PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Influence of Sports, Physical Education, and Active Commuting to School on Adolescent Weight Status

Keith M. Drake, Michael L. Beach, Meghan R. Longacre, Todd MacKenzie, Linda J. Titus, Andrew G. Rundle and Madeline A. Dalton

Pediatrics; originally published online July 16, 2012;
DOI: 10.1542/peds.2011-2898

Influence of Sports, Physical Education, and Active Commuting to School on Adolescent Weight Status

WHAT'S KNOWN ON THIS SUBJECT: Among adolescents, weight status has been inversely associated with sports participation but not active commuting or physical education. Studies of each form of physical activity have not included adequate adjustments for other physical activities, previous body weight, or diet quality.

WHAT THIS STUDY ADDS: Estimates indicate overweight/obesity and obesity prevalence would decrease by 11% and 26%, respectively, if adolescents played on at least 2 sports teams per year; obesity prevalence would decrease by 22% if adolescents walked/biked to school 4–5 days per week.

abstract

OBJECTIVE: To compare the associations between weight status and different forms of physical activity among adolescents.

METHODS: We conducted telephone surveys with 1718 New Hampshire and Vermont high school students and their parents as part of a longitudinal study of adolescent health. We surveyed adolescents about their team sports participation, other extracurricular physical activity, active commuting, physical education, recreational activity for fun, screen time, diet quality, and demographics. Overweight/obesity (BMI for age ≥ 85th percentile) and obesity (BMI for age ≥ 95 percentile) were based on self-reported height and weight.

RESULTS: Overall, 29.0% (n = 498) of the sample was overweight/obese and 13.0% (n = 223) were obese. After adjustments, sports team participation was inversely related to overweight/obesity (relative risk [RR] = 0.73 [95% confidence interval (CI): 0.61, 0.87] for >2 sports teams versus 0) and obesity (RR = 0.61 [95% CI: 0.45, 0.81] for >2 sports teams versus 0). Additionally, active commuting to school was inversely related to obesity (RR = 0.67 [95% CI: 0.45, 0.99] for >3.5 days per week versus 0). Attributable risk estimates suggest obesity prevalence would decrease by 26.1% (95% CI: 9.4%, 42.8%) if all adolescents played on 2 sports teams per year and by 22.1% (95% CI: 0.1%, 43.3%) if all adolescents walked/biked to school at least 4 days per week.

CONCLUSIONS: Team sport participation had the strongest and most consistent inverse association with weight status. Active commuting to school may reduce the risk of obesity, but not necessarily overweight, and should be studied further. Obesity prevention programs should consider strategies to increase team sport participation among all students. *Pediatrics* 2012;130:e296–e304

AUTHORS: Keith M. Drake, BA,[a,b] Michael L. Beach, MD, PhD,[a,c,d] Meghan R. Longacre, PhD,[a,e] Todd MacKenzie, PhD,[a,c,f] Linda J. Titus, PhD,[a,c,e] Andrew G. Rundle, DrPH,[g] and Madeline A. Dalton, PhD[a,c,e]

[a]Hood Center for Children and Families, Departments of [c]Community and Family Medicine, and [e]Pediatrics, The Geisel School of Medicine at Dartmouth, Lebanon, New Hampshire; [b]Center for Education, The Dartmouth Institute for Health Policy and Clinical Practice, Lebanon, New Hampshire; Departments of [d]Anesthesiology, and [f]Statistics, Dartmouth–Hitchcock Medical Center, Lebanon, New Hampshire; and [g]Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, New York

KEY WORDS

overweight, obesity, exercise, sports, team sports, physical education, active travel, walking, bicycling, commuting, adolescent, body weight, secondary school

ABBREVIATIONS

CI—confidence interval
PE—physical education
RR—relative risk

Mr Drake, Drs Beach, Longacre, Titus, and Dalton contributed to the conception and design of the study and/or article; Mr Drake and Drs Longacre and Dalton helped acquire the data; Mr Drake conducted the data analysis and drafted the article; and all the authors aided with interpreting the data analysis, critically revised the article, and approved the final version.

www.pediatrics.org/cgi/doi/10.1542/peds.2011-2898

doi:10.1542/peds.2011-2898

Accepted for publication Mar 23, 2012

Address correspondence to Keith Drake, BA, Hood Center for Children and Families, The Geisel School of Medicine at Dartmouth, One Medical Center Dr, HB 7465, Lebanon, NH 03756. E-mail: keith.drake@dartmouth.edu

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: *The authors have indicated they have no financial relationships relevant to this article to disclose.*

FUNDING: This study was supported by the National Institute of Environmental Health Sciences, National Institutes of Health, grant number ES014218. The funding agency had no involvement in the study. Funded by the National Institutes of Health (NIH).

Increasing physical activity among youth is an essential component of the broad strategy needed to curb the obesity epidemic. Many forms of physical activity could be targeted, including extracurricular physical activities, physical education (PE), and active commuting. Given limited funding for schools and public health efforts, identifying forms of physical activity that most effectively reduce overweight/obesity is important.

