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Physical Activity and Anthropometric Characteristics Among Urban Youth in Mexico: A Cross-Sectional Study

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Abstract

Background: Obesity is a critical problem among Mexican youth, but few studies have investigated associations among physical activity (PA) modes and anthropometries in this population. This study examined associations among active commuting to school (ACS), sports or other organized PA, outdoor play, and body mass index (BMI) percentile and waist circumference (WC) among Mexican youth.

Methods: Parents of school children (N = 1996, ages 6 to 14 years, 53.1% female) in 3 Mexican cities reported PA participation using the (modified) fourth grade School Physical Activity and Nutrition Survey. Trained assessors measured BMI percentile and WC in person.

Results: Parents reported that 52.3% of children engaged in ACS, 57.3% participated in sports or organized PA, and a median of 2 days in the previous week with at least 30 minutes of outdoor play. In complete case analyses (n = 857), ACS was negatively associated with BMI percentile, and outdoor play was negatively associated with WC after adjusting for school, age, sex, and income. In analyses incorporating data from multiple imputation (N = 1996), outdoor play was negatively associated with WC (all *P*s < . 05).

Conclusions: ACS and outdoor play are favorably associated with anthropometries and may help prevent childhood obesity in Mexico. ACS and outdoor play should be priorities for increasing youth PA in Mexico.

Keywords

active commuting to school; sports; outdoor play; body mass index; waist circumference

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Low physical activity (PA) contributes to high childhood obesity in Mexico, with overweight and obesity prevalence currently exceeding 34% in children between ages 5 to 11 years.[1,2] Physical inactivity and obesity among youth constitute persistent public health threats in Mexico.[3] The country already has the world's highest rates of adult overweight and obesity,[4] and cardiovascular disease and diabetes are the top causes of adult mortality.[5] Physical inactivity among youth is recognized as an international health challenge, and it is a critical challenge in Mexico.[2] A 2014 review using the Report Card on Physical Activity for Children and Youth in Mexico found that PA was insufficient, and sedentary behavior exceeded international recommendations.[6]

Regularly performed PA is associated with the development of favorable anthropometric characteristics among youth. Studies in the United States and Canada have shown cross-sectional and longitudinal relationships between active commuting to school (ACS) and reduced obesity.[7,8] Nearly 70% of children and adolescents walk or bicycle to school in Mexico,[2,9,10] and, among adolescents, each additional minute spent commuting actively reduced odds of overweight or obesity by 1%.[9] Due to the lack of research in this area, it is unclear whether ACS is associated with lower obesity among younger children in Mexico.

Participation in organized sports has been linked to lower body mass index (BMI), reduced likelihood of overweight and obesity, and healthier body composition among US and Canadian youth.[11,12] Data from the 2012 Encuesta Nacional de Salud y Nutrición (National Survey of Health and Nutrition) in Mexico reported that 41% of children between the ages of 10 to 14 years participated in at least 1 organized sport in the previous year.[2,6] It is important to investigate relationships between participation in sports and obesity among Mexican youth.

In addition to ACS and sports participation, outdoor play has been identified as an important strategy to increase PA and promote healthy body weight.[13] A recent study in Mexico estimated that urban youth accumulate only 11.7 minutes of PA during unstructured recess time at school each day.[14] Therefore, recess may actually provide little PA, and time spent playing outside beyond the school day may be particularly important for increasing PA. It is unclear whether outdoor play is associated with lower obesity among Mexican children.

Studies examining PA and obesity among Mexican youth have generally included only BMI as the primary outcome.[9,15,16] Although BMI is generally accepted as a reliable estimate of overweight or obesity status among children,[17] it does not quantify adiposity centralized in the abdominal region. Central adiposity in childhood is a dangerous health risk factor for developing metabolic syndrome,[18] and it may be increasing more rapidly than BMI in high-income countries.[19] Central adiposity may be particularly harmful to children and is associated with less favorable health outcomes, such as elevated blood pressure and unhealthy cardiac hypertrophy.[20] Few studies among Mexican youth have examined relationships between PA and measures of central adiposity, such as waist circumference (WC).[21,22] This is important because Mexico is at a high risk of burden from chronic diseases related to excess central adiposity such as cardiovascular disease and diabetes.[23,24]

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Taken together, the existing research investigating associations between PA and obesity in youth in Mexico is scant and hampered by an incomplete measurement of obesity. The current study helps to close this gap by determining how ACS, participation in sports or other organized activities, and outdoor play are associated with age- and sex-specific BMI percentile and WC among urban youth in Mexico. We hypothesized that ACS, participation in sports and organized PAs, and days with at least 30 minutes of outdoor play in the previous week would be associated negatively with age- and sex-specific BMI percentile and WC among urban youth in Mexico.

