *Psychol Sport Exerc*. 2019;42:146–55.
3. Erickson KI, Hillman C, Stillman CM, et al. Physical activity, cognition, and brain outcomes: a review of the 2018 physical activity guidelines. *Med Sci Sports Exerc*. 2019;51(6):1242–51.
4. Donnelly JE, Hillman CH, Castelli D, et al. Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Med Sci Sports Exerc*. 2016;48(6):1197–222.
5. Valkenborghs SR, Noetel M, Hillman CH, et al. The impact of physical activity on brain structure and function in youth: a systematic review. *Pediatrics*. 2019;144(4):e20184032.
6. World Health Organization. *Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World*. Geneva: World Health Organization; 2019.
7. Schmidt M, Jäger K, Egger F, Roebers CM, Conzelmann A. Cognitively engaging chronic physical activity, but not aerobic exercise, affects executive functions in primary school children: a group-randomized controlled trial. *J Sport Exerc Psychol*. 2015;37(6):575–91.
8. Moreau D, Morrison AB, Conway AR. An ecological approach to cognitive enhancement: complex motor training. *Acta Psychol (Amst)*. 2015;157:44–55.
9. Galligan F. *Advanced PE for Edexcel*. Bath: Bath Press; 2000.

10. Zhu H, Chen A, Guo W, Zhu F, Wang B. Which type of exercise is more beneficial for cognitive function? A meta-analysis of the effects of open-skill exercise versus closed-skill exercise among children, adults, and elderly populations. *Appl Sciences*. 2020;10(8):2737.
11. Gu Q, Zou L, Loprinzi PD, Quan M, Huang T. Effects of open versus closed skill exercise on cognitive function: a systematic review. *Front Psychol*. 2019;10:1707.
12. Tomporowski PD, Pesce C. Exercise, sports, and performance arts benefit cognition via a common process. *Psychol Bull*. 2019;145(9):929–51.
13. Bangert-Drowns RL. Review of developments in meta-analytic method. 1992. Available from: https://psycnet.apa.org/doiLanding?doi=10.1037%2F10109-034.
14. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med*. 2009;151(4):264–9.
15. Schneider M, Preckel F. Variables associated with achievement in higher education: a systematic review of meta-analyses. *Psychol Bull*. 2017;143(6):565–600.
16. Rosenthal R. *Meta-analytic Procedures for Social Research*. Vol. 6. Newbury Park (CA): Sage; 1991.
17. Rosenthal R, Cooper H, Hedges L. Parametric measures of effect size. *The Handbook of Research Synthesis*. 1994;621(2):231–44.
18. Hedges LV, Olkin I. *Statistical Methods for Meta-analysis*. Orlando (FL): Academic Press; 2014.
19. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale (NJ): Erlbaum; 1988.
20. Cheung M. metaSEM: meta-analysis: a structural equation modeling approach. R package version 0.5-3. Available from: http://courses. nus. edu. sg/course/psycwlm/Internet/metaSEM. 2011.
21. R Core Team. *A Language and Environment for Statistical Computing*. Vienna (Austria): R Foundation for Statistical Computing; 2014.
22. Higgins J, Thompson S, Deeks J, Altman D. Measuring inconsistency in meta-analyses. *Br Med J*. 2003;327(7414):557–60.
23. Higgins JP, Green S. *Cochrane Handbook for Systematic Reviews of Interventions*. Chichester (UK): Wiley Online Library; 2008.
24. Howie EK, Pate RR. Physical activity and educational achievement: dose–response relationships. In: *Physical Activity and Educational Achievement*. Routledge; 2017. pp. 9–31.
25. Sneck S, Viholainen H, Syväoja H, et al. Effects of school-based physical activity on mathematics performance in children: a systematic review. *Int J Behav Nutr Phys Act*. 2019;16(1):109.
26. Eime R, Harvey J, Charity M. Sport drop-out during adolescence: is it real, or an artefact of sampling behaviour?*Int J Sport Policy Politics*. 2019;11(4):715–26.
27. Rothstein HR, Sutton AJ, Borenstein M. *Publication Bias in Meta-analysis: Prevention, Assessment and Adjustments*. Chichester (UK): John Wiley & Sons; 2005. pp. 1–7.
