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School-based physical activity during the COVID-19 pandemic

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Abstract
School closures and restrictions related to the COVID-19 pandemic changed opportunities for youth physical activity (PA). We sought to identify school and other contextual conditions associated with youth PA during the COVID-19 pandemic. A nationally representative, United States sample consisted of 500 parents of children ages 6-10 years old and 500 parent-child dyads with children and adolescents ages 11-17 years old who completed a web-based questionnaire. Multivariable linear regression was used to assess the association between days per week of at least 60 minutes of PA with school, family, and neighborhood characteristics, controlling for child age and gender. Youth engaged in significantly more days per week of PA when they attended school in person; participated in school physical education (PE), school sports, and community sports; and had parents that engaged in high versus low levels of PA. The COVID-19 pandemic negatively impacted youth PA, in part, due to restriction of school-based PA opportunities. During future pandemics or conditions that necessitate remote learning, attention to opportunities for PA outside of PE class may be important for equitable PA promotion across school modalities.

Keywords: physical activity; schools; youth; disparities

Physical activity (PA) is important for mental and physical wellbeing, yet is rarely adequate among children and adolescents in the United States (US) (Rusby et al., 2014; Ortega et al., 2008; Smith et al., 2014). Prior to the COVID-19 pandemic, fewer than one in four youth met aerobic PA recommendations of at least 60 minutes per day of moderate- to vigorous-intensity PA (MVPA) (Troiano et al., 2008). A scoping review conducted in 2021, after the first year of the coronavirus disease 2019 (COVID-19) pandemic, observed a decrease in PA among school-aged children and adolescents (Paterson et al., 2021). Consistent with Lee's Ecological Model of Physical Activity, PA is constrained by opportunities and affordances in the child's microenvironments (e.g., school, neighborhood, home), which are in turn shaped by macro-environmental conditions (e.g., pandemic conditions, systemic racism, policies, norms) (Lee et al., 2009).

Pre-pandemic, schools played a central role in PA promotion, through physical education (PE) classes and other school-based activities. Early in the pandemic, most schools in the US transitioned to remote instruction and canceled extracurricular sport, and many community-based recreation facilities temporarily closed or reduced access. Students from families experiencing financial insecurity in high density living conditions had constraints on the space available for participating in home-based PE, as well as computer access and Internet connectivity difficulties that limited their engagement with remote schooling (Whalen et al., 2021; Dolan, 2016). Given constraints on organized PA opportunities during the pandemic, informal home- and neighborhood-based PA provided the primary opportunities for youth PA. Data from a sample of school-aged Canadian children suggests that during the pandemic, such outdoor activities were most likely among youth living in low density communities, away from major roads, and with access to parks (Mitra et al., 2020).

As cities and states lifted "stay-at-home" orders, schools and community groups offering organized sport responded very differently, likely based in part on financial resources. Youth attending well-funded schools in affluent communities were the most likely to resume in-person school, meaning they resumed in-person PE, and potentially school-based extracurricular PA (e.g., sports teams) (Kroshus et al., 2020; Hawrilenko et al., 2021; Johnson et al., 2023; Daum, 2020). Privately funded and intensive community-based sports (e.g., "travel" or "rep" teams), quickly resumed practice and competition, potentially due to parental pressure and the ability to pay for risk mitigation measures (Edwards et al., 2021). Community centers, and non-profit organizations like the Boys and Girls Club or the YMCA were slower to re-open sports programming (Dorsch & Blazo, 2021). Conditions in the family microenvironment may have compounded economic place-based inequities. Families experiencing intersecting forms of socioeconomic disadvantage, including financial insecurity and exposure to systemic racism, were the most burdened by the COVID-19 pandemic, financially and in terms of illness and mortality rates (Khazanchi et al., 2020). Parents in these families were also most likely to be employed as front-line or essential workers (Rogers et al., 2020). These structural differences may have heightened challenges in supporting remote learning, paying for and transporting their children to organized PA (e.g., sport, lessons), and limited their capacity and availability to engage in informal family-based PA (Kroshus et al., 2021; Post et al., 2018).