Methods

Participants and Schools

Mexican school children (N = 1996) participated in a multisite investigation of neighborhood and health in children in schools in Guadalajara (n = 904), Mexico City (n = 867), and Puerto Vallarta (n = 225) in 2012. Inclusion criteria required that children be ambulatory and apparently healthy, currently enrolled in grades 3 through 5, and present in school on the day on which measurements were conducted. Informed consent was completed by parents and returned with children to school. Researchers also obtained assent from students to ensure understanding of the study before enrolling. All study procedures and protocols were approved by the appropriate institutional review boards at the Instituto Nacional de Salud Publica de México (National Public Health Institute of Mexico), Queen's University, Universidad de Guadalajara, and University of Houston.

The Secretaría de Educatión Jalisco (Department of Education for the State of Jalisco, Mexico) selected schools in Guadalajara (n = 11) and Puerto Vallarta (n = 7). Schools in Mexico City (n = 14) were selected based on inclusion in a previous study of obesity-related policies in México.[25] Schools were selected to be at least 1600 m apart to enhance geographic variability. Study procedures have been described previously.[26]

Measures

Demographic Characteristics.—A modified version of the fourth grade School Physical Activity and Nutrition (SPAN) survey was used to measure demographic characteristics. Surveys were distributed to parents for completion. The SPAN survey is a reliable surveillance instrument used to measure demographic information, nutrition attitudes, PA, and food behaviors in children.[27] The survey, including the questions used in the current study, was adapted and pilot tested in Spanish for a Mexican audience. Face validity was ensured using translation and back-translation and a final content and readability review by native Mexican Spanish speakers. Items measuring demographic characteristics in the modified survey included child's age (continuous variable), sex, and annual household income (ordinal variable with 8 possible values ranging from "less than $5000" to "$30,000 or more" US dollars [USD]).

PA.—SPAN items measuring PA included questions about mode of transport to school ("On most days, how does your child get to school?" with response options of "walk," "school bus," "family car with only your family," "bike," "city bus," and "carpool with children from other families”), sports team participation (“During the past 12 months, on how many sports teams did your child play?” with response options ranging from 0 to 3 or more sports teams), other organized PA (“Does your child currently take part in any other organized physical activities or take lessons, such as martial arts, dance, gymnastics, soccer, baseball, or tennis?” with a yes/no response option), and outdoor play (“Last week, on which days did your child play outdoors for 30 minutes or more?” with response options including “none” and each possible weekday).[27] Participation on sports teams and participation in other organized PA were distinct items on the survey. The former included playing on a team (ie, in practices and games), and the latter included taking lessons or receiving instruction (ie, outside of playing in practices and games) for individual or team sports.

Anthropometric Characteristics.—Anthropometric characteristics were measured in a private location at each school by trained research assistants. Height (standing, in cm) was measured with a stadiometer (capacity of 2 m, accurate to 1 mm; SECA North America, Chino, CA); weight (in kg) was measured with a portable electronic scale (Tanita TBF-300A; Tanita Corporation of America, Inc, Arlington Heights, IL). BMI percentile was calculated using the standard formula derived from measured height and weight, adjusted for age and sex.[28] WC was measured with a standard anthropometric tape following the Anthropometry Procedures Manual for the National Health and Nutrition Examination Survey (NHANES) 2000 for children more than 8 years old.[29] Codes identifying participants’ schools were recorded on all data forms so that analyses could account for the nesting effect of children within schools.

