Physical Activity and Sports Participation Associates With Cognitive Functioning and Academic Progression: An Analysis Using the Combined 2017–2018 National Survey of Children’s Health

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Background: The purpose of this study was to examine the independent and joint associations between physical activity (PA) and sports participation on academic performance variables within a representative sample of children and adolescents. **Methods:** Data were analyzed from the combined 2017–2018 National Survey of Children’s Health. Household addresses were randomly selected within each US state. One household parent answered health and wellness questions pertaining to one randomly selected household child ($N = 37,392$; 48.1% female; 6- to 17-y old). Weighted logistic regression models were employed to examine the independent and joint associations between child PA frequency and sports participation with academic performance variables, adjusting for child- and family-level covariates. **Results:** Child PA frequency independently associated with 37% to 46% lower odds and child sports participation independently associated with 53% lower odds of reported difficulty concentrating, remembering, or making decisions ($P < .001$). For children who participated in sports, PA associated with 47% to 56% lower odds of ever repeating a grade level ($P = .01$). **Conclusions:** Frequency of weekly PA and sports participation independently and negatively associated with difficulty concentrating, remembering, and making decisions, whereas the negative association between PA and ever repeating a grade level differed by child sports participation status.

Keywords: adolescent, behavioral science, pediatrics, survey research

Higher levels of physical activity (PA) have consistently been shown to positively associate with a variety of academic performance factors, including cognitive functioning, academic behavior, and school grades.^{1–3} The PA, particularly of higher intensities, manifests physiological mechanisms at the cellular, molecular, and structural level of the brain to improve cognitive skills,⁴ including enhancement of neurogenesis and central nervous system metabolism.⁵ In addition to impacting physiological mechanisms that may improve cognitive skills,^{6–8} PA may also impact behavior in the academic classroom.^{9–12} Potential mechanisms for these positive effects on behavior may be due to moderating psychological arousal yielding an internal psychological state conducive for learning, possibly supplementing other physiological, cognitive, emotional, and learning mechanisms.¹³

Although the links between PA and academic performance have been relatively well studied, much less is known regarding the independent association between sports participation and academic performance. Sport is an organized contest or game in which people do certain PAs according to a specific set of rules to compete against each other. In other words, sport participation includes structured PAs characterized by specific rules and regulations.¹⁴ Sport participation also provides exposure to social factors that are often not present during unstructured PA. Sports participation provides opportunities to enhance task-specific self-efficacy, personal enjoyment, prosocial behavior, and a sense of social support from coaches and teammates.^{15,16} These characteristics of sport participation may lead to improvements in specific aspects of academic performance

above and beyond that provided by other modes of PA.^{17,18} However, a paucity of work has compared both PA and sports participation on various aspects of academic performance variables while also controlling for important factors at both the child and family level.

The yearly administered National Survey of Children’s Health (NSCH) collects a variety of child- and family-level information using a representative sample of US children and adolescents.^{19,20} Specifically, the NSCH collects information pertaining to child physical and mental health, child schooling (including indicators of academic performance), the reported weekly frequency of a child meeting the 60 minutes of daily PA recommendation, and whether or not a child has participated in sports during the past 12 months.^{19,20} The NSCH also collects important information pertaining to the family, including adult education, family Federal Poverty Level (FPL), and the family structure, all of which may influence PA, sports participation, and/or academic performance.^{21–26} To the authors’ knowledge, no study has examined the independent and joint associations between PA and sports participation in multiple variables related to academic performance while concurrently controlling for important potential confounding factors at both the child and family levels. Therefore, the purpose of this study was to examine the independent and joint associations between PA and sports participation on academic performance variables within a representative sample of children and adolescents from the combined 2017–2018 NSCH.

