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Factors associated with in-school physical activity among urban children with asthma

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Abstract

Objective—A cross-sectional study was conducted to determine if in-school physical activity (PA) varied by age, gender, weight and asthma status, participation in physical education (PE), outdoor recess, and other in-school PA among urban schoolchildren with asthma.

Methods—PA was measured by tri-axial accelerometers. Height and mass were measured and overweight defined as BMI ≥ 85th percentile. Asthma impairment and risk were assessed as per national guidelines, and asthma status variable with three categories (mild, moderate, and severe) was created. Multivariable generalized linear mixed models adjusting for clustering due to school and student were fitted to identify variables predictive of PA.

Results—108 children with asthma participated. Children spent 374 minutes in school, of which 253 minutes were sedentary, 105 minutes in light PA, and 16 minutes in moderate-to-vigorous PA (MVPA). Only 3 participants reached the recommended ≥ 30 minutes/day of MVPA. Multivariable

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Declaration of interest

The views expressed are those of the authors and not necessarily those of the NHS, the NIHR, NIH-NICHD, or the Department of Health.

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analysis revealed age, gender, participation in PE class, outdoor recess, and other in-school PA as independent predictors of PA. BMI and asthma status were not associated with PA.

Conclusions—Children with asthma were mostly sedentary at school. Older children and girls were particularly at risk for inactivity. PE, recess, and other in-school PA participation are modifiable factors that should be targeted in school-based interventions aimed at increasing PA in this population.

Keywords

Accelerometer; exercise; reactive airway disease; students

Introduction

Asthma affects 9.6% of the US children [1]. Asthma prevalence is higher in minority children living in inner cities, such as the Bronx, New York (NY), where 25% of schoolchildren have asthma [2–4]. National guidelines recommend regular physical activity (PA) for children with asthma for both asthma management and overall health [5]. PA has been associated with decreased severity of asthma symptoms, reduced school absenteeism, and improved quality of life [6–10]. Despite these benefits, children with asthma have lower levels of PA, fitness, and sports participation than children without asthma [11–14]. Minority children with asthma may have even lower levels of PA. There is a lack of studies using objective measures to evaluate PA levels during school-time in urban, minority children with asthma.

Schools are the optimal setting for programs to increase PA in children with asthma [15]. To maximize the effectiveness of such programs, it is important to understand factors that influence PA in this population. While age and gender have been shown to be predictors of PA among healthy youth [16], relatively little is known about these and modifiable determinants of PA among children with asthma. These factors can then be included in school-based programs and interventions to increase PA levels of children with asthma.

Previous studies have identified factors associated with school-time PA in healthy children, including older age, lack of outdoor facilities, participation in physical education (PE), class and outdoor recess [17–19]. Our literature review found no studies evaluating predictors of in-school PA in urban, minority US children with asthma. The purposes of this study were to (1) assess accelerometer-determined PA levels during school-time in urban, minority children with asthma and (2) to examine if PA levels varied by school, age, gender, weight status, asthma status, participation in PE class, outdoor recess, and other in-school PA. Results of this study will inform development of a school-based intervention for urban, minority children with asthma.

Methods

Participants and settings

We conducted a cross-sectional study of children with asthma, aged 7–10 years old, attending second to fourth grades at four elementary schools (1, 2, 3, and 4 with similar

sociodemographic characteristics) in the Bronx, NY. We identified students with asthma by sending home a 6-item screening survey in English and Spanish to all students from respective grades [4]. Caregivers completed the survey and gave consent to being contacted by phone.

Research staff assessed study eligibility over the telephone with caregivers who indicated that their child had asthma on the screening survey (192/768 (25%) of surveys). Families were eligible for participation if they had children of 7–10 years with: (1) caregiver report of physician-diagnosed asthma; (2) prescription for asthma medication in the past 12 months; and (3) English or Spanish speaking caregiver. Children with other chronic pulmonary diseases were excluded. Once eligibility was confirmed, research staff met with the caregiver and child to sign consent/assent forms. A total of 109 children (89% participation rate) were recruited. One child dropped out prior to any data collection, leaving 108 participants. All assessments were completed during November 2012 – February 2013.

The study was approved by both the New York City Department of Education and Hospital Institutional Review Boards.