Analyses

For purposes of analyses, responses regarding transport to school were collapsed into a binary variable (nonactive transport vs. active transport). Participation on sports teams and participation in organized PAs in the previous year were combined to form a single binary variable (yes/no). Days with at least 30 minutes of outdoor play in the previous week were summed to create a continuous variable with a range of 0 to 7. Due to low frequencies in the higher categories of the original variable, the 8 potential categories for annual household income were collapsed into 3 categories (less than $5000, $5000–$9999.99, and $10,000 or more in USD) to better distribute income levels across the sample. Descriptive statistics were run for covariates and independent variables (means and SDs or frequencies and percentages when appropriate) and for dependent variables (means and SDs).

Bivariate analyses were used to examine relationships between covariates (age, sex, and household income), independent variables (transport to school, sports teams or organized PAs, and outdoor play), and dependent variables (BMI percentile and WC). Pearson bivariate correlations were used to examine associations between pairs of continuous variables (ie, age, outdoor play, BMI percentile, and WC). One-way analysis of variances (ANOVAs) were used to examine associations between pairs with 1 categorical variable and 1 continuous variable (ie, sex, household income, ACS, sports teams, and organized PAs vs. BMI percentile, WC, age, and outdoor play). We used χ^2 tests to examine associations between pairs of categorical variables (eg, sex, household income, ACS, participation in sports or other organized PAs). Bivariate associations were considered significant at $P <$

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.05. All assumptions for bivariate tests were checked before the analyses. Dummy codes (reported vs. missing) were created for each variable, and 1-way ANOVAs or χ^2 tests were used to examine associations between the degree of missing data for each analytic variable and all other variables.[30]

To evaluate the possible biasing effects of missing data on study conclusions, 2 sets of hierarchical linear regression models, controlling for the nesting of children within schools,[31] were used to examine relationships between PA variables (ACS, participation in sports or other organized PAs, and outdoor play) and the 2 separate anthropometric characteristics (BMI percentile and WC). The first set of models involved complete case analysis, and the second set of models involved multiple imputation using all analytic variables under the assumption that data were missing at random.[32–34] Five imputed datasets were created,[35] with linear regression analyses based on pooled estimates. Due to the binary nature and non-normal distributions of some study variables, descriptive statistics from pooled estimates from the multiple imputation datasets were screened to ensure they approximated the data from complete case analyses. The individual-level covariates included in both sets of models (age, sex, and household income) were selected based on evidence of correlation with independent or dependent variables in bivariate analyses. All assumptions for linear regression were checked before analyses. Differences between unadjusted means and proportions and the regression model estimates were considered significant at $P < .05$. All analyses were performed in SPSS version 22 (IBM Corporation, New York, NY), with multiple imputation modeling performed using the standard Impute Missing Data Values procedure included in this package.

Results

Participant Characteristics

Table 1 shows sociodemographic, PA, and anthropometric characteristics for both analytic samples. Based on reported data, the mean age of study participants was 9.6 years old (SD =1.1). More than one-half of participants were female (53.1%) and had parent-reported annual household income less than $5000 (US) (50.3%). More than one-half of participants engaged in ACS on most days (52.3%), and more than one-half of participants participated in at least 1 organized sport or other PA in the previous year (57.3%). The median number of days in the previous week on which children played outside for at least 30 minutes was 2 (interquartile range = 3). Nearly one-quarter (23.7%) of participants' parents reported that they had 0 days with at least 30 minutes of outdoor play in the previous week, and nearly three-quarters (74.1%) reported 3 or fewer days. The mean age- and sex-specific BMI percentile among participants was 68.2 (SD = 29.2), and the mean WC was 67.7 cm (SD = 12.4).

With multiple imputation to account for missing data, the mean age of study participants remained 9.6 years old. The percentage of female participants increased (53.7%), and the percentage with parent-reported annual household income less than $5,000 (USD) decreased (49.0%). A smaller percentage of participants engaged in ACS on most days (52.2%), and a smaller percentage of participants participated in at least 1 organized sport or other PA in the previous year (56.2%). The median number of days with at least 30 minutes of outdoor play

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in the previous week remained 2. The mean age- and sex-specific BMI percentile among participants decreased to 67.7, and the mean WC increased to 67.8 cm. Distributions of pooled estimates were compared with the original distributions to ensure plausibility, and paired *t* tests and χ^2tests revealed no significant differences between the original, observed data, and pooled estimates (all $P > .05$).