Methods

Participants

The participants were a nationally representative sample of children and adolescents from the United States, aged 6- to 17-years

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old, whose parents completed either the 2017 or the 2018 NSCH. The NSCH is a national survey that is fielded annually by the US Census Bureau and provides data on multiple aspects of child and adolescent health and well-being. The data for the 2017 and 2018 NSCH were combined to provide opportunities for analyses using variables with small sample sizes or low prevalence. A total of 52,129 surveys were completed for 2017 and 2018 combined, with 21,599 surveys completed in 2017 and 30,530 completed in 2018 for children aged 0–17 years. The overall weighted response rate was 37.4% for 2017 and 43.1% for 2018. Children younger than 6 years old were omitted from the current study because PA, sports participation, and academic performance variables were only collected for children who were 6- to 17-years old. Data from a total of 37,392 children and adolescents (48.1% female; 6- to 11-y old = 15,896, 12- to 17-y old = 21,496) were used in the current study. The NSCH data collection does not undergo an external institutional review board review. Instead, the process for the review of methods and procedures for the NSCH was incorporated into the responsibilities of the US Census Bureau and Office of Management and Budget officials.^{19,20}

Procedures

Randomly selected US household addresses were mailed instructions to access the NSCH online. Addresses were randomly selected within each US state and the District of Columbia. After 2 reminder letters and postcard reminders to complete the NSCH online, households that had not accessed the online survey were mailed a paper screening questionnaire.^{19,20} An adult within the household was asked to complete a web or paper screener questionnaire to identify all children 0- to 17-years old who were living in the household. If a child or children were reported to live in the household, adult participants were directed to a detailed age- and web-based topical questionnaire for one randomly selected household child. Adult respondents completed 1 of 3 versions of the survey depending on the child's age: 0–5 years, 6–11 years, and 12–17 years. The survey topics included child and family demographics, child physical and mental health status, family health and activities, and parental health status, among others. Based on web keystroke data and paper cognitive testing, the estimated survey length for households without children was 5 minutes, and the estimated survey length for households with children was 39 minutes.^{19,20}

Data Processing

The 2017–2018 NSCH combined data set contained 2 stratum identifiers corresponding to the state of residence and an identifier corresponding to households flagged with children.^{19,20} The 2017–2018 NSCH combined data set also included an adjusted probability weight variable that accounted for combining 2 years of data.^{19,20} Missing values for child demographic variables were imputed using hot-deck imputation, and the adult education, household size, and poverty ratio missing values were imputed using sequential regression imputation methods.^{19,20}

The dependent variables were 2 items on the NSCH that aligned with cognitive functioning and academic progression, which both constitute an academic performance. Aligned with cognitive functioning, an item asked if the child has had “Serious difficulty concentrating, remembering, or making decisions because of a physical, mental, or emotional condition?” and was binary coded (0 = no; 1 = yes). Academic progression aligned with an item on the NSCH that asked about ever repeating a grade level,

“Since starting kindergarten, has this child repeated any grades?” which was binary coded (0 = no; 1 = yes). Repeating a grade level is a measure of academic achievement, as achieving a passing grade is needed for progression within US schools.

The primary predictor variables were 2 items on the NSCH that asked about child PA and sports participation. The PA variable asked “During the past week, on how many days did this child exercise, play a sport, or participate in physical activity for at least 60 minutes?” Responses for this item ranged from 0 days (coded 0), 1 to 3 days (coded 1), 4 to 6 days (coded 2), and every day (coded 3) and were treated on the ordinal measurement scale. The sports performance predictor variable asked “During the past 12 months, did this child participate in a sports team or did he or she take sports lessons after school or on the weekend?” Responses for the sports participation item were binary-coded (0 = no participation; 1 = participation).

Important child- and family-level covariates were included in the analysis to adjust for potential confounding associations. Child-level covariates included child age (6–11 and 12–17 y), child sex (female and male), child body mass index class (underweight, normal weight, overweight, or obese), and child race/ethnicity (White-non-Hispanic, Hispanic, Black-non-Hispanic, other/multiracial-non-Hispanic). Family-level covariates included items regarding highest adult education within household (college degree or higher, some college, high school/GED, less than high school), household poverty level (400% FPL or greater, 200%–399% FPL, 100%–199% FPL, 0%–99% FPL), and the family structure (2 married parents, 2 unmarried parents, single parent, and grandparent).