Extracurricular physical activity includes sports and other organized out-of-school activities (eg, dance). Sports participation has been inversely related to overweight/obesity[1–6] with some variation by sport.[5,7] Elkins et al[7] found that football was associated with an increased risk of overweight/obesity, whereas basketball, track, and cheerleading were associated with a decreased risk of overweight/obesity. After Title IX's passage (1972), which banned gender discrimination in academic and athletic programs, sports participation among high school girls increased by 600%. This increase was linked to increased physical activity and decreased BMI in high school girls.[8] Additionally, childhood sports participation has consistently predicted future physical activity and body weight up to 21 years later.[9–18]

US children walk/bike to school and other places less than they did 20 to 30 years ago.[19] In 2001, <16% of children aged 5 to 15 actively commuted to school, compared with 48% in 1969.[20] In an effort to increase active commuting to school, the US federal government has invested over $100 million dollars per year in the Safe Routes to School program since 2005.[21] Although there may be other benefits associated with active commuting to school, to date there is scant evidence that it reduces childhood obesity.[20,22] A systematic review of active commuting to school in elementary school children[23] revealed that active commuters were more physically active than their peers in 11 out of 13 studies,[24–34] but only 1 study revealed an inverse relationship with BMI. In that study, active commuting among fourth graders was associated with a lower BMI at baseline but did not significantly predict overweight/obesity at baseline or 2 years later.[31] Studies of high school students have not supported an association between active commuting to school and overweight/obesity.[27,35]

PE has been associated with increased physical activity and decreased body weight among elementary school students,[36,37] and increased physical activity but not decreased body weight among high school students.[38] The authors of 1 experimental study examined the effects of an enhanced PE program in high school students and found similar results; the PE program significantly increased physical activity, but a change in body weight was not detected.[39]

In this study, we aimed to determine the extent to which different forms of physical activity were associated with weight status among high school students, after adjusting for diet quality and individual characteristics. Our approach differed from previous studies because we concurrently examined the influence of multiple forms of physical activity on high school students' BMI while adjusting for their previous body weight.

METHODS

Survey Design

The data come from adolescent and parent telephone surveys conducted during a 7-year longitudinal study of adolescent health that has been previously described.[40–42] Briefly, we conducted 5 waves of surveys between 2002 and 2009. This study primarily uses data collected through waves 4 (2007–2008) and 5 (2008–2009). Covariates collected through the baseline parent surveys (2003–2004) were also used. The Dartmouth Committee for the Protection of Human Subjects approved all aspects of this research.

In 2002–2003, we surveyed 87.0% (n = 3705) of students enrolled in grades 4 to 6 at 26 randomly selected New Hampshire and Vermont public schools. Subsequently, we enrolled 71.0% (n = 2631) of these students into a longitudinal telephone survey of adolescent-parent dyads. We completed follow-up surveys at wave 4/5 with 2009 adolescents, of whom 85.5% (n = 1718) were enrolled in high school during 1 of the waves and had data for the primary outcome. At each wave, trained interviewers surveyed adolescents and their parents by using a computer-assisted telephone interviewing system. Interviewers obtained parent consent and adolescent assent before each round of surveys. In all but a few instances, we surveyed adolescents before their parents. We preferentially surveyed mothers for consistency across waves; if no mother lived in the household, we surveyed the adolescent's primary caregiver instead.

Because sport and physical activity opportunities differ substantially between middle and high school, and we had few middle school students, we confined the analysis to high school students. We used data from the wave corresponding to when adolescents first enrolled in high school; wave 4 responses were used for 1178 adolescents, and wave 5 responses for 540 adolescents. Our final sample of 1718 adolescents resembled the baseline sample in terms of the proportion of boys (49.4% vs 51.5%, respectively), the proportion of white participants (91.5% vs 89.9%, respectively), and the baseline weight-for-age z score (mean = 0.5, SD = 1.1, for both).

Measures

Whenever possible, we adapted survey questions from previously validated

instruments.[43–46] All surveys were pretested for telephone administration and comprehension. Measures of height, weight, physical activity, and the majority of covariates were collected from adolescents at wave 4/5. Variables were also collected from parents at wave 4/5 (parent education, parent income, single-parent household, and adolescent height and weight) or baseline (adolescent weight).

Adolescent Weight Status

We used the Centers for Disease Control and Prevention's SAS macro[47] and adolescent height, weight, gender, and age to calculate gender-specific BMI-for-age percentiles. Two risk-based cutoffs were used as outcomes: (1) overweight/obese, defined as greater than or equal to the 85th percentile, and (2) obese, defined as greater than or equal to the 95th percentile.[48] At wave 4/5, adolescents self-reported their height and weight in response to the following questions:

- Self-reported height: "How tall are you without shoes?"
- Self-reported weight: "How much do you weigh?"
- Self-reported scale weight: "Do you have a bathroom scale in your house? [If yes…] Would you be willing to go and weigh yourself, and I will wait on the phone? [If yes…] What did the scale say?"

For the majority (n = 1003) of adolescents, we used self-reported height and self-reported scale weight to calculate BMI percentiles. We used self-reported weight (n = 649) only if self-reported scale weight was unavailable. For 3.8% of the sample, we used parent report of adolescent height and weight (n = 27) or a combination of self and parent report of adolescent height and weight (n = 39) from wave 4/5 because adolescent values were missing or adolescent self-report was deemed physically impossible based on growth charts and values from other waves. Adolescents' ages were calculated based on the survey date and their date of birth.

