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Predicting Maintenance or Achievement of Healthy Weight in Children: The Impact of Changes in Physical Fitness

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Abstract

Physical fitness is often inversely associated with adiposity in children cross-sectionally, but the effect of becoming fit or maintaining fitness over time on changes in weight status has not been well studied in children. We investigated the impact of changes in fitness over 1–4 years of follow-up on the maintenance or achievement of healthy weight among 2,793 schoolchildren who were first measured as 1st to 7th graders. Students were classified as "fit" or "underfit" according to age- and gender-specific norms in five fitness domains: endurance, agility, flexibility, upper body strength, and abdominal strength. Weight status was dichotomized by BMI percentile: "healthy weight" (<85th percentile) or "overweight/obese" (≥85th percentile). At baseline, of the 38.3% overweight/obese children, 81.9% (*N* = 875) were underfit. Underfit overweight students were more likely to achieve healthy weight if they achieved fitness (boys: odds ratio (OR) = 2.68, 95% confidence interval (CI) = 1.24–5.77; girls: OR = 4.67, 95%CI = 2.09–10.45). Initially fit overweight children (*N* = 194) were more likely to achieve healthy weight if they maintained fitness (boys: OR = 11.99, 95%CI = 2.18–65.89; girls: OR = 2.46, 95%CI = 1.04–5.83). Similarly, initially fit healthy-weight children (*N* = 717) were more likely to maintain healthy weight if they maintained fitness (boys: OR 3.70, 95%CI = 1.40–9.78; girls: OR = 4.14, 95%CI = 1.95–8.78). Overweight schoolchildren who achieve or maintain physical fitness are more likely to achieve healthy weight, and healthy-weight children who maintain fitness are more likely to maintain healthy weight. School-based policies/practices that support physical fitness may contribute to obesity reduction and maintenance of healthy weight among schoolchildren.

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DISCLOSURE
The authors declared no conflict of interest.

INTRODUCTION

The prevalence of overweight/obesity in US school-aged children was estimated at 35% in 2007–2008 (ref. 1). Obesity in childhood has both immediate and long-term psychological, physiological, and economic consequences, including increased risk for psychosocial disorders, asthma, sleep apnea, type 2 diabetes, as well as obesity in adulthood (2–5). Several serial observational studies (6–9) in child populations have reported that obesity rates have increased while fitness levels have fallen, and others have shown inverse cross-sectional associations between various measures of fitness and adiposity (10–15). However, there are few longitudinal studies on anthropometry and fitness in elementary- and middle-school-aged children (16–24), and just two, to our knowledge, have been conducted in American children (18,20). Because declining physical fitness in childhood may be an important predictor of childhood obesity, understanding whether declines in physical fitness in children signal the onset of obesity, or whether obesity signals an eventual decline in fitness, may provide valuable impetus for policy and funding for public health and/or school-based initiatives intended to foster fitness improvement as a way to mitigate future overweight/obesity and its associated risks and costs. Therefore, in this research, we use longitudinal, repeated measures of school-based fitness and BMI assessment data collected from schoolchildren as part of a routine health surveil-lance program to investigate the relationship between fitness levels and maintenance or achievement of healthy weight.

METHODS AND PROCEDURES

Participants

The Cambridge Public Schools comprise a diverse, urban area located outside of Boston, Massachusetts. Schoolchildren in kindergarten through 8th grade have been routinely measured for their level of physical fitness and BMI (as a proxy for adiposity) since 2000 as a part of the Cambridge Public School Health Surveillance System. Surveillance measurements are a mandatory part of the physical education curriculum and students may opt out only with written parental permission. The surveillance measurements collected during the timeframe of this study coincided with a community-based, participatory obesity prevention intervention (2004/2005–2006/2007 school years) in the schools and the community (25).

Approximately 1 month before data collection, physical education teachers participated in a 3-h training session on anthropometry and data entry based on a standardized protocol (26). Approximately 2 weeks before data collection, students' families were informed by a letter sent home with students that measurements would be taking place. The institutional review board of the Cambridge Health Alliance approved this secondary analysis of the school data.