Bivariate Correlations

Age and WC were positively correlated ($r = 0.14$, $P < .01$). Boys reported more days of outdoor play (2.6 days vs. 2.1 days, $F = 19.1$, $P < .01$) and higher levels of participation in sports or organized PAs than girls (61.2% vs. 50.2%, $\chi^2 = 18.7$, $P < .01$) as previously reported.[36] The proportion of children commuting actively to school decreased (65.7% vs. 51.4% vs. 39.4%, $\chi^2 = 42.9$, $P < .01$) with increasing categories of household income (less than $5,000, $5,000–$9,999.99, and $10,000 or more, respectively), as previously reported.[26] The proportion of children participating on sports teams or organized PAs decreased (50.1%, 42.0%, and 40.7%, respectively, $\chi^2 = 7.6$, $P < .05$) with the same increasing categories of household income.

Missing Data

For sex and age, there were no significant differences between children with and without reported values for any of the other study variables. Children with reported income were, on average, younger (9.6 vs. 9.7 years), more likely to engage in ACS (56% vs. 46%), and less likely to participate in sports or other organized PAs (53% vs. 61%) compared with children without reported income (all $P < .05$). Children with reported mode of transport to school played outside for at least 30 minutes on more days in the previous week (2.4 days vs. 1.7 days) compared with children without reported mode of transport to school ($P < .05$). Children with reported participation in sports or other organized PA were less likely to engage in ACS (49% vs. 59%), but played outside for at least 30 minutes on more days in the previous week (2.7 days vs. 1.9 days) compared with children without reported participation in sports or other organized PA (both $P < .05$). There were no significant differences between children with and without reported outdoor play in the previous week. Children with measured BMI percentile were, on average, younger (9.6 years vs. 9.7 years), less likely to participate in a sport or other organized PA (50% vs. 72%), and played outside for at least 30 minutes on fewer days in the previous week (2.3 days vs. 2.6 days) compared with children without measured BMI percentile (all $P < .05$). Children with measured WC were, on average, younger (9.6 years vs. 9.8 years), less likely to participate in a sport or other organized PA (51% vs. 72%), and played outside for at least 30 minutes on fewer days in the previous week (2.3 days vs. 2.6 days) compared with children without measured WC (all $P < .05$).

Multivariate Models

Table 2 presents hierarchical linear regression models measuring the effects of different modes of PA on anthropometric characteristics among children in the study. There was a significant negative association between transport to school (0 = inactive transport, 1 = active transport) and age- and sex-specific BMI percentile after adjusting for school, age, sex, and household income in the model incorporating only reported data (eg, without

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multiple imputation). ACS was associated with a 5.02% reduction in age- and sex-specific BMI percentile. The negative association between transport to school and age- and sex-specific BMI percentile was not statistically significant in the model incorporating data from multiple imputation. There were no statistically significant associations between participation on sports teams or other organized PAs or days of outdoor play and age- and sex-specific BMI percentile after adjusting for school, age, sex, and household income in the models incorporating only reported data or in those incorporating data from multiple imputation. However, the relationship between days of outdoor play and BMI percentile approached significance ($P = .06$) in the models incorporating data from multiple imputation, with each additional day of outdoor play in the previous week associated with a 0.67% reduction in age- and sex-specific BMI percentile.

There were significant negative associations between days of outdoor play and WC after adjusting for school, age, sex, and annual household income in both sets of models. In the model incorporating only reported data, spending at least 30 minutes playing outside on 1 additional day in the previous week was associated with a reduction of 0.39 cm in WC. In the model incorporating data from multiple imputation, spending at least 30 minutes playing outside on 1 additional day in the previous week was associated with a reduction of 0.35 cm in WC. There were no significant associations between ACS or participation on sports teams or other organized PAs and WC after adjusting for school, age, sex, and household income in either set of models.