Forms of Physical Activity

Sports Teams

We measured the number of sports teams adolescents participated on by asking: "In the past 12 months, on how many sports teams did you play?"

Other Extracurricular Physical Activity

We measured other extracurricular physical activity by asking adolescents, "In the past 7 days, what was the total amount of time you spent doing physical activities like dancing, drill team, marching band, or playing games with your friends; for example capture the flag, paint ball, Frisbee?"

Active Commuting to School

We measured active commuting to school by asking adolescents, "On average, how many days a week do you [walk/bike] to or from school in the [fall/winter/spring]?" We calculated the average by multiplying the number of days participants biked/walked per week in each season by the number of weeks in each season.

Active Commuting to Other Places

We measured active commuting to other places by summing adolescents' responses to 6 questions: "On how many of the past 7 days did you walk or ride your bike to or from…(1) a friend's house? (2) a store? (3) work? (4) a place where you exercise? (5) an after school activity? (6) another place you needed to get to?"

PE

We measured participation in PE by asking adolescents, "On how many of the past 7 days did you go to physical education, or PE, class at school?"

Recreational Physical Activity for Fun

We measured recreational activity for fun by asking adolescents, "In the past 7 days, what was the total amount of time you spent doing any other physical activities you do for fun, that you haven't already told us about; for example bike riding, skating, hiking, snowshoeing, or hunting?"

Football Participation

Football participation was considered a potential moderator of sports participation because, in contrast to other sports, football has been consistently shown to have a positive association with BMI.[5,7] Adolescent boys who reported playing football in response to the question: "Can you please tell me what physical activities you did during the Fall?" were classified as football players.

Covariates

We measured and adjusted for the following covariates: adolescent demographics (gender, grade in school, and race [white/nonwhite]); screen time; academic performance; employment status; diet quality (fast food, fruit and vegetable consumption over the past week); baseline weight-for-age z score; and family socioeconomic status (parent education, annual household income, and single-parent household status). We measured screen time by summing adolescents' responses to the questions: "What was the total amount of time you spent in the past 7 days watching TV, DVDs, or videos?" and "What was the total amount of time you spent in the past 7 days playing videogames or using the computer for things other than homework?" To assess academic performance, adolescents were asked, "How would you describe your grades in school?" Response options included "below average," "average," "good," and "excellent." Because of few responses, we grouped "below average"

TABLE 1 Unadjusted Predictors of Overweight/Obesity and Obesity

	Total *N*	Overweight/Obese (≥85 BMI %)		Obese (≥95 BMI %)	
		Row %	Unadjusted Risk Ratio [95% CI]	Row %	Unadjusted Risk Ratio [95% CI]
Total	1718	29.0	—	13.0	—
Sports teams in past 12 mo					
0	492	40.4	Reference	21.1	Reference
1	298	31.2	0.77 [0.63, 0.95]*	15.8	0.75 [0.54, 1.03]
2	320	24.7	0.61 [0.48, 0.77]***	9.4	0.44 [0.31, 0.64]***
≥3	607	20.9	0.52 [0.43, 0.62]***	6.9	0.33 [0.22, 0.48]***
Extracurricular physical activity in past week, h					
0	492	33.7	Reference	16.9	Reference
0.1–2.5	724	27.5	0.81 [0.70, 0.95]**	10.9	0.65 [0.51, 0.82]***
>2.5	501	26.3	0.78 [0.67, 0.90]***	12.2	0.72 [0.52, 0.99]*
Active commuting to school, average d per wk					
0	1190	28.1	Reference	12.6	Reference
0.1–1.5	187	26.7	0.95 [0.72, 1.25]	12.3	0.98 [0.69, 1.39]
1.51–3.5	166	33.1	1.18 [0.91, 1.54]	17.5	1.39 [0.96, 2.01]
>3.5	175	33.7	1.20 [1.00, 1.44]	12.0	0.95 [0.65, 1.39]
Active commuting to other places, trips per wk					
0	445	27.3	Reference	9.6	Reference
1–7	772	27.6	1.01 [0.88, 1.16]	12.9	1.34 [1.02, 1.77]*
≥8	489	32.7	1.19 [0.96, 1.46]	16.2	1.69 [1.25, 2.27]***
PE classes in the past wk					
0	1024	30.6	Reference	13.9	Reference
1–5	692	26.6	0.87 [0.73, 1.03]	11.6	0.83 [0.59, 1.17]
Recreational physical activity for fun in past wk, h					
0	870	30.3	Reference	13.8	Reference
0.1–2.5	455	25.7	0.85 [0.71, 1.02]	10.5	0.76 [0.53, 1.11]
>2.5	393	29.7	0.98 [0.80, 1.21]	14.0	1.01 [0.78, 1.32]
Football participation					
No	1518	26.7	Reference	11.3	Reference
Yes	200	46.5	1.74 [1.48, 2.06]***	25.5	2.25 [1.67, 3.03]***
Gender					
Girl	870	25.1	Reference	9.5	Reference
Boy	848	33.0	1.32 [1.17, 1.49]***	16.5	1.73 [1.37, 2.18]***
Grade in school					
9th	1074	28.8	Reference	12.5	Reference
10th	480	29.2	1.01 [0.83, 1.24]	14.2	1.14 [0.83, 1.56]
11th and 12th	164	29.9	1.04 [0.79, 1.36]	12.8	1.03 [0.65, 1.62]
Race					
White	1572	29.1	Reference	13.0	Reference
Nonwhite	146	28.1	0.97 [0.73, 1.28]	13.0	1.00 [0.68, 1.48]
Screen time in past wk, h					
0–6.9	795	26.3	Reference	10.1	Reference
7–14	541	28.8	1.10 [0.94, 1.28]	13.5	1.34 [1.05, 1.72]*
>14	381	34.9	1.33 [1.13, 1.56]***	18.4	1.83 [1.35, 2.47]***
Academic performance					
Below average/average	570	36.5	Reference	20.0	Reference
Good	795	26.3	0.72 [0.63, 0.83]***	10.2	0.51 [0.41, 0.64]***
Excellent	350	22.9	0.63 [0.51, 0.77]***	7.7	0.39 [0.27, 0.55]***
Part-time job					
No	1174	28.0	Reference	12.5	Reference
Yes	541	31.2	1.11 [0.98, 1.27]	14.0	1.12 [0.88, 1.42]
Fast food meals in the past wk					
0	810	27.5	Reference	12.5	Reference
1	543	31.7	1.15 [0.96, 1.37]	15.3	1.23 [0.92, 1.62]
≥2	362	28.5	1.03 [0.83, 1.28]	10.8	0.86 [0.60, 1.24]
Times fruits and vegetables were consumed in past wk					
0–5	567	34.2	Reference	17.5	Reference
6–10	674	28.8	0.84 [0.72, 0.99]*	11.4	0.65 [0.46, 0.94]*
≥11	476	23.1	0.68 [0.54, 0.85]***	9.9	0.57 [0.40, 0.80]**