School-based interventions can be informed by 1) determining the extent of youth PA inequities during the COVID-19 pandemic, and 2) identifying pathways through which they may be reduced. Examining differential access to PA opportunities by socioeconomic, racial/ethnic, and neighborhood characteristics is an important step in addressing barriers to regular PA participation. It is particularly important to support equitable PA during times of heightened societal and individual stress (e.g., COVID-19 pandemic), when PA could be helping mitigate negative consequences on youth wellbeing. Further, PA habits established during childhood often persist into adulthood, and identifying factors associated with activity levels during this critical period can help inform efforts to promote healthy behaviors across the lifespan (Telama, 2009).

The aims of this study were to describe the PA practices of youth from a nationally representative US sample of children ages 6-17. Framed by Lee's Ecological Model of Physical Activity, we describe the extent to which PA practices (days per week of PA, organized PA participation) were associated with 1) school-level exposures (school modality, organized PA opportunities), 2) other micro-environmental exposures [e.g., family socioeconomic status (SES)], and 3) neighborhood characteristics (Lee et al., 2009).

Methods

Study Sample

Survey data were obtained from an opt-in web-based questionnaire administered from October 22, 2020 to November 2, 2020. Participants were 500 parents of children ages 6-10 years old and 500 parent-child dyads with children and adolescents (hereinafter referred to as children) ages 11-17 years old. Parents of children aged 11 to 17 years each recruited one of their children between the ages of 11 to 17 years for a survey. Recruitment was facilitated by YouGov, a market research company. YouGov's procedures to generate a nationally representative sample using weighted propensity scores and sample matching have been described in more detail elsewhere (Rivers, 2007). Briefly, YouGov surveyed 547 parents of children 6-10 years old and 535 parent-child dyads with children 11-17 years old. Then, respondents were matched down to samples of 500 per cohort using US Census–based sampling frames by age, educational level, and race (children aged 6 to 10 years) and by gender, age, educational level, and race (children aged 11 to 17 years). These frames were constructed by stratified probability sampling from the full 2017 American Community Survey (ACS), propensity scores were used to construct a sample of 500 in each reference child age category that was nationally representative in terms of parent race, age, and

education, resulting in a total sample size of 1000 parents (Bureau USC, 2021).

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cross-sectional studies and the American Association for Public Opinion Research (AAPOR) best practices for survey research (STROBE, n.d.; AAPOR, n.d.). The institutional review board of Seattle Children's Research Institute approved the research procedures and granted a waiver of written documentation of consent. Information describing the research was provided to all participants, who indicated their parental permission/consent online.

Measures

All data on children ages 6-10 years are parent reported. For children ages 11-17 years, parents were asked about family demographics, school modality, and neighborhood characteristics. The children in this age group were asked to self-report on their PA and participation in organized PA.

Physical activity

Youth PA was assessed using items from the Youth Risk Behavior Surveillance Survey (YRBSS), which were adapted for parent report on younger children, and have been shown to have acceptable test-retest reliability (Underwood et al., 2020). A similar PA item, the PACE+ questionnaire, has been shown to have acceptable concurrent validity with accelerometer-measured PA (Hardie Murphy et al., 2015). Child PA was examined by asking about the number of days in the past week that the child engaged in 60 min or more of PA (i.e., activity that made them breathe hard or increased their heart rate). Categorizing these responses into 3 categories (0, 1 to 6, and 7 days/week) allowed us to compare those not reporting PA of 60 min or more on any days of the week, those reporting 60 min or more of PA on some days, and those meeting aerobic PA recommendations.

Participants reported whether the youth was participating in three different types of organized PA: school-provided PE class, school-based extracurricular PA (organized sports team or other school-based organized athletic activity), and community-based organized PA (organized sports team or other organized athletic activity with a club or community organization).

Parent PA was measured using the International Physical Activity Questionnaire (IPAQ), and categorized as low, medium, or high using the thresholds proposed by the IPAQ Research Committee (Lee et al., 2011; IPAQ, 2005).