Discussion

This study examined the associations between participation in different modes of PA and anthropometric characteristics, including both age- and sex-specific BMI percentile and WC, among urban Mexican youth. We found some support for our hypotheses, as ACS was negatively associated with BMI percentile in complete case analyses, and outdoor play was negatively associated with WC in complete case and multiple imputation analyses after controlling for school, age, sex, and household income. ACS and outdoor play may provide viable strategies for increasing PA and preventing obesity among Mexican youth. These findings are consistent with other studies showing that ACS helps prevent obesity among children in Canada and the United States.[8,37] Further, findings regarding outdoor play are consistent with current recommendations to combat childhood obesity with unstructured play.[13] In other populations, more unstructured outdoor play has been associated higher moderate-to-vigorous PA and lower BMI.[38]

The different relationships between PA modes and anthropometries may result from the dose or intensity that different PA modes provide. The findings in this study suggest that both ACS and outdoor play provide PA that aids healthy weight maintenance. In complete case analyses, engaging in ACS was associated with substantially lower age- and sex-adjusted BMI percentile compared with children who did not engage in ACS. However, this relationship was no longer statistically significant in models incorporating data from multiple imputation. In addition, outdoor play, and not ACS, was associated with lower WC. Effect sizes were small, but this suggests that outdoor play may encourage higher intensity PA to help prevent excess abdominal adiposity, which would be consistent with previous

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studies showing that vigorous PA was a stronger predictor of lower obesity compared with moderate PA among European youth.[39] Previous interventions involving children in the United States[40] and Mexico[22] have demonstrated that WC may be a more robust measure than BMI or age- and sex-specific BMI percentile to examine changes in anthropometries with PA. Future studies involving PA among Mexican children should include objective PA measurement to determine whether the intensities of PA performed in different modes are related to abdominal adiposity.

The favorable relationships reported between ACS, outdoor play, and obesity suggest that these may be important strategies for increasing PA among Mexican children. ACS and outdoor play are free and convenient, and they can easily be woven into children's daily routines. Studies in the United States[41] and Canada[42] have demonstrated associations between parents' perceptions of neighborhood safety and deprivation and ACS among children. ACS was negatively associated with household income among children in this study, suggesting that socioeconomic circumstances (eg, low vehicle ownership) and school system infrastructure (eg, lack of school buses) require that many children in urban Mexico reach school actively.[26] Policies improving routes to school may not only improve safety for children who need to commute actively, but also may encourage ACS among families with alternative means of transportation. Measures to calm traffic and improve pedestrian safety in neighborhood streets may also help encourage outdoor play, especially for children living in multifamily housing or apartment complexes that have limited yard space, which is quite common in Mexico.[43] Important socioecological influences on ACS and outdoor play should be considered in future studies or interventions targeting these PA modes.

Proxy report of children's PA is preferable to self-report for young children who are unable to report their own PA accurately or reliably.[44,45] However, the lack of objective PA measurement is a limitation in this study, and future studies should measure PA among Mexican youth objectively, such as with accelerometers. In addition, future studies should validate the modified SPAN questionnaire used in this study. Due to the cross-sectional nature of this study, it is unclear whether participation in different types of PA helps reduce BMI percentile and WC or whether children with favorable anthropometric characteristics simply perform more PA. This study did not measure important variables that may affect or confound relationships between PA and obesity, such as factors in the home environment and children's dietary habits. Longitudinal investigations will provide important information regarding changes in PA that correspond to BMI percentile and WC over time.

Findings are limited by the lack of an overall survey response rate and the degree of missing data for certain variables, ranging from 9.7% (age) to 43.9% (household income). Generally, there were no observed relationships between missing data and analytic variables that would clearly bias relationships with outcome variables. For example, children with reported income data were more likely to engage in ACS (hypothesized to be associated with lower BMI percentile and WC), but less likely to participate in sports or organized PAs (also hypothesized to be associated with lower BMI percentile and WC) than those without reported income data. There were no significant associations between the degree of missing data for PA variables and either BMI percentile or WC. Nonetheless, the negative relationship between ACS and age-and sex-adjusted BMI percentile observed in complete

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case analyses was not statistically significant in the model incorporating data from multiple imputation. Multiple imputation shifted the distribution of household income toward the highest income category. If multiple imputation provided a more accurate representation of the income distribution in the study sample, it is possible that other confounding variables such as healthier dietary habits contributed to lower obesity among children who may not engage in ACS.

