

Organized Physical Activity in Young School Children and Subsequent 4-Year Change in Body Mass Index

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Objective: To determine whether participation in organized outdoor team sports and structured indoor non-school activity programs in kindergarten and first grade predicted subsequent 4-year change in body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) during the adiposity rebound period of childhood.

Design: Longitudinal cohort study.

Setting: Forty-five schools in 13 communities across Southern California.

Participants: Largely Hispanic and non-Hispanic white children (N = 4550) with a mean (SD) age at study entry of 6.60 (0.65) years.

Main Exposures: Parents completed questionnaires assessing physical activity, demographic characteristics, and other relevant covariates at baseline. Data on built and social environmental variables were linked to the neigh-

borhood around children's homes using geographical information systems.

Main Outcome Measures: Each child's height and weight were measured annually during 4 years of follow-up.

Results: After adjusting for several confounders, BMI increased at a rate 0.05 unit/year slower for children who participated in outdoor organized team sports at least twice per week compared with children who did not. For participation in each additional indoor nonschool structured activity class, lesson, and program, BMI increased at a rate 0.05 unit/year slower, and the attained BMI level at age 10 years was 0.48 units lower.

Conclusion: Engagement in organized sports and activity programs as early as kindergarten and the first grade may result in smaller increases in BMI during the adiposity rebound period of childhood.

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OVERWEIGHT AND OBESITY during childhood increase the risk for a number of serious health conditions.¹ Cross-sectional studies show the beneficial effects of increased physical activity participation on obesity risk in children.²⁻⁴ Findings from longitudinal studies are equivocal. In a recently published 4-year study of children aged 10 to 13 years, decreases in sports participation and hours of physical education were associated with increased body mass index (BMI; calculated as weight in kilograms divided by height in meters squared).⁵ Likewise, Fulton and colleagues⁶ found an inverse relationship between moderate to vigorous physical activity and fat mass in children aged 10 to 18 years. In contrast, physical activity was not associated with change in BMI in several longitudinal studies of children.⁷⁻⁹

The variability in results of previous studies may be explained by the different effects of physical activity on body fat change at different periods during childhood. It has been hypothesized that there are critical developmental windows of obesity susceptibility.¹⁰ A particularly important time is the period of adiposity rebound when body fat increases rapidly.¹¹ Levels of body fat are usually at their lowest levels immediately before this window begins (at age 5-6 years) and then increase through adulthood. Children who enter the period of adiposity rebound at younger ages have a greater risk of obesity as adults.¹² To date, only a few longitudinal studies have examined the association of physical activity on change in body fat during the period of adiposity rebound. Children in the Framingham study who were in the highest tertile of daily physical activity from ages 4 to 11 years

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had smaller increases in BMI during this period.¹³ Also, boys and girls enrolled in the Iowa Bone Development study who engaged in higher levels of moderate to vigorous physical activity at age 5 had lower fat mass at ages 8 and 11 years.¹⁴ However, these studies included primarily white children from middle- to upper-income families. Research on the association of physical activity with change in body fat during the period of adiposity rebound is lacking for ethnically diverse, lower- to middle-income children. Information is also lacking on whether certain types of physical activity (eg, organized team sports or structured indoor classes and lessons) are associated with smaller changes in body fat during the adiposity rebound period.

To address these research gaps, the present study sought to determine whether levels of participation in organized team sports and structured activity classes, lessons, and programs in kindergarten and first grade children predicted subsequent 4-year change in BMI in a large cohort of socioeconomically diverse, largely Hispanic and non-Hispanic white children enrolled in the Southern California Children's Health Study, investigating the influence of environmental factors on health.^{15,16}

METHODS

STUDY DESIGN

During the 2002-2003 school year, the cohort of children attending kindergarten and first grade were enrolled from classrooms in 45 schools in 13 communities across Southern California. Communities exhibited a wide range of population densities, socioeconomic conditions, land uses, and exposure to ambient air pollution in Southern California. A total of 8139 eligible children were given an informed consent form to take home and for parents to complete, of which 5341 (65.6%) were returned. Further characteristics of this cohort are described elsewhere.¹⁷ This study was approved by the institutional review board at the University of Southern California.