Statistical Analysis

To account for NSCH's complex survey design and use of probability weights, the STATA survey prefix command “svy” was employed to compute weighted prevalence within the descriptive analysis and to compute appropriate variances and confidence intervals within the primary analyses. Unweighted and weighted prevalence statistics were computed for the PA and sports participation predictors in addition for the child- and family-level covariates. The primary analyses consisted of the use of weighted simple and multiple logistic regression models to calculate crude (unadjusted) and adjusted parameter estimates, respectively. Separate models were run for each academic performance dependent variable. Post hoc analyses were employed to examine the joint associations (interactions) between child PA and sports participation on each academic performance variable to determine if the association between PA and a respective dependent variable differed according to sport participation status. To test for age and sex effect modification, subpopulation analyses were employed within the adjusted models using STATA's “svy, subpop:” prefix command. Communication of the results involved the reporting of odds ratios with the associated 95% confidence intervals. The 2-sided alpha level was set at $P < .05$, and all analyses were conducted using STATA statistical software package (version 15.0; StataCorp, College Station, TX).

Results

Unweighted and weighted prevalence for all variables are reported in Table 1. During the past 12 months, approximately 10.1% (weighted prevalence = 9.6%) of the parents reported that their child has had serious difficulty concentrating, remembering, or making decisions, and 5.4% (weighted prevalence = 6.3%) reported that their child ever repeated a grade level. Approximately

Table 1 Counts, Unweighted Prevalence, and Weighted Prevalence Statistics for All Observed Variables

Variable	Level	Count	Unweighted %	Weighted %
Difficulty concentrating, remembering, making decisions	No	33,270	89.9	90.4
	Yes	3748	10.1	9.6
Repeated a grade level	No	34,876	94.6	93.7
	Yes	2008	5.4	6.3
60 min of PA	0 D	3312	9.0	9.5
	1–3 d/wk	14,301	38.7	39.9
	4–6 d/wk	11,600	31.3	28.2
	Every day per week	7767	21.0	22.6
	Did not participate	13,270	36.1	42.3
Sports participation	Participated	23,509	63.9	57.7
	Did not participate	13,270	36.1	42.3
Child age	6- to 11-y old	15,896	42.5	50.0
	12- to 17-y old	21,496	57.5	50.0
Child sex	Male	19,415	51.9	51.1
	Female	17,977	48.8	48.9
Child BMI class	Normal weight	17,310	65.9	62.5
	Underweight	1701	6.5	6.7
	Overweight/obese	7255	27.6	30.8
Child race/ethnicity	White/non-Hispanic	25,867	69.2	49.9
	Hispanic	4377	11.7	25.7
	Black/non-Hispanic	2497	6.7	14.3
	Other/multiracial-non-Hispanic	4651	12.4	10.1
Highest adult education	College degree or higher	22,195	59.4	47.3
	Some college	9063	24.3	22.3
	High school/GED	5127	13.7	19.8
	Less than high school	1007	2.7	10.6
Household poverty level	0%–99% FPL	4566	12.2	20.2
	100%–199% FPL	5884	15.7	21.7
	200%–399% FPL	11,248	30.8	27.1
	400% FPL or greater	15,694	42.0	31.0
Family structure	2 married parents	25,744	70.3	64.7
	2 unmarried parents	2239	6.1	8.0
	Single parent	7108	19.3	21.3
	Grandparent household	1262	3.4	4.4

Abbreviations: BMI, body mass index; FPL, federal poverty level; GED, General Educational Development; PA, physical activity.

21.0% (weighted prevalence = 22.6%) of the parents reported that their child engaged in 60 minutes of PA every day during the past week, and approximately 63.9% (weighted prevalence = 57.7%) of the parents reported that their child participated in sports during the past 12 months.