School modality

Current school attendance was reported as in person, hybrid (i.e., some combination of in person and remote), or remote.

Child and parent demographic characteristics

Child age (numeric), gender identity (boy, girl), and race and ethnicity (US Census categories) were self-reported for adolescents (ages 11-17), and parent-reported for children (ages 6-10). The highest level of formal parent education was measured and used as a proxy for family SES. Parents responded in six categories: no high school, high school degree, some college, 2-year degree, 4-year college degree, post-graduate degree. These were subsequently grouped into three theoretically indicated categories: High school or less; some college or 2-year degree; 4-year college or post-graduate degree. The responding parent indicated whether they are working full time (>35 hours/week), part-time (<35 hours/week) or not working. They also indicated their spouse's employment status (full-time, part-time, not working, or N/A). From these responses, we constructed a three-level variable reflecting the employment status of all parents (1) both parents or single parent working full-time; (2) at least one parent working part-time or part-time employed single parent; (3) neither parent employed or unemployed single parent.

Neighborhood characteristics

The Neighborhood Environment Walkability Scale-Youth (NEWS-Y) was used to measure four aspects of the family's surrounding community: places for walking/cycling, neighborhood aesthetics, traffic safety, and crime safety. Responses to each item were on a four-point scale (1=strongly disagree, 2=somewhat disagree, 3=somewhat agree, 4=strongly agree); summed within each of the four subscales; and averaged to create a mean item-level score (Rosenberg, 2009).

Statistical Analysis

For summary statistics, categorical variables were presented as counts and weighted proportions. Continuous variables were presented as means and standard deviations (SD). Descriptive characteristics were reported for the full sample, PA variables were reported separately for ages 6-10 and 11-17. Level of PA was reported as the mean number of days per week with 60 or more minutes of PA; the proportion of days with 60 or more minutes of PA is also presented. Also reported are the proportions of individuals participating in the three types of organized PA (PE, school, and community-based extracurricular PA). Three separate logistic regression models were fitted to examine the associations between participating in the three different forms of organized PA and micro-environmental predictors (school modality, parent education, neighborhood characteristics). Regression analyses controlled for child age and gender. Due to limited range of level of PA, truncated linear regression predicting days of PA from family, school, and neighborhood characteristics was similarly conducted (Hausman & Wise, 1977). All analyses were conducted using R statistical software version 4.1.2.

Results

Participant characteristics

Participant characteristics are presented in Table 1, overall and by age group. The mean age of youth in the sample was 10.8 years (SD=3.5), with 500 youth in the 6-10 year age range, and 500 youth in the 11-17 year age range. In the total sample, 467 (47.4%) children were girls and 517 (52.6%) were boys. Seven hundred seventy-nine children (75.6%) in the sample were White; 233 (27.8%) were Hispanic/Latino. Among the 1000 children included in the analysis, 220 children (22.2%) were attending school in person; 494 (50.6%), virtually; and 285 (27.2%), in a hybrid setting. Among the parents, 322 (37.6%) did not complete high school, and 361 (36.1%) were in a household where all parents worked full-time.