The population of interest for this analysis included the 3,238 school-children enrolled in Cambridge Public Schools who were in 1st to 7th grade when they had a baseline, in-school anthropometric and fitness assessment in the 2004/2005–2006/2007 school years, and at least one other follow-up assessment beyond baseline conducted not later than 8th grade and not later than the end of the 2007/2008 school year.

We excluded students (*N* = 10) with biologically implausible cross-sectional values (i.e., BMI *Z* scores <–4 or >5, based on the Centers for Disease Control and Prevention recommendations; ref. 27). As recommended cut points for biologically implausible values for year-to-year changes are unavailable for longitudinal surveillance data, we additionally excluded students (*N* = 435) with single-year changes of >10% increase or >2% decrease in height, and >27% increase or >5% decrease in weight. After these exclusions, data on 2,793 students with 9,552 unique observations (two or more observations per student) were available for these analyses.

Anthropometric assessment

In February of each year, trained physical education teachers and school nurses measured each child's standing height to the nearest 0.25 inch once with a wall-mounted stadiometer (216 Accu-Hite; Seca, Snoqualmie, WA). Weight was measured to the nearest 0.2 pound with an electronic scale (216 Bellisima-digital; Seca) in indoor clothing without shoes (18,28). A small reliability study (29) conducted with Cambridge physical education teachers resulted in high intra- and inter-rater height and weight correlation coefficients in a controlled setting ($r \geq 0.96$) and in a natural (in-class) setting ($r \geq 0.98$). BMI was calculated as weight in kilograms divided by squared height in meters (kg/m^2). BMI percentiles and BMI *Z* scores were assigned based on the Centers for Disease Control and Prevention Growth Charts using a SAS macro program obtained from the Centers for Disease Control and Prevention (27).

Fitness assessment

Physical fitness in five fitness domains was assessed annually by trained physical education teachers in February using the guidelines of the Amateur Athletic Union (30) and Fitnessgram (Cooper Institute; ref. 31). Children's proficiency status (Participation, Attainment, and Outstanding) was assigned for each test based on age and gender cut points, and children were considered “passing” if they achieved “Attainment” or “Outstanding.” The domains are (i) endurance, assessed by a 20-yard shuttle run; (ii) abdominal strength, assessed by isometric curl-ups; (iii) upper body strength, assessed by pull-ups, modified pull-ups, or flexed arm hang; (iv) agility, assessed by a 10-yard shuttle run; and (v) flexibility, assessed by sit-and-reach. Physical education teachers also offered students modified versions of the agility and abdominal strength tests in certain cases, as described elsewhere (18).

Covariates

We included potential confounders of the fitness–weight relationship, including age, gender, race/ethnicity, socioeconomic status (SES), and follow-up time as covariates. Birth date, gender, race/ethnicity, school, and school lunch status were obtained from school administrative records. Age in years, as a continuous variable, was calculated as a child's test date minus his/her birth date. Race/ethnicity, coded as a categorical variable, was collapsed due to small numbers in some categories into the following: white, black, Hispanic, Asian, and other, which included children of mixed race/ethnicity. The 12 schools that contributed student observations were coded as a categorical variable. School lunch status was coded as a binary variable and used as a proxy for family SES (free or reduced-price lunch (≤185% of federal household income level) vs. paid lunch; ref. 32). Follow-up time was calculated as the number of years between baseline and final measures and ranged from 1 to 4 years.

Variable construction and data analysis

Outcome and exposure definitions. Weight status was dichotomized based on Centers for Disease Control and Prevention cutoffs for BMI (33). For our purposes, "healthy weight" was defined as <85th BMI percentile for age and gender; "overweight/obese" was defined as ≥85th BMI percentile for age and gender.

Fitness test results in each domain were used as a categorical measure (Outstanding, Attainment, or Participation). In addition, we defined a binary overall fitness score, as follows: per Cambridge Public Schools standard practice, scoring Attainment or Outstanding in all five fitness domains was defined as "fit"; scoring Participating or no score in one or more domains was defined as "underfit" (18). From these definitions, we identified four categories of students: (i) if students were fit at their baseline measure, but underfit at their final measure, they are said to have "lost fitness"; (ii) if students were underfit at their baseline measure, but fit at their final measure, they "achieved fitness"; (iii) if students were fit at their baseline and final measures, they "maintained fitness"; and (iv) if students were underfit at their baseline and final measures, they "remained underfit."