Measurement of physical activity (PA)

PA was measured using tri-axial accelerometers (GT3X+, ActiGraph, Pensacola, FL), which provide an objective measurement of the temporal pattern of PA and their use in school-aged children has been validated [20, 21]. Children wore the accelerometer positioned above the right hip on a belt around their waist for 5 consecutive school days. Accelerometers were initialized to collect data at a 30 Hz sampling rate. Research staff visited schools daily to collect information on child's attendance, whether the monitor was worn and if the child participated in any PA during the school day. Students received a small toy each day of data collection and a \$10 gift card when the accelerometer was returned. In this paper, we analyzed school-hour data only.

Accelerometer data reduction

ActiGraph software (Actilife 6.4.5, ActiGraph, Pensacola, FL) was used to convert raw acceleration into activity counts per 10 second epochs, and include only hours the child was in school (average school duration was 6.2 hours). Activity counts were classified into the time spent in sedentary, light physical activity (LPA), moderate-to-vigorous physical activity (MVPA) using Evenson et al. cut points [22], shown to be the most accurate for children [23]. An interval of at least 60 consecutive minutes of zero counts was defined as non-wear time [24]. A day was considered "valid" if wear time during school hours had at least 4.5 hours (70% of 6.2 hours) of data from the school day [25]. Participants were also required to have 4 valid school days to be included in the analysis. All students had at least 4 days of valid data (range 4–6 days, mean 5.08 (SD 0.53) days) with a minimum of 4.83 hours of wear time and no student was excluded from the analysis. PA outcome variables were minutes spent in sedentary behavior, LPA, and MVPA and number of steps per school day.

Participation in PE, outdoor recess, and other in-school PA

Student participation in PE class, outdoor recess, and other in-school PA on days of activity monitoring was collected from the classroom and PE teachers daily by the research staff and recorded as “yes/no.” During recess (20–25 minutes daily), students would either go outside where activity is not organized or stay inside to read a book or watch a movie. Only two schools (1 and 3) had outdoor playgrounds equipped with a jungle gym and basketball hoops. School 2 had a small area designated for outdoor recess covered with blacktop and without play equipment. School 4 had permission to use a nearby public park for outdoor recess. Students in Schools 2 and 4 had no outside recess during accelerometer data collection due to inclement weather, student misbehavior, or lack of staff to supervise students. The other two schools had outdoor recess, but not daily, due to the same reasons. These are common reasons that often preclude outside recess in children in public schools in the Bronx. The limited opportunity for spontaneous play and organized PA is representative of the overall school year in these low-resource, urban schools. Examples of other in-school PA included: Mighty Milers, a running program for schoolchildren designed to prevent obesity [26], dance programs, and classroom-based activity breaks.

Anthropometric assessment

Height and weight were measured to the nearest 0.006 m and 0.045 kg, respectively, using a digital scale (Health O Meter® Professional Model# 500KL). Body mass index (BMI) was calculated from height and weight. Students were classified as underweight, normal weight, overweight, or obese by sex- and age-specific BMI percentiles on CDC’s 2000 BMI-for-age growth charts [27]. Underweight was defined as a BMI <5th percentile, normal weight as a BMI 5th but <85th percentile, overweight as a BMI 85th but <95th percentile, and obese as a BMI of ≥95th percentile. We combined underweight and normal-weight students into one category since there was only one underweight student.

Asthma status assessment

Information on child’s gender, race, ethnicity, asthma medications, and duration of asthma diagnosis was collected through caregiver surveys. Caregivers reported on child’s asthma-related impairment over the previous month (number of days with daytime symptoms, nighttime symptoms, rescue medication use or interference with activity) based on the national guidelines [5]. We created an “asthma status” variable with three categories (1 = “mild” [daytime symptoms ≤2 days/week, nighttime symptoms ≤2 times/month, rescue medication use ≤2 days/week, or no interference with activity]; 2 = “moderate” [daytime symptoms 3–7 days/week but not all the time, nighttime symptoms 3 times/month to 6 times/week, rescue medication use 3–7 days/week but not several times per day, or some limitation in activity]; and 3 = “severe” [daytime symptoms every day and all the time, nighttime symptoms every night, rescue medication use several times per day, or extreme limitation in activity]). Caregivers also provided an estimate of risk by reporting the number of times systemic corticosteroids were required over the previous year. Due to difficulties in scheduling, caregiver surveys were conducted on average 19 days (range 0–48 days) after the child began PA assessment with the exception of one participant, for whom caregiver survey was conducted one day before the start of the accelerometer data collection.