Table 2 presents the unadjusted crude odds ratios for predicting each academic performance dependent variable. Any reported child weekly PA frequency associated with 47% to 64% lower odds of child difficulty concentrating, remembering, or making decisions compared with no reported child PA ($P < .001$). Child sports participation associated with 58% lower odds of reported difficulty concentrating, remembering, or making decisions compared with reported no sports participation ($P < .001$). In addition, reported child PA of 4 to 6 days per week associated with 37% lower odds of ever repeating a grade level ($P < .001$), and sports participation associated with 39% lower odds of ever repeating a grade level ($P < .001$).

Table 3 presents the adjusted odds ratios for predicting each academic performance dependent variable. After adjusting for child- and family-level covariates, weekly child PA independently associated with 37% to 46% lower odds of difficulty concentrating, remembering, or making decisions. Likewise, after adjusting for child- and family-level covariates, child sports participation during the past 12 months independently associated with 53% lower odds of difficulty concentrating, remembering, or making decisions. No age or sex effect modification was found using the cognitive functioning outcome. In addition, after covariate adjustment, reported weekly child PA and child sports participation during the past 12 months did not independently associate with ever repeating a grade level using the total sample. However, the relationship between sports participation and academic progression was moderated by age, as sports participation associated with 26% lower odds of ever repeating a grade level in 12- to 17-year-old adolescents

Table 2 Crude Parameter Estimates Predicting Academic Performance Variables Using Weighted Simple Logistic Regression

Predictor	Level	Difficulty concentrating, remembering, making decisions (no = referent) crude OR (95% CI)	Repeated a grade level (no = referent) crude OR (95% CI)
60 min of PA	0 days	Referent	Referent
	1–3 d/wk	0.53[†] (0.42–0.67)	0.83 (0.62–1.11)
	4–6 d/wk	0.36[†] (0.28–0.46)	0.63[†] (0.46–0.87)
	Every day per week	0.45[†] (0.34–0.59)	0.93 (0.68–1.28)
Sports participation	Did not participate	Referent	Referent
	Participated	0.42[†] (0.37–0.49)	0.61[†] (0.51–0.74)
Child age	6- to 11-y old	Referent	Referent
	12- to 17-y old	0.97 (0.84–1.13)	1.63[†] (1.35–1.98)
Child sex	Male	Referent	Referent
	Female	0.58[†] (0.50–0.68)	0.66[†] (0.54–0.80)
Child BMI class	Normal weight	Referent	Referent
	Underweight	1.59[†] (1.19–2.11)	1.40 (0.95–2.07)
	Overweight/obese	1.38[†] (1.15–1.66)	1.45[†] (1.14–1.84)
Child race/ethnicity	White/non-Hispanic	Referent	Referent
	Hispanic	0.76 (0.76–1.22)	1.61[†] (1.26–2.06)
	Black/non-Hispanic	1.26[†] (1.01–1.57)	2.10[†] (1.66–2.64)
	Other/multiracial-non-Hispanic	0.87 (0.71–1.07)	1.07 (0.80–1.44)
Highest adult education	College degree or higher	Referent	Referent
	Some college	1.57[†] (1.33–1.84)	2.14[†] (1.74–2.62)
	High school/GED	1.70[†] (1.41–2.06)	3.08[†] (2.46–3.87)
	Less than high school	1.52[†] (1.06–2.18)	3.71[†] (2.62–5.27)
Household poverty level	0%–99% FPL	Referent	Referent
	100%–199% FPL	0.80 (0.63–1.02)	0.78 (0.60–1.02)
	200%–399% FPL	0.55[†] (0.44–0.69)	0.44[†] (0.34–0.58)
	400% FPL or greater	0.43[†] (0.35–0.54)	0.28[†] (0.23–0.36)
Family structure	2 married parents	Referent	Referent
	2 unmarried parents	1.87[†] (1.36–2.58)	1.97[†] (1.43–2.71)
	Single parent	1.69[†] (1.43–1.99)	1.96[†] (1.58–2.44)
	Grandparent household	2.48[†] (1.73–3.55)	3.34[†] (2.33–4.78)

Abbreviations: BMI, body mass index; FPL, Federal Poverty Level; GED, General Educational Development; OR, odds ratio; PA, physical activity; 95% CI, 95% confidence interval. Note: Bold values indicate the statistical significance and [†]statistical significance, $P < .05$.