Table 1. Child, family, school and community characteristics

	Child age 6-10	Child age 11-17	Child age 6-17
	Mean (SD)	Mean (SD)	Mean (SD)
Child age	8.08 (1.38)	13.96 (2.00)	10.83 (3.51)
Child gender	n (%)	n (%)	n (%)
Boys	265 (52.58%)	252 (50.60%)	517 (52.57%)
Girls	228 (47.42%)	239 (49.40%)	467 (47.43%)
Child race/ethnicity	n (%)	n (%)	n (%)
White	353 (67.37%)	354 (70.82%)	779 (75.63%)
Black	59 (12.26%)	52 (9.86%)	117 (10.98%)
Asian	9 (2.89%)	14 (2.73%)	24 (2.89%)
American Indian/Alaska Native	14 (2.63%)	5 (1.52%)	19 (2.09%)
Native Hawaiian/Pacific Islander	1 (0.28%)	0 (0.00%)	1 (0.11%)
Other races	64 (14.57%)	75 (15.06%)	60 (8.30%)
Hispanic	120 (27.57%)	113 (30.68%)	233 (27.77%)
Parent education	n (%)	n (%)	n (%)
High school or less	170 (38.32%)	152 (36.83%)	322 (37.64%)
Some college	156 (27.54%)	167 (26.61%)	323 (26.42%)
4-year college	115 (21.75%)	109 (23.14%)	224 (22.50%)
Graduate degree	59 (12.40%)	72 (13.42%)	131 (13.44%)
Parent employment	n (%)	n (%)	n (%)
All parents unemployed	79 (17.52%)	81 (17.84%)	160 (14.72%)
One or more parents works part-time	244 (48.98%)	235 (44.05%)	479 (49.17%)
All parents work full-time	177 (33.50%)	184 (38.11%)	361 (36.11%)
Parent physical activity	n (%)	n (%)	n (%)
Low	152 (32.10%)	160 (34.13%)	312 (33.33%)

Medium	86 (17.67%)	91 (14.53%)	177 (15.31%)
High	262 (50.22%)	249 (51.35%)	511 (51.37%)
School modality	n (%)	n (%)	n (%)
In-person	124 (24.68%)	96 (17.06%)	220 (22.22%)
Hybrid	132 (24.71%)	153 (32.36%)	285 (27.20%)
Virtual	243 (50.62%)	251 (50.57%)	494 (50.57%)
Neighborhood characteristics	Mean (SD)	Mean (SD)	Mean (SD)
Walkability	2.54 (0.98)	2.70 (0.97)	2.63 (0.98)
Surroundings	2.90 (0.76)	2.91 (0.78)	2.91 (0.75)
Traffic	2.28 (0.52)	2.27 (0.53)	2.27 (0.53)
Crime	2.41 (0.86)	2.30 (1.00)	2.29 (0.92)

SD = Standard deviation

Physical activity

Level of PA (days/week) and organized PA participation is reported separately for 6-10 and 11-17 year olds (Table 2). The mean number of days per week with 60 or more minutes of PA was 4.1 (SD=2.2) for ages 6-10, and 3.5 (SD=2.1) for ages 11-17. Over 7.5% of younger youth and 11.0% of older youth did not participate in 60 minutes of PA on any day during the prior week. Eighty-three percent of younger youth (83.1%) and 72.5% of older youth participated in PE class. Over 11% of younger youth and 21.8% of older youth played on an organized school sports team or participated in another organized school-based athletic activity. Roughly 19.4% of younger youth and 19.2% of older youth played on an organized community sports team or participated in another organized community-based athletic activity.

Table 2. Organized physical activity and total physical activity participation among school-aged children

	Child age 6-10	Child age 11-17	Child age 6-17
	n (%)	n (%)	n (%)
Participate in PE class	407 (83.11%)	360 (72.51%)	767 (76.65%)
	n (%)	n (%)	n (%)
Played on an organized school sports team or other organized athletic activity	69 (11.52%)	96 (21.81%)	165 (17.47%)
	n (%)	n (%)	n (%)
Played on an organized community sports team or other organized athletic activity	106 (19.43%)	94 (19.19%)	200 (19.67%)
Days in past week with 60 or more minutes of physical activity	n (%)	n (%)	n (%)
0	32 (7.51%)	58 (11.01%)	90 (8.37%)
1	34 (6.86%)	41 (7.80%)	75 (7.61%)
2	64 (12.19%)	70 (13.43%)	134 (13.64%)
3	75 (14.01%)	85 (20.21%)	160 (16.77%)

4	61 (14.31%)	63 (15.60%)	124 (12.05%)
5	84 (15.79%)	77 (13.43%)	161 (15.13%)
6	31 (6.00%)	24 (4.86%)	55 (5.55%)
7	119 (23.32%)	76 (13.50%)	195 (20.88%)
	Mean (SD)	Mean (SD)	Mean (SD)
Mean number of days per week with 60 or more minutes of physical activity	4.09 (2.22)	3.49 (2.12)	3.89 (2.23)