Power consideration

In the 108 students recruited from 4 schools, they provided an average of 5 observations per student per outcome variable and the intra-student correlation coefficient ranged from 0.41 to 0.69 for measurements of PA level, whereas the intra-school correlation coefficient ranged from 0.06 to 0.14. With the above data structure, the study was able to detect a standardized coefficient ranged from 0.78 to 1.10 with 80% power.

Statistical analysis

Descriptive statistics of demographic characteristics and key variables related to school activities were generated for all participating students pooled and separated by school. These student characteristics were compared between the four schools using chi-square test for categorical variables and analysis of variance (ANOVA) for continuous variables. Bivariate associations between participant demographic and clinical characteristics and PA levels were evaluated by generalized linear mixed model (GLMM) to adjust for within-cluster correlations at two different levels of student and school. Unstructured correlation matrices were assumed for the within-cluster correlations in the GLMM analyses.

Multivariable GLMMs accounting for clustering due to school and student were fitted to identify variables predictive of PA levels among age, gender, BMI status, asthma status, PE class, outdoor recess, and other in-school PA. Analyses adjusted for school and duration of school day to account for potential confounding. As the test of potential interaction between asthma status and age, gender, or BMI status was not statistically significant in our sample, we did not include any interaction terms in our multivariable models. PA levels were not normally distributed, so a log transformation was applied. Results were converted back into anti-log scales and reported as a ratio of PA levels, which can be represented as a percent change in PA levels for ease of interpretation. p -value 0.05 was considered statistically significant. Data were analyzed using SAS software (version 9.4; SAS Institute, Inc, Cary, NC).

Results

Sample characteristics

A total of 108 students from second to fourth grades in four elementary schools participated (mean age 9.01 years (SD = 1.04), 52.78% were male, 81.91% were Hispanic, and 57.94% were overweight/obese). Duration of asthma diagnosis and BMI distribution differed between the four schools. During the assessment period (4–6 school days), PE classes, outdoor recess, and other in-school PA were offered on about 18.94%, 15.85%, and 27.69% of those days, respectively. Students in the lower grades were offered slightly more PE classes than students in the higher grades during the assessment period (24.49% of those days for second grader, 18.58% for third grader, and 15.53% for fourth grader); however, the difference was not statistically significant ($p = 0.2622$). Students spent an average of 374.22 minutes (6.24 hours) in school of which 252.15 (SD = 37.02) minutes were sedentary, 105.39 (SD = 30.97) minutes in LPA, and 16.68 (SD = 8.04) minutes in MVPA (Table 1). Only 3 (2.78%) of participants reached 30 minutes of MVPA a day.

While the proportion of days that PE classes were offered was generally low, School 4 had significantly less PE classes compared to the other three schools. Schools 2 and 4 had no outdoor recess; however, School 2 had significantly higher proportion of days with other in-school PA. Students in School 4 spent significantly less time in LPA and those in School 3 had significantly higher step counts.

Accelerometer-determined PA

Tables 2 and 3 show the comparisons of PA by school, gender, BMI, asthma status, PE class, outdoor recess, and other in-school PA participation, and age. LPA levels and step count were significantly different among four schools. Students in School 3 spent more time in LPA and had a greater mean number of steps than those in other schools. Boys displayed significantly less time sedentary and more time in LPA and MVPA with a greater number of steps, compared to girls. Obese students spent more time sedentary and were less physically active than their normal-weight/underweight or overweight counterparts, but this difference was not statistically significant. Asthma status was not significantly associated with PA. Students who attended PE class and participated in other in-school PA spent significantly less time sedentary and more time in LPA and MVPA with more steps, compared to those without the corresponding activities. Students who had outdoor recess spent significantly more time in MVPA and had a greater mean number of steps than those who did not (Table 2).

Older age was associated with higher sedentary behavior, while younger age was associated with higher LPA, MVPA, and step counts (Table 3). Age was significantly associated with PE class participation but not with outdoor recess or other in-school PA (Table 3).

Multivariable analysis

Multivariable analysis using multi-level hierarchical model revealed the following variables as independent predictors of all PA outcome variables: age, gender, participation in PE class, and other in-school PA. Outdoor recess was a predictor of MVPA and step count (Table 4).