($P = .049$) but not in 6- to 11-year-old children. No sex effect modification was found using the academic progression outcome.

Post hoc analyses consisted of testing the joint associations (interactions) between reported child PA and sports participation on each academic performance dependent variable. Covariates that were found to be statistically significant within the respective adjusted models were controlled for within each post hoc analysis. There was a statistically significant joint association between child PA and sports participation on ever repeating a grade level. The results of this post hoc analysis are illustrated in Figure 1. If a child did not participate in sports within the past 12 months, PA did not significantly associate with ever repeating a grade level. However, among children who were reported to have participated in sports during the past 12 months, reported weekly child PA associated with lower odds of ever repeating a grade level compared with no reported child PA (OR_{1–3 d} = 0.52, $P_{1–3 d}$ = .004; OR_{4–6 d} = 0.44, $P_{4–6 d}$ = .001; OR_{Every day} = 0.53, $P_{Every day}$ = .003).

Discussion

The purpose of this study was to examine the independent and joint associations between PA and sports participation on academic performance variables within a representative sample of US children and adolescents. After controlling for important child- and family-level covariates, any frequency of child PA during the past week and sports participation during the past 12 months associated with lower odds of reported difficulty concentrating, remembering, or making decisions. Interestingly, sports participation moderated the association between child PA frequency and ever repeating a grade level as any frequency of weekly PA associated with lower odds of ever repeating a grade level only in those children who participated in sports. An interpretation of these results and a discussion of potential future research directions are provided.

Previous research has shown that higher levels of PA associates with specific aspects of academic performance in children and

Table 3 Adjusted Parameter Estimates Predicting Academic Performance Variables Using Weighted Multiple Logistic Regression

Predictor	Level	Difficulty concentrating, remembering, making decisions (no = referent) adjusted OR (95% CI)	Repeated a grade level (no = referent) adjusted OR (95% CI)
60 min of PA	0 days	Referent	Referent
	1–3 d/wk	0.63[†] (0.49–0.79)	1.02 (0.73–1.44)
	4–6 d/wk	0.52[†] (0.39–0.71)	1.00 (0.65–1.52)
	Every day per week	0.54[†] (0.39–0.76)	1.20 (0.80–1.82)
Sports participation	Did not participate	Referent	Referent
	Participated	0.47[†] (0.39–0.57)	0.84 (0.63–1.11)
Child age	6- to 11-y old	Referent	Referent
	12- to 17-y old	0.83 (0.66–1.05)	1.18 (0.88–1.60)
Child sex	Male	Referent	Referent
	Female	0.55[†] (0.45–0.66)	0.65[†] (0.51–0.82)
Child BMI class	Normal weight	Referent	Referent
	Underweight	1.39[†] (1.02–1.89)	1.13 (0.72–1.77)
	Overweight/obese	1.14 (0.93–1.39)	1.14 (0.89–1.48)
Child race/ethnicity	White/non-Hispanic	Referent	Referent
	Hispanic	0.96 (0.57–1.01)	1.08 (0.80–1.46)
	Black/non-Hispanic	0.85 (0.66–1.10)	1.44[†] (1.07–1.94)
	Other/multiracial-non-Hispanic	0.79 (0.61–1.03)	1.11 (0.78–1.59)
Highest adult education	College degree or higher	Referent	Referent
	Some college	1.21 (0.99–1.48)	1.69[†] (1.32–2.16)
	High school/GED	0.98 (0.75–1.29)	1.90[†] (1.41–2.56)
	Less than high school	0.81 (0.48–1.36)	2.22[†] (1.35–3.62)
Household poverty level	0%–99% FPL	Referent	Referent
	100%–199% FPL	0.93 (0.66–1.28)	0.81 (0.58–1.17)
	200%–399% FPL	0.70[†] (0.53–0.93)	0.56[†] (0.40–0.79)
	400% FPL or greater	0.73[†] (0.56–0.96)	0.50[†] (0.36–0.67)
Family structure	2 married parents	Referent	Referent
	2 unmarried parents	1.44 (0.95–2.17)	1.35 (0.89–2.05)
	Single parent	1.38[†] (1.12–1.70)	1.22 (0.94–1.61)
	Grandparent household	1.73[†] (1.15–2.61)	2.47[†] (1.54–3.95)