TABLE 1 Continued

	Total *N*	Overweight/Obese (≥85 BMI %)		Obese (≥95 BMI %)	
		Row %	Unadjusted Risk Ratio [95% CI]	Row %	Unadjusted Risk Ratio [95% CI]
Baseline wt-for-age *z* score					
<0	532	4.9	Reference	1.1	Reference
0.1–1	603	19.6	4.00 [2.78, 5.76]***	3.3	2.94 [1.20, 7.21]*
>1	542	62.5	12.80 [9.41, 17.41]***	34.9	30.92 [16.15, 59.18]***
Single parent household					
No	1372	27.3	Reference	12.2	Reference
Yes	290	37.2	1.37 [1.13, 1.65]**	16.6	1.35 [1.06, 1.72]*
Parent education					
High school diploma or less	335	38.3	Reference	20.6	Reference
Some college or associate's degree	507	32.7	0.86 [0.72, 1.01]	17.4	0.84 [0.66, 1.08]
Bachelor's or graduate degree	718	21.9	0.57 [0.47, 0.70]***	6.2	0.30 [0.21, 0.45]***
Annual household income					
$0–$50 000	503	35.4	Reference	18.7	Reference
$50 001–$75 000	447	33.6	0.95 [0.81, 1.12]	15.2	0.81 [0.62, 1.06]
≥$75 001	679	21.8	0.62 [0.51, 0.75]***	7.5	0.40 [0.29, 0.56]***

* $P < .05$; ** $P < .01$; *** $P < .001$.

and "average" together. To assess single-parent household status, we asked parents: "Do you have a partner/spouse who lives with you?" To calculate weight-for-age *z* scores, parents were asked at baseline (5–6 years before wave 4/5), "How much does [child name] weigh?" We used parent report because we did not ask children to report their weight in previous survey waves. We used weight-for-age *z* scores instead of BMI percentiles because parents more reliably estimated their children's weight than height at baseline.

Statistical Analyses

Relationships between forms of physical activity were examined by using correlation coefficients. We used Poisson regression to determine risk ratios, with robust[49] cluster[50] variance estimates to account for the binomial outcome variable[51] and the within-school correlation. Initially, we examined overweight/obesity and obesity as a function of each variable separately. Next, we examined overweight/obesity and obesity as a function of all variables simultaneously. We categorized all count variables based on their distributions, but truncation yielded similar results. We estimated attributable risks with bootstrapped confidence intervals (CIs) by adjusting rates of sports team participation and active commuting to school and associated changes in overweight/obesity and obesity. All analyses were conducted in Stata version 11 (StataCorp LP, College Station, TX).

RESULTS

About half of the adolescents were girls (50.6%) and the majority were in the ninth (62.8%) or 10th (27.9%) grades (Table 1). Twenty-nine percent ($n = 498$) were overweight/obese and 13.0% ($n = 223$) were obese. Almost three-quarters of the participants played on sports teams: 17.4% played on 1 sports team, 18.6% on 2 sports teams, and 35.3% on 3 or more sports teams. Active commuting to school was less common than sports team participation, only 10.2% walked/biked to school more than 3.5 days per week, and 69.3% never walked/biked to school. Participants who walked/biked to school were more likely to walk/bike to other places ($r = 0.46$, $P < .001$). Many forms of physical activity were significantly correlated to each other but to a lesser extent than the active commuting variables (rs < 0.22).