Older students were significantly less physically active than their younger counterparts. Specifically, older students spent 5% more time sedentary, 10% less time in LPA, 9% less time in MVPA and took 7% fewer steps, than their 1-year younger peers, while adjusting for other factors in the models. Boys were significantly more physically active than girls. Compared to girls with the same characteristics (age, BMI, asthma status, and PA opportunity), boys spent 6% less time sedentary, 16% and 25% more time in LPA and MVPA, respectively, and accumulated 10% more steps.

Participation in PE class, outdoor recess, and other in-school PA was significantly associated with lower sedentary activity and higher LPA, MVPA, and step counts during school day. Students who attended PE class and other in-school PA displayed 6% and 5% lower sedentary activity, 8% and 10% higher LPA, 80% and 42% higher MVPA, and took 42% and 19% more steps, respectively, compared to students who did not attend these activities. In addition, students who had outdoor recess spent 38% more time in MVPA and took 20% more steps. BMI and asthma status were not associated with PA.

Discussion

Our findings revealed that urban, minority students with asthma spent over half of their school day being sedentary (67.38%), nearly one-third of their school day undertaking LPA (28.16%), and only 4.46% in MVPA. Age, gender, participation in PE class, outdoor recess, and other in-school PA were found to be independent predictors of school-time PA. To our knowledge, this study is the first to assess objectively measured school-time PA levels and determine predictors of PA in urban, minority US students with asthma. Identifying factors associated with school-time PA in children with asthma would allow tailoring in-school PA interventions and informing policies for promoting PA in this population.

Older students were less physically active due to younger children having more PE classes. Our results support prior studies revealing that PA levels decline as children get older [16, 28]. As shown in Table 3, the magnitude of change per one unit increase in age (i.e., the regression coefficient) was similar across all PA variables. However, we did not observe statistically significant association of some PA variables (such as outdoor recess and other in-school PA) with age. This may be explained by the lack of statistical power as these two variables had greater standard errors for their corresponding regression coefficients compared to standard errors of the other PA variables (such as LPA, MVPA, step counts). Similar to our findings, accelerometer-determined PA literature indicates that in healthy children, boys are more physically active than girls [28–30].

In our earlier work assessing pedometer-determined PA during school in healthy kindergarten and first graders, participation in PE class and outdoor recess was found as independent predictors of school-time PA [19]. Our current study of children with asthma found similar results. Several programs, such as Action for Healthy Kids [31] and Spark [32], provide opportunities for children to engage in PA during outdoor recess. However, the use of these programs is limited by inclement weather, lack of staff training, and availability to provide supervision. Students who participated in other in-school PA (e.g., Mighty Milers program [26], dance classes, classroom activity breaks) had significantly higher levels of PA than students who did not participate. In spite of built environment constraints in urban low-resource schools, providing such programs may be a creative and effective way to get all children, including children with asthma, more active.

We found significant differences in step counts among four schools. Students attending School 3 had greater number of steps than the other schools. This could be because School 3, the largest of four schools in student enrollment, occupied a building with several floors and students had to walk longer distances to get to classrooms or other areas within the school.

Several studies described school-time PA of healthy children with MVPA ranging between 28.3 and 69.3 minutes, which are higher than what was observed in our study [29, 33, 34]. One study of primarily White third to fifth grade healthy students revealed similar to our study's school-time MVPA of 18.1 minutes [30]. Literature on association between PA and weight status has been inconsistent. Some studies reported that overweight healthy children spent significantly less time in MVPA than normal-weight children [30, 35]. Studies of

younger children, including our prior research, showed that PA did not differ by BMI status [19, 36]. In this study, while overweight/obese students with asthma were more sedentary and less physically active than non-overweight students, this difference was not statistically significant.

Surprisingly, asthma status was not associated with PA. This finding could be explained by several factors. School-time mean minutes of LPA, MVPA, and mean step counts were similar among three asthma subgroups indicating that this population of urban, minority children with asthma had low overall school-time PA levels. Unmeasured factors, including children and parents' perception of asthma as a barrier to PA, fears about the effects of exercise on asthma, suboptimal management of asthma in schools, and knowledge and attitudes of school personnel may preclude student participation in PA and could mediate or confound the association between asthma status and PA. Effects of these factors on PA should be evaluated in future studies. Finally, asthma-related impairment assessed by caregiver self-report has a potential for over-or under-reporting of child's asthma symptom frequency biasing the association toward the null.