SD = Standard deviation
PE = Physical education

Odds of participating in physical activity at school and in the community

Results of multivariate logistic regression (Table 3) indicated greater odds of participating in PE classes among girls compared to boys (OR=1.31, 95% CI=1.01 to 1.62); youth with at least one parent employed part-time compared to all parents unemployed (OR=1.67, 95% CI=1.21 to 2.12); and youth attending school in person compared to remote (OR=1.48, 95% CI=1.07, 1.89). Results of multivariate logistic regression indicated greater odds of participating in school-based extracurricular organized PA among youth whose parents have a 4-year college degree (OR=1.61, 95% CI=1.14 to 2.07) or have a graduate education (OR=1.83, 95% CI=1.30 to 2.37) compared to high school diploma or less formal education; and students attending school in-person (OR=3.45, 95% CI=3.05 to 3.85) or in a hybrid setting (OR=2.01, 95% CI=1.55 to 2.48) compared to remote. Results of multivariate logistic regression indicated greater odds of participating in organized community-based PA among non-Hispanic versus Hispanic youth (OR=1.98, 95% CI=1.55 to 2.41), whose parents have post-graduate education as compared to high school diploma or less formal education (OR=1.76, 95% CI=1.26 to 2.26).

Table 3. Logistic regression describing odds of participating in physical activity at school and in the community

	PE class	School-based extracurricular PA	Community-based organized PA
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Child age	0.94*** (0.89, 0.98)	1.04 (0.99, 1.09)	0.99 (0.94, 1.03)
Child gender			
Boys	REF	REF	REF
Girls	1.31* (1.01, 1.62)	0.64** (0.28, 0.99)	0.88 (0.56, 1.20)
Race/ethnicity			
White	REF	REF	REF
Black	1.52 (0.97, 2.07)	0.78 (0.14, 1.42)	0.70 (0.11, 1.29)
Other	1.08 (0.68, 1.46)	0.90 (0.43, 1.37)	1.40 (0.99, 1.81)
Hispanic			
Yes	REF	REF	REF
No	0.84 (0.47, 1.20)	1.08 (0.66, 1.51)	1.98*** (1.55, 2.41)
Parent education			
High school or less	REF	REF	REF
Some college	1.00 (0.59, 1.40)	0.86 (0.37, 1.35)	0.98 (0.54, 1.41)
4-year college	0.73 (0.31, 1.15)	1.61** (1.14, 2.07)	1.25 (0.80, 1.70)

Graduate degree	0.49*** (0.02, 0.97)	1.83** (1.30, 2.37)	1.76** (1.26, 2.26)
Parent employment			
All parents unemployed	REF	REF	REF
At least one parent employed part time	1.67** (1.21, 2.12)	0.77 (0.20, 1.35)	0.81 (0.30, 1.33)
All parents employed full time	1.34 (0.86, 1.82)	1.34 (0.76, 1.92)	1.23 (0.70, 1.77)
School modality			
Remote	REF	REF	REF
Hybrid	1.14 (0.78, 1.50)	3.45*** (3.05, 3.85)	0.91 (0.53, 1.30)
In person	1.48* (1.07, 1.89)	2.01*** (1.55, 2.48)	1.03 (0.62, 1.44)

*p<0.1; **p<0.05; ***p<0.01
PE = Physical education
PA = Physical activity

Predicting physical activity from child, family, school, and neighborhood characteristics

Results of linear regression find that days/week of PA are significantly higher among youth who participate in school PE (B=0.83, SE=0.23, p<0.001), school sports (B=0.98, SE=0.25, p<0.001), and community sports (B=0.68, SE=0.23, p=0.003) (Table 4). Youth met PA guidelines of at least 60 minutes of PA on more days when they lived in neighborhoods with higher scores on the "surroundings" subscale (B=0.66, SE=0.13, p<0.001), and when their parents engaged in high versus low levels of PA (B=1.22, SE=0.21, p<0.001). Youth attending school in-person engaged in more days of PA than youth attending school fully remotely (B=0.75, SE=0.22, p<0.001). In the multivariate model, no significant associations were observed between child race/ethnicity, child gender, parent employment status, or parent education with days of PA.