In unadjusted models, significant negative predictors of both overweight/obesity and obesity included sports team participation, other extracurricular physical activity, academic performance, fruit and vegetable consumption, parental education, and annual household income (Table 1). Significant positive predictors included football participation, gender (boy), screen time, weight-for-age at baseline, and living in a single-parent household.

In adjusted models, sports team participation was the only form of physical activity with an inverse relationship to both overweight/obesity and obesity (Table 2). Adolescents who played on 3 sports teams or more in the last year were 27% less likely to be overweight/obese and 39% less likely to be obese compared with adolescents who did not play on any sports teams. Although active commuting to school was not significantly related to overweight/obesity, it did have a significant inverse association with obesity. Adolescents who walked/biked to school more than 3.5 days per week were 33% less likely to be obese compared with adolescents who never walked/biked to school.

The attributable risk calculations indicate that, after adjusting for all covariates, including baseline weight-for-age *z* scores, the prevalence of overweight/obesity would decrease by 10.6% (95%

TABLE 2 Adjusted Predictors of Overweight/Obesity and Obesity

	Adjusted Risk Ratio [95% CI]	
	Overweight/Obese (≥85 BMI %)	Obese (≥95 BMI %)
Sports teams in past 12 mo		
0	Reference	Reference
1	0.90 [0.75, 1.08]	0.98 [0.75, 1.27]
2	0.78 [0.62, 0.99]*	0.61 [0.42, 0.89]**
≥3	0.73 [0.61, 0.87]***	0.61 [0.45, 0.81]***
Extracurricular physical activity in past wk, h		
0	Reference	Reference
0.1–2.5	0.98 [0.86, 1.12]	0.87 [0.69, 1.09]
>2.5	0.90 [0.72, 1.11]	0.84 [0.58, 1.22]
Active commuting to school, average d per wk		
0	Reference	Reference
0–1.49	0.86 [0.73, 1.03]	0.85 [0.62, 1.16]
1.5–3.5	0.86 [0.67, 1.09]	0.80 [0.58, 1.11]
>3.5	1.00 [0.82, 1.23]	0.67 [0.45, 0.99]*
Active commuting to other places, trips per wk		
0	Reference	Reference
1–7	0.89 [0.77, 1.01]	0.96 [0.72, 1.29]
≥8	0.97 [0.79, 1.18]	1.24 [0.91, 1.69]
PE class in the past wk		
No	Reference	Reference
Yes	1.00 [0.97, 1.04]	0.99 [0.93, 1.06]
Recreational physical activity for fun in past wk, h		
0	Reference	Reference
0.1–2.5	1.09 [0.93, 1.29]	1.04 [0.74, 1.47]
>2.5	0.96 [0.82, 1.13]	0.92 [0.73, 1.17]
Football participation		
No	Reference	Reference
Yes	1.20 [0.97, 1.48]	1.20 [0.90, 1.59]
Gender (boy)	1.07 [0.89, 1.28]	1.27 [1.05, 1.55]*
Grade	0.96 [0.86, 1.07]	0.97 [0.82, 1.13]
Not white	0.94 [0.73, 1.21]	0.95 [0.70, 1.28]
Screen time in past wk, h		
0–7	Reference	Reference
7.1–14	1.04 [0.91, 1.18]	1.28 [1.06, 1.55]*
>14	1.09 [0.95, 1.26]	1.37 [1.09, 1.71]**
Academic performance	0.96 [0.89, 1.03]	0.83 [0.71, 0.97]*
Adolescent has job	1.13 [1.00, 1.27]*	1.25 [1.04, 1.51]*
Past wk fast food meals	1.02 [0.97, 1.08]	0.94 [0.85, 1.04]
Fruits/vegetables in the past wk	0.98 [0.97, 1.00]*	0.97 [0.94, 1.00]*
Baseline wt-for-age *z* score	2.26 [2.10, 2.45]***	3.45 [2.96, 4.01]***
Single parent household	0.97 [0.78, 1.21]	0.70 [0.51, 0.94]*
Parent education	0.93 [0.86, 1.00]	0.80 [0.69, 0.93]**
Annual household income	0.97 [0.94, 1.00]	0.94 [0.86, 1.03]

* $P < .05$; ** $P < .01$; *** $P < .001$.

CI: 1.1%–20.2%), from 28.8% to 25.7%, and the prevalence of obesity would decrease by 26.1% (95% CI: 9.4%–42.8%), from 12.8% to 9.5%, if all adolescents played on at least 2 sport teams per year. By comparison, the prevalence of obesity would decrease by 22.1% (95% CI: 0.1%–43.3%), from 12.8% to 10.0%, if all adolescents walked/biked to school at least 4 days per week throughout the school year. These estimates presume that significant associations between forms of physical activity and weight status are causal.

DISCUSSION

Compared with other forms of physical activity, sports participation had the strongest, most consistent inverse relationship with elevated weight status. High school sports participation typically involves regular practices and competitions, leading to consistent moderate to strenuous activity, which may explain the strength of its relationship with weight status compared with other forms of physical activity. Our finding supports previous research demonstrating sports were related to a substantially lower risk of both overweight/obesity and obesity.[1–6] Because of adjustments, our estimate may more accurately reflect the influence of sport team participation compared with cross-sectional studies of US adolescents, which revealed larger effect sizes.[6]

Our finding that active commuting to school was inversely related to obesity differs from previous studies that did not support this relationship.[23–35] Our large sample size provided more power to detect a relationship compared with smaller studies[23–35] and enabled us to examine relationships between active commuting and obesity, not just BMI or overweight/obesity.[31,33,34] Our result was only statistically significant after adjustments, indicating previous studies may not have detected the relationship because important covariates were not included. Specifically, adjusting for socioeconomic status variables and other forms of physical activity (especially active commuting to other places) largely influenced the effect of active commuting to school. Authors of future studies should examine this association with detailed measures of active commuting to other places.