Since children spend many hours in school, schools are well positioned to provide PA opportunities to contribute to children meeting the 60 minute/day MVPA guideline [37]. The recommendation for elementary schools is to provide children with 30 minute/day of MVPA through PE, recess, and other opportunities [15]. Only 2.78% of our recruited students met this criterion. Many public schools in low-income communities, such as the Bronx, are not meeting this recommendation due to overcrowding, lack of resources, and physical space for PA.

Our study had several limitations. First, this study was conducted in urban low-income public elementary schools in the Bronx, NY; thus, the conclusions may not be generalizable to schools in other communities. Second, while travel to and from school and out of school activity could contribute considerably to a child's overall PA, accelerometer data were analyzed only during school hours as the purpose of the study was to identify modifiable school-based factors that could be considered in development of a school-time intervention to increase PA in children with asthma. Therefore, conclusions from this study cannot be drawn regarding the overall PA of children with asthma. Third, we surveyed most caregivers to determine child's asthma recent impairment after the child began wearing the accelerometer with a wide range of days between the two assessments. The time discrepancy between the accelerometer data collection and the caregiver survey may have contributed to measurement error due to recall difficulty. Asthma severity was not measured objectively using spirometry or validated child-Asthma Control Test (c-ACT) [38]. We used questions based on the national asthma guidelines, a method widely used in clinical practice, to assess asthma severity of participants. Fourth, other factors such as child's motivation and confidence, family's encouragement, and teaching staff's attitudes may affect PA of children with asthma. These factors should be considered in analyses of future studies. Finally, the present study is a cross-sectional analysis and no definitive conclusions can be made on causation or direction of associations.

Conclusions

In conclusion, students with asthma in our study were mostly sedentary or engaged in LPA at school. Age, gender, participation in PE class, outdoor recess, and other in-school PA were found as independent predictors of school-time PA. Promoting participation in PE, outdoor recess, and other in-school PA may be important components of future school-based interventions aimed at increasing PA in children with asthma.

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Abbreviations

PA	physical activity
PE	physical education
LPA	light physical activity
MVPA	moderate-to-vigorous physical activity
BMI	body mass index

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Table 1

Characteristics of study participants^a.

Characteristics	Total (N = 108)	School 1 (N = 28)	School 2 (N = 21)	School 3 (N = 31)	School 4 (N = 28)	p-value ^f
Child age, years [mean (SD)]	9.01 (1.04)	8.74(1.05)	9.13(1.06)	8.87 (1.12)	9.33 (0.83)	0.1391
Male	57 (52.78)	13 (46.43)	13 (61.90)	18 (58.06)	13 (46.43)	0.5817
Ethnicity ^b						0.1569
Hispanic	86 (81.91)	25 (92.59)	15 (71.43)	26 (86.67)	20 (74.07)	
Non-Hispanic	19 (18.09)	2 (7.41)	6 (28.57)	4 (13.33)	7 (25.93)	
Race ^b						0.2767
African-American	30 (28.57)	4 (14.81)	10 (47.62)	9 (30.00)	7 (25.93)	
White	13 (12.38)	3 (14.11)	3 (14.29)	3 (10.00)	4 (14.81)	
Unspecified	62 (59.05)	20 (74.07)	8 (38.10)	18 (60.00)	16 (59.26)	
Duration of asthma diagnosis, years [mean (SD)]	6.40 (2.30)	5.54 (2.09)	6.04 (2.73)	6.74 (1.95)	7.14 (2.28)	0.0491
Medicaid ^b	90 (85.72)	24 (85.71)	17 (80.95)	28 (90.32)	21 (75.00)	0.4419
BMI ^c						0.0089
Normal/underweight	45 (42.06)	13 (46.43)	3 (14.29)	20 (64.52)	9 (33.33)	
Overweight	27 (25.23)	8 (28.57)	8 (38.10)	6 (19.35)	5 (18.52)	
Obese	35 (32.71)	7 (25.00)	10 (47.62)	5 (16.13)	13 (48.15)	
Asthma Status ^b						0.3337
Mild	25 (23.81)	7 (25.93)	8 (38.10)	4 (13.33)	6 (22.22)	
Moderate	52 (49.52)	15 (55.56)	9 (42.86)	14 (46.67)	14 (51.85)	
Severe	28 (26.67)	5 (18.52)	4 (19.05)	12 (40.00)	7 (25.93)	
PE class [mean (SD)] ^d	0.19 (0.18)	0.25 (0.14)	0.20 (0.12)	0.28 (0.21)	0.03 (0.10)	<0.0001
Outdoor recess [mean (SD)] ^d	0.16 (0.24)	0.29 (0.20)	0.00 (0.00)	0.31 (0.30)	0.00 (0.00)	<0.0001
Other in-school PA (Mean (SD)) ^d	0.29 (0.32)	0.29 (0.28)	0.54 (0.41)	0.15 (0.22)	0.24 (0.28)	0.0001
Time in activities, minutes (Mean (SD)) ^a						
Sedentary, minutes	252.15 (37.02)	245.68 (38.11)	251.33(38.07)	244.40 (37.01)	267.82 (31.86)	0.0623
LPA, minutes	105.39 (30.97)	109.94 (32.51)	104.14(31.75)	116.89 (30.35)	8.04 (22.86)	0.0042
MVPA, minutes	16.68 (8.04)	16.39 (5.84)	15.71 (7.80)	19.21 (8.77)	14.92 (8.94)	0.1897