Table 4. Regression predicting days/week of at least 60 minutes of physical activity from child, family, school, neighborhood characteristics

	B (SE)
Child Characteristics	
Child age	-0.12*** (0.03)
Child gender	
Boys	REF
Girls	-0.26 (0.17)
Race/ethnicity	
White	REF
Black	-0.15 (0.29)
Other	0.20 (0.23)
Hispanic	
Yes	REF
No	0.41* (0.22)
Parent Characteristics	
Parent physical activity	
Low	REF
Moderate	0.27 (0.27)
High	1.22*** (0.21)
Parent education	
High school or less	REF
Some college	-0.03 (0.22)
4-year college	-0.30 (0.25)
Graduate degree	-0.25 (0.30)
Parent employment	
All parents unemployed	REF
At least one parent employed part time	0.12 (0.26)
All parents employed full time	-0.16 (0.28)
School Characteristics	

School modality	
Remote	REF
Hybrid	0.39* (0.21)
In person	0.75*** (0.22)
School PE	
No	REF
Yes	0.83*** (0.23)
School sports	
No	REF
Yes	0.98*** (0.25)
Neighborhood Characteristics	
Community sports	
No	REF
Yes	0.68*** (0.23)
Neighborhood- Walkability	-0.17 (0.10)
Neighborhood- Surroundings	0.66*** (0.13)
Neighborhood- Traffic	0.0 (0.19)
Neighborhood- Crime	0.12 (0.11)

*p<0.1; **p<0.05; ***p<0.01
PE = Physical education

Discussion

In this nationally representative sample of school-aged youth ages 6-17 in the US, aerobic guidelines of at least 60 minutes of PA were met, on average, 3-4 days per week. Although these findings are comparable to pre-pandemic estimates of approximately four days/week, studies examining overall changes in youth PA report a significant decline in PA during the pandemic (McCoy et al., 2016; Tulchin-Francis et al., 2021).

School characteristics and community sports

Youth engaged in more days of PA when they participated in organized PA, including PE class, school-based extracurricular activities, and community-based extracurricular activities, consistent with pre-pandemic findings (Mooses et al., 2017). Prior to the pandemic, roughly half of high school students attended PE class at least one day a week, and over 75% of youth ages 6-17 years participated in some sort of past-year extracurricular activity (Kann et al., 2018; Child Initiative AHM, 2020). The present findings suggest a decline in participation in both forms of organized PA during the pandemic, likely due to the pandemic's disruption of many schools and organized sports programs (Shepard & Mohohlwane, 2021). Additionally, youth who attended school in-person engaged in more days of PA than peers who were attending school remotely. Collectively, these findings underscore the importance of maintaining access to organized PA particularly during periods of remote learning. This could include virtual PE classes or providing resources and guidance for at-home PA.

Aside from PE and organized extracurricular sport, there are opportunities for formal and informal PA before, during, and after the school day that are possible when children are present in person but that are challenging to replicate in remote learning. Examples include active transport to and from school and recess or lunchtime PA.

The loss of such in-person opportunities may particularly impact youth in family or neighborhood microenvironments that are less conducive to PA. The Institute of Medicine recommends a "whole of school" approach to PA promotion for youth, with schools functioning as hubs for PA promotion beyond just PE class (Kohl & Cook, 2013). Further work is needed to understand how schools can adapt during times of remote learning to equitably promote PA during and outside of the school day, including support for active transit and other forms of unstructured PA. Future research could also examine how virtual platforms can be levered to maintain and enhance youth PA levels, as well as examine the combined impact of PA predictors, such as school modality and parent employment.