MEASURES

Physical Activity

At baseline, parents reported information about their child's participation in outdoor organized team sports. Items were adapted from the Middle School Physical Activity and Nutrition intervention evaluation instrument,¹⁸ which has demonstrated acceptable levels of reliability. Parents were asked, "Since September of this school year, has your child played outdoors in any organized team sports at least twice per week?" Examples were baseball/softball/T-ball, soccer, swimming, basketball, football, tennis, volleyball, skating/roller blading, track/field, golf, and other. For the purpose of analysis, data were dichotomized as "Yes—participated in outdoor organized team sports at least twice per week" and "No—did not participate in outdoor organized teams sports at least twice per week." Information about participation in nonschool indoor structured activity programs was assessed through the following question: "Has your child taken any of the following exercise classes, lessons, or special programs during that past 12 months (outside of school only)?" Response options included dance, aerobics, gymnastics or tumbling, martial arts, other, and none of the above. Parents were instructed to mark all that applied. For

the data analysis, responses were recoded as 0 programs, 1 program, or 2 or more programs (treated ordinally).

Height and Weight

Every child enrolled in the Children's Health Study had height and weight measured by a trained technician annually through the entire 5-year study. Technicians followed a standardized procedure that included details on scale calibration and interaction with the children. Height and weight were measured to the nearest centimeter and pound, respectively. These objective measures of height and weight allowed for precise and accurate calculation of BMI.

Covariates

Parents also reported information about their educational level, child demographic characteristics, whether the child had ever been diagnosed with asthma, whether anyone had ever smoked in the household, and whether the family owned a pet. Parental stress levels were assessed with a 4-item version of the Perceived Stress Scale.^{19,20} Individual information was linked to built environment measures (eg, access to fast food restaurants) within a 500-m buffer around the children's homes, along with social environment variables in the census tract of residence (eg, poverty and population density). Home locations were geocoded in ArcGIS software, version 8.3 (Environmental Systems Research Institute, Inc), using the Teleatlas geocoding database for the corresponding road network (see Jerrett and colleagues²¹ for more detail on the environmental variable compilation).

STATISTICAL METHODS

We used a multilevel linear model that allowed for examination of effects of risk factors on the attained BMI level at age 10 years and the rate of growth during the follow-up period.²² This modeling approach allowed for examination of the effects of covariates of interest at various levels: between times (within individual), between individuals, and between other levels of aggregation (eg, neighborhood and community). The analytical data set was restricted to children who had 2 or more measurements of height and weight during the longitudinal study (N = 4550). Models were tested using the baseline observation of the physical activity variable of interest. Individuals who were missing physical activity data at baseline were not included in the analytic models. Missing indicators were created for other covariates so that the sample size was not reduced by missing values.²³ All models were adjusted for ethnicity, sex, and community of residence. In multilevel models, the following variables were evaluated as potential additional confounders of the effect of baseline physical activity on 4-year change in BMI (slope) and attained BMI at age 10 years (level): parental educational level, perceived stress, any diagnosis of asthma by a physician, use of Spanish to complete the questionnaire, exposure to secondhand smoke, and pet ownership. In addition, we tested whether the total population within a 500-m buffer of participants' homes and the availability of fast food restaurants confounded the association between physical activity and BMI. Community-level percentages of poverty and violent crime were further screened as possible confounders. A final model was developed by including all confounders that changed the effect of interest on the attained BMI level at age 10 years (level) or the rate of change in BMI levels (slope) by at least 10%. Once the final model was developed, interaction terms and sex-specific terms were used to test whether the effects were different for boys compared with girls. Unstandardized β coefficients are reported, which represent the effects in terms of actual BMI units.

RESULTS

After exclusions for missing geocodes and BMI data, the analytic cohort used in this study included 4550 children. **Table 1** shows the descriptive statistics for participant individual, neighborhood, and community characteristics. The mean (SD) age of children was 6.60 (0.65) years at the baseline observation and 9.61 (1.24) years at the last observation. Boys were more likely than girls (46.9% vs 28.7%) to participate in outdoor organized team sports at least twice per week during the previous school year ($\chi^2=134.86$; $P<.001$), whereas girls were more likely than boys (37.9% vs 20.3%) to participate in 1 or more indoor nonschool structured activity classes, lessons, and programs in the previous 12 months ($\chi^2=178.80$; $P<.001$). The mean (SD) BMI at the first observation was 16.79 (2.81). On the basis of the classifications of the Centers for Disease Control and Prevention, the BMI z scores indicated 29.0% of the children were overweight or obese at the first observation.²⁴ On average, the children increased approximately 2.6 units in BMI during the 4 years of follow-up, with boys showing a slightly greater increase in BMI.