Abbreviations: BMI, body mass index; FPL, Federal Poverty Level; GED, General Educational Development; OR, odds ratio; PA, physical activity; 95% CI, 95% confidence interval. Note: Bold values denote the statistical significance and [†]statistical significance, $P < .05$.

adolescents.^{27–29} However, not all research shows this favorable pattern with null associations observed in a number of longitudinal and experimental studies.^{30–32} Singh et al³² found that between 48% and 60% of high-quality studies showed a beneficial impact of PA on specific academic performance variables. However, 6 out of 7 high-quality studies (86%) showed a beneficial effect of PA on mathematics performance.³² These contrasting results from previous work highlight that there may be important moderators and mediators of effect when considering the relationship between PA and academic performance and that this relationship also differs by the type of academic outcomes examined (eg, cognitive skills, behavior, and subject achievement). The novelty of the current study is the consideration of multiple aspects of academic performance and examination of both PA and sports participation together within the analysis. The results of this study indicate that both PA and sports participation are independently associated with lower odds of difficulty concentrating, remembering, and making decisions, an item on the NSCH that relates to executive

control, which is a core cognitive process including inhibition, working memory, and cognitive flexibility.^{33,34} These cognitive skills are needed to complete complex goal-directed cognitive tasks that are often undertaken in academic settings.

The results support prior research identifying the role of PA on specific cognitive skills and also show that this relationship is independent of sports participation and several child- and family-level potential confounding variables.^{27,35} The current study also found an independent association between sports participation and cognitive functioning, a relationship found in other work,^{36–39} and an independent association between sports participation and academic progression in older adolescents only. Bang et al³⁷ found that sports participation had positive effects on locus of control, or how well an individual feels that they are in control of their life, which may contribute to better academic performance. This improved locus of control may relate to the structured characteristic of sports participation. The social aspect of sports participation also may improve social ties between individuals and limit antisocial

Figure 1 — Joint association of reported weekly child PA frequency and sports participation on adjusted ORs of ever repeating a grade level. Note: odds ratio referent = 1; odds ratios adjusted for child sex, race/ethnicity, adult education, family Federal Poverty Level, and family structure. OR indicates odds ratio; PA, physical activity. †Statistical differences in odds ratios between sport participation groups within a respective PA stratum, $P < .05$.

behaviors within individuals.^{40,41} These social relations may, in turn, promote self-confidence, social interactions, and reciprocal modeling and learning among higher-achieving individuals.^{40,41} Thus, both the structured and social characteristics of sport may positively influence the skills needed for academic success. However, the independent association between sports participation and academic progression was only found in older adolescents. A possible mechanism for this may be that within the higher grade levels, adolescents who fail a grade may not be allowed to participate in sports. In addition, athletes who compete in highly competitive sports programs may enroll in less challenging coursework to cope with concurrent academic and athletic priorities. These plausible mechanisms suggest potential bidirectionality between sports participation and academic progression and, thus, it should be explored with future research.