Our results did not support a relationship between high school PE and adolescent weight status, which is consistent with previous research.[38,39] PE classes may not involve a substantial enough duration or intensity level of physical activity to affect overall energy balance in high school students,[38,39] but we were unable to examine this based on the measure we

used. In contrast, PE for younger children has been shown to be protective against overweight/obesity.[36,37] More detailed assessments of PE activity levels may be needed to understand why PE appears to be more protective for younger children.

The main limitation of this study was our reliance on self-reported measures of height, weight, and physical activity. Among adolescents, obesity prevalence based on self-reported height and weight has been 17% to 43% lower than obesity prevalence based on measurements.[52–55] Underestimation of the true prevalence would decrease our ability to detect significant associations unless there was related bias in self-report of specific forms of physical activity. Reporting bias for most forms of physical activity remains unknown; however, self-report of sports participation has been shown to be accurate.[56] Cutoffs based on BMI do not take body composition or fat mass into account, possibly masking the protective impact of physical activities that build muscle mass. We did not examine specific sports (other than football) or account for intensity levels of any of the physical activities. Comparisons were slightly more difficult because we used different units and time frames to measure each form of activity (eg, number of sports teams in the past year versus hours of screen time in the past week), but our question wording was appropriate for each activity. Despite these limitations, our comparisons still provide useful metrics for evaluating potential interventions.

Our adjustment for baseline, gender-specific, weight-for-age *z* scores strengthened this study. Although the majority of data were collected from a single time point, this longitudinal component of our analysis made reverse-causality less likely. Adjusted relative risks are interpreted with the stipulation that adolescents' previous body weight is held constant. Because of this adjustment, we believe an attributable risk calculation is appropriate and provides a useful metric for weighing the merits of potential interventions.

Our findings suggest that sports participation substantially impacts weight status. For example, the prevalence of obesity in this sample would decrease by ~26% (95% CI: 9.4%–42.8%) if all the adolescents played on at least 2 sports teams per year. Active commuting to school may also influence weight status. Our findings indicate the prevalence of obesity would decrease by ~22% (95% CI: 0.1%–43.3%) if adolescents walked/biked to school 4 to 5 days per week. However, because we did not detect an association when using the overweight/obesity cutoff, active commuting to school may have a protective effect only for adolescents who are near the 95th BMI-for-age percentile cutoff.

Nationwide, ~60.3% of high school students participate in sports[57] and 34.2% are overweight/obese,[58] compared with 71.3% sports participation and 29.0% overweight/obese in this study. Our estimates of the potential benefit of increasing sports participation would be even higher in areas with lower rates of sports participation and higher rates of overweight/obesity, as in most of the country. Due to shrunken school budgets, school sports have been reduced or cut in many areas.[59,60] Our findings suggest that this may exacerbate overweight/obesity rates because other forms of physical activity do not appear to be as effective in preventing excess weight among adolescents.

CONCLUSIONS

Sports participation was inversely associated with overweight/obesity and obesity, even after adjusting for previous body weight. Increasing opportunities for all adolescents, regardless of athletic ability, to participate in sports should be prioritized for obesity prevention. Although authors of future studies should examine active commuting to school by using detailed measures of active commuting to other places, our findings offer evidence that active commuting to school may also prevent obesity, supporting efforts to enhance neighborhood connectivity around schools.

ACKNOWLEDGMENTS

We thank Susan Martin and our team of survey administrators for data collection.

REFERENCES

1. Sirard JR, Pfeiffer KA, Dowda M, Pate RR. Race differences in activity, fitness, and BMI in female eighth graders categorized by sports participation status. *Pediatr Exerc Sci*. 2008;20(2):198–210
2. Elgar FJ, Roberts C, Moore L, Tudor-Smith C. Sedentary behaviour, physical activity and weight problems in adolescents in Wales. *Public Health*. 2005;119(6):518–524
3. Viner RM, Cole TJ. Who changes body mass between adolescence and adulthood? Factors predicting change in BMI between 16 year and 30 years in the 1970 British Birth Cohort. *Int J Obes (Lond)*. 2006;30(9):1368–1374
4. Ara I, Vicente-Rodriguez G, Perez-Gomez J, et al. Influence of extracurricular sport activities on body composition and physical fitness in boys: a 3-year longitudinal study. *Int J Obes (Lond)*. 2006;30(7):1062–1071
5. Nelson TF, Stovitz SD, Thomas M, LaVoi NM, Bauer KW, Neumark-Sztainer D. Do youth sports prevent pediatric obesity? A systematic review and commentary. *Curr Sports Med Rep*. 2011;10(6):360–370
6. Dowda M, Ainsworth BE, Addy CL, Saunders R, Riner W. Environmental influences, physical

activity, and weight status in 8- to 16-year-olds. *Arch Pediatr Adolesc Med*. 2001;155(6):711–717