Characteristics	Total (N = 108)	School 1 (N = 28)	School 2 (N =21)	School 3 (N = 31)	School 4 (N = 28)	p-value ^f
Steps counts [mean (SD)] ^a	3141.80 (1011.98)	3138.65 (803.39)	2846.82 (983.96)	3566.16 (987.17)	2896.37 (1129.67)	0.0286

SD, standard deviation; BMI, body mass index; PE, physical education class; PA, physical activity; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.

^aData presented as N (%) unless otherwise specified. Data presented by subjects and by data observations per each school.

^bData available on 105 participants.

^cData available on 107 participants.

^dMean proportion of the days that PE classes, outdoor recess, or other in-school PA were offered during the assessment period.

^eNumber of data used to obtain mean (SD)were 549 generated by 108 participants.

^fp-values of chi-square test for categorical variables and of ANOVA for continuous variables.

Table 2

Generalized linear mixed model (GLMM) examining bivariate associations between participant demographic and clinical characteristics and physical activity levels.

Characteristics	Sedentary				LPA				Total MVPA				Steps Counts			
	Mean ^a	SD	MD ^b	p	Mean ^a	SD	MD ^b	p	Mean ^a	SD	MD ^b	p	Mean ^a	SD	MD ^b	p
School ^c				0.0540				0.0062				0.1685				.0089
1	245.09	42.85	-23.60		110.26	36.50	22.06		16.45	9.06	1.77		3142.14	1196.73	272.50	
2	251.81	47.74	-16.88		103.54	37.01	15.34		15.81	9.70	1.13		2853.13	1173.54	-16.51	
3	245.11	45.12	-23.58		116.38	34.13	28.18		19.09	11.84	4.41		3545.91	1341.03	676.27	
4	268.69	38.35	Ref		88.20	26.90	Ref		14.68	9.58	Ref		2869.64	1186.01	Ref	
Gender				0.0025				0.0024				0.0002				.0067
Female	264.10	43.41	21.78		96.38	35.97	-16.25		13.71	7.38	-5.52		2860.86	1018.47	-512.49	
Male	242.32	42.83	Ref		112.63	32.88	Ref		19.23	11.75	Ref		3373.35	1404.90	Ref	
BMI				0.5626				0.7009				0.2726				.5453
Normal/underweight	251.30	46.22	-7.25		106.96	37.08	7.13		17.32	11.56	2.44		3195.57	1369.13	216.64	
Overweight	246.54	42.70	-12.10		108.47	35.02	8.64		17.88	9.61	3.00		3235.22	1172.73	256.29	
Obese	258.55	43.25	Ref		99.83	32.99	Ref		14.88	8.92	Ref		2978.93	1193.49	Ref	
Asthma status				0.8624				0.9965				0.5089				0.3800
Mild	253.45	42.60	-1.07		102.54	33.94	-1.66		15.60	9.65	-0.11		2946.57	1139.44	-70.54	
Moderate	251.53	47.18	-2.99		105.97	37.91	1.77		17.71	11.31	2.00		3286.56	1395.70	269.45	
Severe	254.52	40.28	Ref		104.20	31.22	Ref		15.71	8.64	Ref		3017.11	1049.26	Ref	
PE class				< 0.0001				0.0187				< 0.0001				< 0.0001
Yes	233.79	39.67	-22.99		113.79	31.02	10.69		25.55	12.05	11.04		4228.47	1471.54	1348.87	
No	256.78	44.55	Ref		103.10	36.06	Ref		14.51	8.66	Ref		2879.60	1067.01	Ref	
Outdoor recess				0.9593				0.2049				< 0.0001				< 0.0001
Yes	243.40	42.32	-10.69		114.33	34.94	10.94		21.42	11.16	5.69		3853.17	1287.30	853.45	
No	254.09	44.75	Ref		103.39	35.28	Ref		15.73	9.97	Ref		2999.72	1225.87	Ref	
Other in-school PA				0.0291				0.0007				< 0.0001				0.0008
Yes	237.44	44.14	-20.42		116.48	35.68	15.61		20.01	10.76	4.57		3435.45	1374.33	395.55	
No	257.86	43.28	Ref		100.87	34.24	Ref		15.44	9.96	Ref		3039.90	1210.19	Ref	