Participation in outdoor organized team sports at the first observation was associated with negative effects on the attained level at age 10 years and the slope of BMI growth curves of the children (**Table 2**). Further evaluation of the effects of outdoor organized team sports participation revealed that they were confounded by other variables, particularly the language used to complete the questionnaire (Spanish or English) and the number of fast food outlets within 500 m of the child's home. In the fully adjusted model (Table 2), all effect estimates were attenuated, but the negative effects of outdoor organized team sports participation at study entry on BMI slope remained significant. Moreover, the effects on level (at age 10 years) were reduced by the confounders and were of borderline significance. **Figure 1** shows that during the study period, BMI increased at a rate 0.05 unit/year slower for children who participated in outdoor organized team sports at least twice per week compared with children who did not. The interactions between sex and participation in outdoor organized team sports were not statistically significant ($P = .09$ for likelihood ratio test of model improvement with the inclusion of the interaction terms for intercept and slope).

Participation in indoor nonschool structured activity classes, lessons, and programs at the first observation was also associated with reduced attained BMI level at age 10 years and the slope of BMI growth curves for children (Table 2). The covariate screening procedure revealed that these effects were confounded by whether the questionnaire was completed in Spanish. The fully adjusted model is shown in Table 2. The negative effects of indoor nonschool structured activity class, lesson, and program participation at the first observation on attained BMI level (at age 10 years) and slope remained significant after accounting for these confounders. **Figure 2** shows that BMI increased at a rate 0.05 unit/year slower during the study for participation in each additional indoor nonschool structured activity class, lesson, and program. Like-

Table 1. Baseline Individual, Neighborhood, and Community Characteristics, Children's Health Study 2002^a

Characteristic	Value
Individual^b	
Race/ethnicity, No. (%)	
African American	122 (2.68)
Asian	145 (3.19)
Hispanic	2462 (54.11)
Non-Hispanic white	1464 (32.18)
Others	357 (7.85)
Sex, No. (%)	
Male	2297/4548 (50.51)
Female	2251/4548 (49.49)
Spanish speaker, No. (%)	
No	3417/4550 (75.10)
Yes	1133/4550 (24.90)
Parent educational level, No. (%)	
Less than high school	905/4261 (21.24)
High school	781/4261 (18.33)
More than high school	2575/4261 (60.43)
Exposure to secondhand smoke, No. (%)	
No one ever smoked in the house	3962/4271 (92.77)
Anyone ever smoked in the house	309/4271 (7.23)
Pet ownership, No. (%)	
Yes	1012/4244 (23.85)
No	3232/4244 (76.15)
Asthma diagnosis, No. (%)	
Yes	564/4065 (13.90)
No	3501/4065 (82.49)
Stress, mean (SD) (n=4078) ^c	8.00 (2.90)
Body mass index (BMI), mean (SD) (n=4550)	16.79 (2.81)
Neighborhood, mean (SD)^d	
Total population (n=3968)	1703.90 (1426.65)
No. of fast food establishments (n=4117)	1.95 (0-57)
Community, mean (SD)^e	
Proportion in poverty	0.15 (0.06)
Violent crime ^f	511.73 (268.04)

^a The total number of children in the analytic cohort number was 4550, which represents children with 2 or more observations of BMI (calculated as weight in kilograms divided by height in meters squared).

^b The number of children varies owing to missing covariate values.

^c Mean (SD) of a total score of 20.0.

^d Calculated within the 500-m buffer of participant's residence.

^e Calculated for the community/town level.

^f Crime per 100 000 population.

wise, the attained BMI level at age 10 years was 0.48 units lower for participation in each additional indoor nonschool structured activity class, lesson, and program. The interactions between sex and participation in outdoor organized teams sports were statistically significant for neither BMI level (at age 10 years) nor slope ($P = .06$ for likelihood ratio test of model improvement with the inclusion of the interaction terms for intercept and slope).