7. Elkins WL, Cohen DA, Koralewicz LM, Taylor SN. After school activities, overweight, and obesity among inner city youth. *J Adolesc*. 2004;27(2):181–189
8. Kaestner R, Xu X. Effects of Title IX and sports participation on girls' physical activity and weight. *Adv Health Econ Health Serv Res*. 2007;17:79–111
9. Perkins DF, Jacobs JE, Barber BL, Eccles JS. Childhood and adolescent sports participation as predictors of participation in sports and physical fitness activities during young adulthood. *Youth Soc*. 2004;35(4):495–520
10. Horn DB, O'Neill JR, Pfeiffer KA, Dowda M, Pate RR. Predictors of physical activity in the transition after high school among young women. *J Phys Act Health*. 2008;5(2):275–285
11. Alfano CM, Klesges RC, Murray DM, Beech BM, McClanahan BS. History of sport participation in relation to obesity and related health behaviors in women. *Prev Med*. 2002;34(1):82–89
12. Aarnio M, Winter T, Kujala UM, Kaprio J. Familial aggregation of leisure-time physical activity — a three generation study. *Int J Sports Med*. 1997;18(7):549–556
13. Kjønniksen LL, Anderssen N, Wold B. Organized youth sport as a predictor of physical activity in adulthood. *Scand J Med Sci Sports*. 2009;19(5):646–654
14. Tammelin T, Näyhä S, Hills AP, Järvelin MR. Adolescent participation in sports and adult physical activity. *Am J Prev Med*. 2003;24(1):22–28
15. Tammelin T. A review of longitudinal studies on youth predictors of adulthood physical activity. *Int J Adolesc Med Health*. 2005;17(1):3–12
16. Telama R, Yang X, Viikari J, Välimäki I, Wanne O, Raitakari O. Physical activity from childhood to adulthood: a 21-year tracking study. *Am J Prev Med*. 2005;28(3):267–273
17. Trudeau F, Laurencelle L, Shephard RJ. Tracking of physical activity from childhood to adulthood. *Med Sci Sports Exerc*. 2004;36(11):1937–1943
18. van Mechelen W, Twisk JW, Post GB, Snel J, Kemper HC. Physical activity of young people: the Amsterdam Longitudinal Growth and Health Study. *Med Sci Sports Exerc*. 2000;32(9):1610–1616
19. Tudor-Locke C, Ainsworth BE, Popkin BM. Active commuting to school: an overlooked source of childrens' physical activity? *Sports Med*. 2001;31(5):309–313
20. Davison KK, Werder JL, Lawson CT. Children's active commuting to school: current knowledge and future directions. *Prev Chronic Dis*. 2008;5(3):A100
21. Funding. www.saferoutesinfo.org/legislation_funding/. Accessed October 14, 2010
22. Lee MC, Orenstein MR, Richardson MJ. Systematic review of active commuting to school and childrens physical activity and weight. *J Phys Act Health*. 2008;5(6):930–949
23. Faulkner GE, Buliung RN, Flora PK, Fusco C. Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Prev Med*. 2009;48(1):3–8
24. Alexander LM, Inchley J, Todd J, Currie D, Cooper AR, Currie C. The broader impact of walking to school among adolescents: seven day accelerometry based study. *BMJ*. 2005;331(7524):1061–1062
25. Cooper AR, Page AS, Foster LJ, Qahwaji D. Commuting to school: are children who walk more physically active? *Am J Prev Med*. 2003;25(4):273–276
26. Cooper AR, Andersen LB, Wedderkopp N, Page AS, Froberg K. Physical activity levels of children who walk, cycle, or are driven to school. *Am J Prev Med*. 2005;29(3):179–184
27. Cooper AR, Wedderkopp N, Wang H, Andersen LB, Froberg K, Page AS. Active travel to school and cardiovascular fitness in Danish children and adolescents. *Med Sci Sports Exerc*. 2006;38(10):1724–1731
28. Duncan EK, Scott Duncan J, Schofield G. Pedometer-determined physical activity and active transport in girls. *Int J Behav Nutr Phys Act*. 2008;5:2
29. Loucaides CA, Jago R. Differences in physical activity by gender, weight status and travel mode to school in Cypriot children. *Prev Med*. 2008;47(1):107–111
30. Michaud-Tomson M, Davidson M, Cuddihy TF. Walk to school: does it make a difference in children's physical activity levels? *ACHPER Health Life J*. 2004;50(3–4):16–24
31. Rosenberg DE, Sallis JF, Conway TL, Cain KL, McKenzie TL. Active transportation to school over 2 years in relation to weight status and physical activity. *Obesity (Silver Spring)*. 2006;14(10):1771–1776
32. Saksvig BI, Catellier DJ, Pfeiffer K, et al. Travel by walking before and after school and physical activity among adolescent girls. *Arch Pediatr Adolesc Med*. 2007;161(2):153–158
33. Sirard JR, Riner WF Jr, McIver KL, Pate RR. Physical activity and active commuting to elementary school. *Med Sci Sports Exerc*. 2005;37(12):2062–2069 http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=19314360&site=ehost-live
34. Tudor-Locke C, Ainsworth BE, Adair LS, Popkin BM. Objective physical activity of Filipino youth stratified for commuting mode to school. *Med Sci Sports Exerc*. 2003;35(3):465–471
35. Evenson KR, Huston SL, McMillen BJ, Bors P, Ward DS. Statewide prevalence and correlates of walking and bicycling to school. *Arch Pediatr Adolesc Med*. 2003;157(9):887–892
36. Fernandes MM, Sturm R. The role of school physical activity programs in child body mass trajectory. *J Phys Act Health*. 2011;8(2):174–181
37. Datar A, Sturm R. Physical education in elementary school and body mass index: evidence from the early childhood longitudinal study. *Am J Public Health*. 2004;94(9):1501–1506
38. Cawley J, Meyerhoefer C, Newhouse D. The impact of state physical education requirements on youth physical activity and overweight. *Health Econ*. 2007;16(12):1287–1301
39. Pate RR, Ward DS, Saunders RP, Felton G, Dishman RK, Dowda M. Promotion of physical activity among high-school girls: a randomized controlled trial. *Am J Public Health*. 2005;95(9):1582–1587
40. Dalton MA, Adachi-Mejia AM, Longacre MR, et al. Parental rules and monitoring of children's movie viewing associated with children's risk for smoking and drinking. *Pediatrics*. 2006;118(5):1932–1942
41. Adachi-Mejia AM, Longacre MR, Gibson JJ, Beach ML, Titus-Ernstoff LT, Dalton MA. Children with a TV in their bedroom at higher risk for being overweight. *Int J Obes (Lond)*. 2007;31(4):644–651
42. Titus-Ernstoff L, Dalton MA, Adachi-Mejia AM, Longacre MR, Beach ML. Longitudinal study of viewing smoking in movies and initiation of smoking by children. *Pediatrics*. 2008;121(1):15–21
43. YRBSS. Youth risk behavior surveillance system. Available at: www.cdc.gov/HealthyYouth/yrbs/index.htm. Accessed July 27, 2010
44. Wiecha JL, Finkelstein D, Troped PJ, Fragala M, Peterson KE. School vending machine use and fast-food restaurant use are associated with sugar-sweetened beverage intake in youth. *J Am Diet Assoc*. 2006;106(10):1624–1630
45. Nutritionquest/Block Dietary Data Systems. Blocks Kids Physical Activity Screener. Berkeley, CA: 2004
46. Chasan-Taber S, Rimm EB, Stampfer MJ, et al. Reproducibility and validity of a self-administered physical activity questionnaire for male health professionals. *Epidemiology*. 1996;7(1):81–86