A novel result found from this study was the joint association between reported PA frequency and sports participation with ever repeating a grade level. Children who participated in any frequency of PA and participated in sports had lower odds of ever repeating a grade level. The PA did not associate with repeating a grade level if the child did not participate in sports. Domazet et al⁴⁰ examined if PA, sports participation, or active commuting associated with mathematics performance and inhibitory control in a sample of adolescents. The PA's associations with academic performance were mixed, but sports participation significantly associated with higher mathematics performance.⁴¹ However, no joint associations were tested. Fox et al⁴¹ also examined the associations between PA and sports team participation on grade point average among middle- and high-school students and found that both PA and sports participation had significant associations with grade point average with the associations differing by grade level and sex. Again, however, joint associations between PA and sports participation were not tested.⁴¹ The statistically significant joint associations in the current study suggests, perhaps, that structured PA with social relations, as seen in sports, is a type of PA that may more strongly influence academic achievement. To the authors' knowledge, this is the first study to

observe these findings. Despite the statistical control for a number of child- and family-level covariates, this joint association should be interpreted with caution because of the cross-sectional design and use of survey methods for data collection. However, this unique finding could spur additional research.

This study provides an evidence of both independent and joint associations between reported PA and sports participation with specific aspects of academic performance. However, the broadness of the PA and sports participation items on the NSCH manifests a need for additional research on these associations. Specifically, examining the intensity of PA and participation in different types of sports (eg, team vs individual) will provide important and specific information. Possible other factors to consider within these relationships are the time segment characteristics of these behaviors (eg, weekday, weekend, in school, out of school), how relative time use of PA intensity associates with specific aspects of academic performance within a compositional data analytic framework, the frequency of sports participation, and the interaction between motor skill competency, sports participation, and academic performance. Studies have also shown that children from lower income households have a lower prevalence of sports participation compared with children from higher income households.⁴² Using the current 2017–2018 NSCH sample, there was a relationship between family poverty level and sports participation, as households at 400% FPL or greater had 4.8 times greater odds of child sports participation compared with households at 0% to 100% of FPL. Family poverty level was controlled for within the analyses in the current study; however, the strong association between family poverty level and sports participation provides additional evidence for the imperative need to provide sports participation opportunities for children within lower income families. Important socioenvironmental facilitators to provide these opportunities may be parents and peers, which may mitigate barriers for children's sport participation.⁴³ Most importantly, examining these associations using longitudinal and experimental research designs will provide evidence for causal influences, and testing for bidirectional

relationships among these constructs using cross-lagged panel models may have merit.

This study has several strengths to highlight. First, this study included a large and representative sample of US children and adolescents; thus, the generalizability of findings from this study is not limited. Second, this study included 2 separate dependent variables that constitute academic performance. The study also examined the influence of both PA and sports participation on academic performance; most studies tend to examine only one of these explanatory/predictor variables. Third, the associations examined in this study were adjusted for a number of child- and family-level covariates, attenuating the potential confounding influence of these factors. Finally, the analyses conducted in this study included the combined data from 2 consecutive years of the NSCH, which improves statistical power and provides more precise parameter estimates compared with the use of 1-year data. Limitations of the current study included the use of parent self-report, which may be subject to both recall and response bias. The NSCH is an annual cross-sectional survey; therefore, all relationships are correlational and no causal inferences can be made. In addition, the PA dependent variable only asked about meeting the weekly frequency of the 60-minute-per-day guideline but did not specifically ask about PA intensity. Finally, the academic performance variables were dichotomized for analysis, precluding trend analyses across multiple levels of a respective variable and the examination of possible U-shaped associations within the data.

Conclusions

This study provided information on the relationships among PA, sports participation, and academic performance within a representative sample of US children and adolescents. Both PA and sports participation independently and negatively associated with reported difficulty concentrating, remembering, or making decisions. Most interestingly, the negative relationship between PA and repeating a grade level was moderated by sports participation; that is, any reported weekly PA associated with lower odds of repeating a grade level in children who participated in sports. These results indicate that PA and sports participation both may influence specific aspects of a child's academic performance. Future research should examine these associations using more objective measures within longitudinal and experimental research designs. Determining the types of sports that may more strongly influence academic performance may also have merit in future work. Both PA and sports participation should be considered when utilizing movement-based behaviors to improve specific aspects of academic performance in youth.

Acknowledgments

The authors would like to thank the parents who participated in either the 2017 or the 2018 NSCH. No funding was received for this study.

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