COMMENT

This study addressed several important gaps in the research literature through its focus on longitudinal change in BMI during the adiposity rebound period of childhood, inclusion of ethnically diverse children from lower- to middle-income households, and consideration of effects of different types of physical activity (eg, organized team sports and structured indoor classes and les-

Table 2. Results of the Multilevel Growth Curve Modeling Showing Effects of Physical Activity on BMI Level (Intercept) and Growth (Slope)^a

Variable	No. (%)	β (95% CI) [P Value]			
		Unadjusted Model		Adjusted Model	
		Intercept	Slope	Intercept	Slope
Outdoor organized team sports ^b					
No	2517/4031 (62.44)	-0.30 (-0.58 to 0.03)	-0.07 (-0.12 to -0.02)	-0.24 (-0.51 to 0.04)	-0.05 (-0.10 to -0.005)
Yes	1514/4031 (37.56)	[.03]	[.004]	[.09]	[.03]
No. of indoor nonschool structured activity programs ^c					
0	2913/4111 (70.86)	-0.68 (-0.92 to -0.45)	-0.15 (-0.19 to -0.11)	-0.48 (-0.73 to -0.24)	-0.11 (-0.15 to -0.06)
1	1000/4111 (24.32)	[<.001]	[<.001]	[<.001]	[<.001]
≥2	198/4111 (4.82)				

Abbreviation: BMI, body mass index.

^aPhysical activity variables were assessed at baseline. Intercept is the effect on the attained BMI level at last observation (mean [SD] age, 9.61 [1.24] years). Slope is the effect on the rate of change in BMI levels between the first observation (mean [SD] age, 6.67 [0.71] years) and the last observation.

^bCoefficient adjusted for the language used to complete the questionnaire (Spanish or English), number of fast food outlets within 500 m of the child's home, ethnicity, sex, and community of residence.

^cCoefficient adjusted for the language used to complete the questionnaire (Spanish or English), ethnicity, sex, and community of residence.

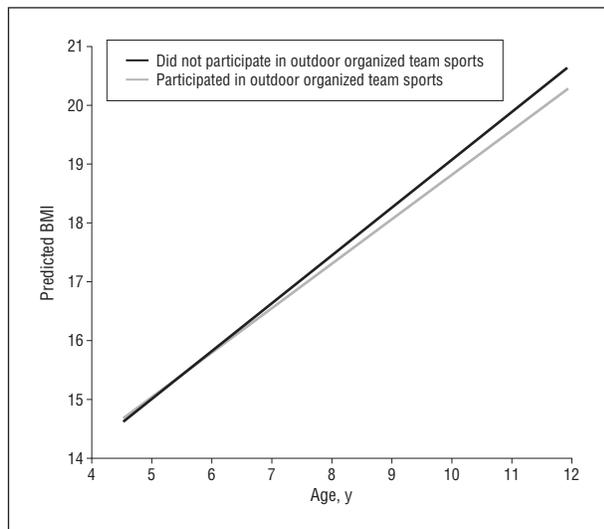


Figure 1. Predicted body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) as a function of age for children who did and did not participate in outdoor organized team sports at the baseline observation (mean age, 6.60 years). Prediction equations adjust for confounders in the final model, including sex, ethnicity, community, Spanish speaking, and fast food availability within 500 m of the child's home. The lines depict the predicted BMI for non-Hispanic/white girls living in Alpine, California, whose parents completed the survey in English and who have an average of 1.725 fast food establishments within 500 m of their residence.

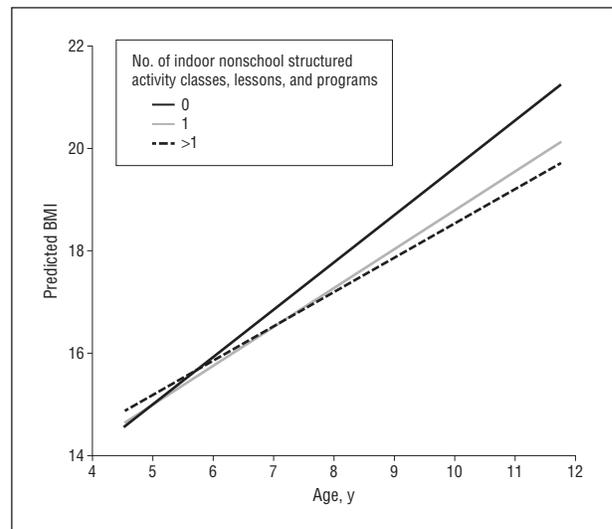


Figure 2. Predicted body mass index (BMI; calculated as weight in kilograms divided by height in meters squared) as a function of age for children who participated in 0, 1, or 2 or more indoor nonschool structured activity classes, lessons, and programs at the baseline observation. Prediction equations adjust for confounders in the final model, including sex, ethnicity, community, Spanish speaking, and fast food availability within 500 m of the child's home. The lines depict the predicted BMI for non-Hispanic/white girls living in Alpine, California, whose parents completed the survey in English.