47. Centers for Disease Control and Prevention (CDC). A SAS program for the CDC growth charts. Available at: www.cdc.gov/nccdphp/dnpao/growthcharts/resources/sas.htm. Accessed October 3, 2010
48. Centers for Disease Control and Prevention. Healthy weight: it's not a diet, it's a lifestyle! Available at: www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html. Accessed June 17, 2011
49. Huber PJ. The behavior of maximum likelihood estimates under nonstandard conditions. In: *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*. Vol 1. Berkeley, CA: University of California Press; 1967:221–233
50. Froot KA. Consistent covariance matrix estimation with cross-sectional dependence and heteroskedasticity in financial data. *J Finan Quantitative Anal*. 1989;24:333–355
51. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159(7):702–706
52. Sherry B, Jefferds ME, Grummer-Strawn LM. Accuracy of adolescent self-report of height and weight in assessing overweight status: a literature review. *Arch Pediatr Adolesc Med*. 2007;161(12):1154–1161
53. Goodman E, Hinden BR, Khandelwal S. Accuracy of teen and parental reports of obesity and body mass index. *Pediatrics*. 2000;106(1 pt 1):52–58
54. Brener ND, Mcmanus T, Galuska DA, Lowry R, Wechsler H. Reliability and validity of self-reported height and weight among high school students. *J Adolesc Health*. 2003;32(4):281–287
55. Himes JH, Hannan P, Wall M, Neumark-Sztainer D. Factors associated with errors in self-reports of stature, weight, and body mass index in Minnesota adolescents. *Ann Epidemiol*. 2005;15(4):272–278
56. Beets MW, Pitetti KH. Contribution of physical education and sport to health-related fitness in high school students. *J Sch Health*. 2005;75(1):25–30
57. Child Trends Data Bank. Participation in school athletics. Available at: www.childtrendsdatabank.org/?q=node/367. Accessed July 30, 2010
58. Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in US children and adolescents, 2007-2008. *JAMA*. 2010;303(3):242–249
59. Garcia M. At some schools, budget cuts put the kibosh on sports. *USA Today*. September 2, 2009. Accessed August 10, 2011
60. Staples A. School sports programs fight to stay alive in struggling economy. Available at: http://sportsillustrated.cnn.com/2008/writers/andy_staples/07/10/schools.economy/. Accessed August 10, 2011

Influence of Sports, Physical Education, and Active Commuting to School on Adolescent Weight Status

Keith M. Drake, Michael L. Beach, Meghan R. Longacre, Todd MacKenzie, Linda J. Titus, Andrew G. Rundle and Madeline A. Dalton

Pediatrics; originally published online July 16, 2012;
DOI: 10.1542/peds.2011-2898