BMI, body mass index; PE, physical education; PA, physical activity; LPA, light physical activity; MVPA, moderate-to-vigorous physical activity.

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μ Unadjusted means.

η Unadjusted mean difference.

γ Number of participants by school: School 1 = 28; School 2 = 21; School 3 = 31, School 4 = 28; Number of data observations by school: School 1 = 139; School 2 = 107; school 3 = 160; School 4 = 143.

Table 3

Generalized linear mixed model (GLMM) examining variables associated with age.

Variables	b *	SE	<i>p</i> -value
Sedentary	0.0576	0.0133	< 0.0001
LPA	– 0.1146	0.0273	< 0.0001
MVPA	– 0.1331	0.0416	0.0015
Step counts	– 0.0943	0.0264	0.0004
PE class participation	– 0.2416	0.1096	0.0280
Outdoor recess	– 0.1097	0.1571	0.4853
Other school PA	– 0.1238	0.1617	0.4444

*
b is the regression coefficient corresponding to age in GLMM.

LPA, light physical activity; MVPA, moderate-to-vigorous physical activity; PE, physical education; PA, physical activity.

Table 4

Multivariable analysis of physical activity in elementary school students with asthma.

Variable	Level	Physical activity									
		Sedentary			LPA			MVPA			Steps counts
		Estimate ^a	CI ^a	p-value	Estimate ^a	CI ^a	p-value	Estimate ^a	CI ^a	p-value	p-value
Age		1.05	(1.03, 1.08)	<0.0001	0.90	(0.86, 0.95)	0.0002	0.91	(0.84, 0.98)	0.0087	0.0014
Gender (Ref: female)	Male	0.94	(0.89, 0.99)	0.0113	1.16	(1.04, 1.29)	0.0057	1.25	(1.08, 1.46)	0.0031	0.0438
Asthma status (Ref: mild)	Moderate	0.96	(0.91, 1.03)	0.2404	1.04	(0.91, 1.19)	0.5303	1.14	(0.95, 1.38)	0.1584	0.1774
	Severe	1.01	(0.94, 1.08)	0.8246	1.00	(0.86, 1.17)	0.9786	1.03	(0.83, 1.28)	0.7981	0.7737
BMI (Ref: normal/underweight)	Obese	1.01	(0.95, 1.08)	0.6576	1.02	(0.89, 1.16)	0.7989	0.98	(0.81, 1.18)	0.8347	0.5981
	Overweight	0.99	(0.93, 1.05)	0.6707	1.06	(0.93, 1.22)	0.3805	1.12	(0.93, 1.36)	0.2325	0.2192
PE class		0.94	(0.92, 0.96)	<0.0001	1.08	(1.02, 1.13)	0.0033	1.80	(1.65, 1.98)	<0.0001	<0.0001
Outdoor recess		0.98	(0.96, 1.01)	0.2564	1.03	(0.97, 1.09)	0.3974	1.38	(1.23, 1.54)	<0.0001	<0.0001
Other school PA		0.95	(0.93, 0.97)	<0.0001	1.10	(1.04, 1.16)	0.0004	1.42	(1.29, 1.56)	<0.0001	<0.0001

LPA, light physical activity; MVPA, moderate-to-vigorous physical activity; BMI, body mass index; PE, physical education; PA, physical activity; school and duration of school day were also included in the model to adjust for potential confounding.

^aRatio of times spent in each activity by one-unit change of continuous variable or one-level change of categorical variable.

^bRatio of step counts by one-unit change of continuous variable or one-level change of categorical variable.