sons). In this population of children with high rates of overweight and obesity at study entry, early engagement (during kindergarten or first grade) in organized sports and exercise classes, lessons, and programs was associated with smaller increases in BMI during the adiposity rebound period of childhood. Children were enrolled in the current study during a time when levels of body fat are usually at their lowest levels (mean age, 6.60 years). Adiposity rebound typically begins after this age, and body fat increases through adulthood. Our results indicated a pattern of rapid growth in BMI (averaging 3 units during 5 years), which is consistent with adiposity rebound. The smaller increases in BMI among children

who participated in organized sports and exercise classes and lessons observed in our study are consistent with results from other longitudinal studies of the effects of physical activity on body fat accumulation during the adiposity rebound period, such as the Framingham study¹³ and the Iowa Bone Development study.¹⁵

An important strength of our analytic approach was the capacity to test the effects of organized sports and exercise participation not only on change in BMI but also on the level of attained BMI at the end of the study (age 10 years). Engagement in indoor nonschool exercise classes and lessons in kindergarten or first grade was associated with lower BMI levels at age 10. However, the effects of outdoor team sports participation on attained

BMI at age 10 was attenuated by controlling for the language in which the parent questionnaire was completed (English or Spanish), which is a proxy for the primary language spoken by the parent, and the number of fast food establishments available within 500 m of the child's home. Fast food availability was tested as a potential confounder because we did not have a direct measure of dietary consumption. Evidence suggests that children living in neighborhoods with a higher density of fast food outlets and convenience stores have more unhealthy food intake and higher BMI scores and are more likely to be overweight or obese.^{25,26} It is possible that children from Spanish-speaking households and/or neighborhoods with a greater density of fast food restaurants have less access to organized team sports programs.²⁷

Differences existed in the types of organized physical activity that boys vs girls performed at this young age. Consistent with other studies, boys had greater involvement in team sports.^{28,29} In contrast, girls were more likely to participate in physical activity-related lessons and classes offered outside of school, as reported elsewhere.^{30,31} Results indicated that participation in organized physical activity reduced subsequent obesity risk regardless of the type of activity performed. However, special programming efforts may be necessary to make a sufficient number of activity-oriented classes and lessons available for girls given that they are at increased risk of decreasing physical activity levels during childhood.³²

A few limitations should be noted. First, some evidence suggests that parents may overreport their children's physical activity levels.³³ However, parents' reports of activity are thought to be more accurate than children's reports for children younger than 12 years.³⁴ Second, the effects of participation in organized sports, lessons, and classes on BMI could be the result of factors other than physical activity performed during these programs. These uncontrolled factors could include reduced time spent in sedentary behaviors and increased physical activity performed outside the organized program's formal hours but related nonetheless (eg, practice sessions to prepare for the program). We were also unable to adjust for parents' marital and employment status, which could be associated with the amount of time that parents have available to transport and/or accompany children to organized programs as well as with obesity outcomes. Another uncontrolled factor was dietary intake. Children with similar levels of energy expenditure could differ in energy intake—resulting in differential accumulated adiposity. In this study, we did not have the ability to statistically control for effects of dietary consumption when testing the effects of participation in team sports, classes, and lessons on BMI. A number of studies, however, have shown that physical activity and energy intake have independent associations with adiposity.^{6,35-37} Third, another limitation was the use of BMI as the primary indicator of obesity risk in children. The accuracy of BMI as an indicator of body fatness varies according to adiposity level. Body mass index is a good measure of adiposity in children who have excess body fat. However, differences in fat-free mass may account for differences in the BMI scores of children with low levels of body fat.³⁸ Research could be strengthened through the

use of a more accurate measure of body fatness, such as dual-energy x-ray absorptiometry.

In conclusion, this study provides evidence that engagement in organized sports and activity programs among kindergarteners and first graders may result in smaller increases in BMI during the adiposity rebound period of childhood. Participation in organized physical activities could be increased through improved availability of and access to recreational programs at parks and other public facilities.³⁹ Other strategies to encourage participation in organized physical activity among young children feature their inclusion in after-school programs or tax credits for the costs of these programs.⁴⁰ Whether participation during the adiposity rebound period in organized sports and classes results in similar or greater benefits than does physical activity performed during unstructured free play should be a focus of future research. Participating in organized sports alone may not ensure that children attain the recommended level of at least 60 minutes per day.⁴¹ Organized physical activities should be targeted for obesity reduction and control during childhood, and the role of unstructured free play should be further explored.

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