Neighborhood characteristics

Neighborhood microenvironments were also associated with days per week of meeting guidelines of 60 minutes or more of PA. For example, neighborhoods with surroundings that were aesthetically appealing (trees, free from litter, attractive natural sights and buildings) were associated with more youth PA, consistent with Lee's Ecological Model of Physical Activity. These findings also align with previous research, which demonstrate a positive relationship between neighborhood aesthetics and youth PA (Tappe et al., 2013). Research has shown racial inequities in PA-conducive neighborhood conditions, with the percentages of Blacks and Hispanics being negatively linked to both distances to parks and green space coverages (Wen et al., 2013). However, we did not observe racial differences in amount of PA or participation in organized PA in multivariate models controlling for potential micro-environmental differences that are downstream from experiences of systemic racism (e.g., neighborhood conditions). It is possible that PA behavior and participation in organized PA during this time was influenced by factors outside of race, such as neighborhood conditions, school modality, and parent sociodemographics. The relationship between race and PA is inconsistent in research, especially for children, and there is evidence that setting factors are more predictive of opportunities (Belcher et al., 2010; Johnson et al., 2021; Sallis et al., 1992).

Urban planning and community development efforts to increase neighborhood-based activity among youth should consider improvements to neighborhood aesthetics, such as planting trees and landscaping, to help create spaces that feel welcoming and safe to encourage outdoor PA during out-of-school time (Wood et al., 2008). This could include collaborations between schools, community organizations, and local government to engage in strategies such as reducing litter, enhancing greenspaces, and planting trees. Previous research has shown perceived aesthetics to be a determinant of PA, and Wang et al. (2016) provides a comprehensive review of how details within the built environment can enhance active transportation behaviors (e.g., increased greenery reducing noise annoyance and attracting walkers) (Kärmeniemi et al., 2018; Wang et al., 2016).

Parent characteristics

Parents who were more physically active had children who engaged in more PA, independent of other family, neighborhood, and school characteristics. It is possible that this result is a function of parents and children co-participating in PA or parental modeling. It is also possible that parents who are more active place more value in, and thus allocate effort for, facilitating child PA. Determining the etiology of this association can help identify useful strategies for family-focused behavioral interventions, which can emphasize the importance of parental involvement and provide strategies to support parents' promotion of PA within the family. Such efforts may be particularly important during remote learning and when school-based PA opportunities are limited. Independent of its impact on child PA, parent PA has well-established physical and mental health benefits that are important at all times and particularly during the COVID-19 pandemic (Reiner et al., 2013; Marconcin et al., 2022). Behavioral interventions or public health communication addressing family PA should take micro- and macro-environments into account, and involve the whole family. This includes being mindful of variability in PA assets across neighborhoods, differences in individual and family circumstances that constrain the type of PA, and the time available for PA. Strategies may include providing tailored support for parents to engage in PA with their children, as well as emphasizing the importance of parental modeling.

Strengths and Limitations

Strengths of this study include a large, nationally representative sample, which provides external study validity. This study also addresses multiple gaps in the literature by examining the association of PA practices with school-level exposures, micro-environmental exposures and neighborhood characteristics. Study limitations include that PA measures were collected via parent- or child-report, and therefore subject to social desirability and recall biases. Additionally, given that this is a cross-sectional study, it was not possible to look at changes in PA practices. Finally, since this survey was conducted in the fall of 2020, it is likely that pandemic-related circumstances (e.g., status of school, sports, and other PA opportunities) changed over the course of the pandemic.

Conclusion

Youth engaged in more PA when they attended school in person, participated in PA and organized PA, had parents that were more physically active, and lived in neighborhoods with better surroundings. Efforts to support youth PA during future pandemics or conditions that necessitate remote learning should consider the assets and barriers to PA in the microenvironments in which youth live, learn, and play. Particular attention to opportunities for PA outside of PE class may be important for equitable PA promotion across school modalities.

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Conflict of Interest Statement

The authors report there are no competing interests to declare.

Author Contributions

AJ: Writing - Review & Editing; EK: Conceptualization, Funding acquisition, Writing - Original Draft; CZ: Formal analysis, Writing - Review & Editing; MKS: Investigation; KH: Investigation; KG: Investigation; PT: Conceptualization, Funding acquisition, Writing - Review & Editing

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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