28. Sterne J, Egger M, Moher D. Chapter 10: Addressing reporting biases. In: Higgins J, Green S, editors. *Cochrane Handbook for Systematic Reviews of Intervention. Version 5.1.0 (updated March 2011)*: The Cochrane Collaboration. 2011. Available from www.cochrane-handbook.org; 2011.
29. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629–34.
30. Fraser KB. *A case study of the cooperative, healthy, active, motivated, positive students (champs) intramural athletic program in an urban middle school*. Dissertation Abstracts International Section A: Humanities and Social Sciences. Vol.76(3-A(E)). 2015.
31. Lumpkin A, Favor J. Comparing the academic performance of high school athletes and non-athletes in Kansas in 2008–2009. *J Sport Admin Supervision*. 2012;4(1):41–62.
32. Dapp LC, Roebers CM. The mediating role of self-concept between sports-related physical activity and mathematical achievement in fourth graders. *Int J Environ Res Public Health*. 2019;16(15):2658.
33. Moral-García JE, Urchaga-Litago JD, Ramos-Morcillo AJ, Maneiro R. Relationship of parental support on healthy habits, school motivations and academic performance in adolescents. *Int J Environ Res Public Health*. 2020;17(3):882.
34. Vella SA, Swann C, Allen MS, Schweickle MJ, Magee CA. Bidirectional associations between sport involvement and mental health in adolescence. *Med Sci Sports Exerc*. 2017;49(4):687–94.
35. Deighton J, Humphrey N, Belsky J, Boehnke J, Vostanis P, Patalay P. Longitudinal pathways between mental health difficulties and academic performance during middle childhood and early adolescence. *Br J Dev Psychol*. 2018;36(1):110–26.
36. Daly-Smith AJ, Zwolinsky S, McKenna J, Tomporowski PD, Defeyter MA, Manley A. Systematic review of acute physically active learning and classroom movement breaks on children's physical activity, cognition, academic performance and classroom behaviour: understanding critical design features. *BMJ Open Sport Exerc Med*. 2018;4(1):e000341.
37. Morgan H. Relying on high-stakes standardized tests to evaluate schools and teachers: a bad idea. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*. 2016;89(2):67–72.
38. Monique V. *The State of Education: Main Themes of the 2014/2015*. Utrecht (The Netherlands): The Dutch Inspectorate of Education; 2016.
39. Eime R, Sawyer N, Harvey J, Casey M, Westerbeek H, Payne W. Integrating public health and sport management: sport participation trends 2001–2010. *Sport Manage Revi*. 2015;18(2):207–17.
40. Yerkes RM, Dodson JD. The relation of strength of stimulus to rapidity of habit-formation. *Punishment: Issues and Experiments*. 1908;27–41.
41. Onetti-Onetti W, Chinchilla-Minguet JL, Martins FML, Castillo-Rodriguez A. Self-concept and physical activity: differences between high school and university students in Spain and Portugal. *Front Psychol*. 2019;10:1333.
42. Álvarez-Bueno C, Pesce C, Cavero-Redondo I, Sánchez-López M, Garrido-Miguel M, Martínez-Vizcaíno V. Academic achievement and physical activity: a meta-analysis. *Pediatrics*. 2017;140(6):e20171498.
43. Jacobson J, Matthaeus L. Athletics and executive functioning: how athletic participation and sport type correlate with cognitive performance. *Psychol Sport Exerc*. 2014;15(5):521–7.
44. Reece LJ, Owen KB, Foley BC, Bauman A. *AusPlay NSW: Participation Analysis in Structured Sport and Physical Activity amongst Children*. Sydney (Australia): SPRINTER Group, The University of Sydney; 2020. Available from: SPRINTER Group, The University of Sydney.
45. Australian Sports Commission. *AusPlay: Summary of Key National Findings*. Canberra: Australian Sports Commission; 2016.
46. Department of Education SaE. *Support for Science, Technology, Engineering and Mathematics (STEM)*. Australian Government; 2020. Available from: Australian Government https://www.dese.gov.au/australian-curriculum/support-science-technology-engineering-and-mathematics-stem.