This study measured PA and anthropometric characteristics among a large sample of urban Mexican children, a population that is underrepresented in studies despite its high risk for physical inactivity and obesity. The inclusion of 3 medium-to-large, geographically diverse Mexican cities—Guadalajara, Puerto Vallarta, and Mexico City—provides a broad sample of the urban youth population in Mexico. The inclusion of ACS, participation in sports or other organized PAs, and outdoor play provides a thorough picture of PA participation. Obesity outcomes included both BMI and WC, each measured systematically by researchers, to more completely characterize obesity among children in the study. These findings are timely, because physical inactivity and obesity among children are serious threats to public health in Mexico. In general, the findings supported our hypotheses. ACS and outdoor play provide potentially effective strategies to increase PA and improve health among urban Mexican youth. ACS and outdoor play are inexpensive (or free) and do not require any particular facilities, equipment, or skills. Therefore, these opportunities provide accessible means of increasing PA and reducing obesity among Mexican youth, as long as families encourage them and environments support them.

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Table 1

Sociodemographic Characteristics, Physical Activity, and Anthropometric Characteristics Among Participants

	Reported Data Sample		Multiple Imputation Sample	
Variable	**n (%)**	**Mean (SD)**	**n (%)**	**Mean**
Age	1803	9.6 (1.1)	1996	9.6
Gender	1741	—	1996	—
Male	817 (46.9)	—	924 (46.3)	—
Female	924 (53.1)	—	1072 (53.7)	—
Household income	1121	—	1996	—
Less than $5000	564 (50.3)	—	978 (49.0)	—
$5000-$9999.99	377 (33.6)	—	647 (32.4)	—
$10,000 or more	180 (16.1)	—	372 (18.6)	—
Active commuting to school	1766	—	1996	—
Active	923 (52.3)	—	1042 (52.2)	—
Nonactive	843 (47.7)	—	953 (47.7)	—
Sports teams or organized physical activities[a]	1675	—	1996	—
Yes	959 (57.3)	—	1122 (56.2)	—
No	716 (42.7)	—	874 (43.8)	—
Outdoor play[b,c]	1850	2 (3)	1996	2
Body mass index percentile[d]	1526	68.2 (29.2)	1996	67.7
Waist circumference (cm)	1547	67.7 (12.4)	1996	67.8

[a]Participation in the previous year.

[b]Days with at least 30 minutes in the past week.

[c]Data are presented as median(interquartile range) due to skewed distribution.

[d]Age- and sex-adjusted.

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Table 2

Hierarchical Linear Regression Models for Relationships Between Physical Activity Modes and Anthropometric Characteristics

	β	*t*	***P* value**
BMI percentile[a]			
Complete case analysis[b,c]			
Transport to school (n = 857)[d]	−5.02	−2.42	.02
Sports teams or organized physical activities (n = 831)[e]	−2.01	−0.97	.33
Outdoor play (n = 894)[f]	−0.65	−1.40	.16
Multiple imputation analysis (n = 1996)[b,g]			
Transport to school[d]	−2.44	−1.13	.28
Sports teams or organized physical activities[e]	−1.82	−0.93	.37
Outdoor play[f]	−0.67	−1.90	.06
Waist circumference (cm)[a]			
Complete case analysis[c,h]			
Transport to school (n = 827)[d]	−0.71	−0.78	.44
Sports teams or organized physical activities (n = 798)[e]	−0.85	−0.93	.35
Outdoor play (n = 865)[f]	−0.39	−1.97	.05
Multiple imputation analysis (n = 1996)[c,i]			
Transport to school[d]	−0.63	−0.74	.47
Sports teams or organized physical activities[e]	−1.32	−1.83	.08
Outdoor play[f]	−0.35	−2.52	.01

Abbreviations: BMI, body mass index; ICC, intraclass correlation coefficient.

[a]Age- and sex-specific BMI percentile.

[b]School-level ICC = 0.08 (*P* = .55).

[c]Adjusted for the nesting effects of children within schools and individual-level age, sex, household income.

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[d] Active vs. inactive as usual mode of transport to school (1 = active, 0 = inactive).

[e] In the previous year (1 = yes, 0 = no).

[f] Days with at least 30 minutes in the previous week (0–7 days)

[g] School-level ICC = 0.02 (P = .76).

[h] School-level ICC = 0.13 (P = .67).

[i] School-level ICC = 0.03 (P = .56).