Data analysis. We elected *a priori* to stratify all analyses by gender and weight status based on relevant literature. We generated descriptive statistics presented as percentages. Models were developed to predict incidence (i.e., whether initially healthy-weight children maintained healthy weight) or remission of overweight/obesity (i.e., whether initially overweight/obese children achieved healthy weight). We tested initial logistic regression models (SAS PROC LOGISTIC) using baseline fitness, final fitness, and baseline weight status to predict final weight status, as a binary outcome, in initially healthy weight (for incidence) or initially overweight/obese students (for remission) for the presence of an interaction between baseline and final fitness (as a cross-product term). In the presence of a significant two-way interaction, we further stratified by baseline fitness before subsequent analysis.

Multivariable logistic regression models (SAS PROC GENMOD) were then developed to predict final weight status in each of four strata: (i) initially fit, healthy-weight students; (ii) initially fit, overweight/obese students; (iii) initially underfit, healthy-weight students; and (iv) initially underfit, overweight/obese students. Final fitness level was the primary predictor of interest. In addition, to generate hypotheses about which domain is most predictive of incidence/remission of overweight/obese, we assessed the effects of each fitness domain on final weight status in the presence of other domains by developing models, which included all fitness domain scores as separate variables.

Logistic regression models were adjusted for baseline age, race/ethnicity, family SES, and follow-up time. In addition, we accounted for potentially correlated data between students within schools by adjusting for within-school repeated measures in our models.

Additional analyses. To take advantage of the additional information in repeated measures on students, we used differences in consecutive measures in 2,711 students (6,645 observations) to estimate whether the change in fitness between years (e.g., 2004–2005) was predictive of the BMI *Z* score in the following year (e.g., 2005). Change in fitness was modeled as the number of fitness tests passed in a given year (i.e., scoring Attainment or Outstanding in any domain), on a scale ranging from 0 to 5, subtracted from the number of tests passed in the preceding year. These models (SAS PROC MIXED) accounted for the repeated measures in students and schools, and were adjusted for the preceding year's BMI *Z* score, and age, race/ethnicity, and family SES.

Estimates for odds ratios (ORs), 95% confidence intervals (CIs), or *P* values were calculated. A two-sided *P* value of <0.05 was considered statistically significant. All analyses were conducted using the SAS statistical program (version 9.2; SAS Institute, Cary, NC).

RESULTS

The baseline characteristics of students are shown in **Table 1**. Forty-eight percent of students were girls, 35.3% were white, 45.7% received free or reduced priced school lunches, and 15.4% were first measured as first graders. A very small portion (1.3%) of students were underweight. The overall baseline prevalence of overweight/obesity was 38.3%, and of under-fit was 67.4%. Overall, 1,616 (93.7%) students who were at a healthy weight at baseline maintained a healthy weight at the final assessment, while 108 (6.3%) of these children became overweight/obese. Of the 1,069 students who were originally overweight/obese, 16.8% achieved a healthy weight by the final assessment. Of the 911 children who were fit at baseline, 58.7% maintained fitness at the final assessment; 504 (26.8%) of the 1,882 students who were underfit at baseline were able to achieve fitness by the final assessment.

The results of the multivariable logistic regressions are shown in **Tables 2** and **3**. **Table 2** shows the impact of maintaining, achieving, or losing fitness in initially overweight/obese children who were either fit or underfit at baseline, by (i) overall fitness (i.e., Attainment or Outstanding in all five fitness domains) and (ii) separate fitness domains. Girls who were overweight/obese and underfit at baseline were nearly five times more likely to achieve a healthy weight if they achieved fitness compared with those who remained underfit (OR = 4.67; 95%CI = 2.09, 10.45). Similarly, boys who were overweight/obese and underfit at baseline were over 2.5 times more likely to achieve a healthy weight if they achieved fitness compared with those who remained underfit (OR = 2.68; 95%CI = 1.24, 5.77). Overweight/obese girls and boys who were fit at baseline were 2.5 and 12 times as likely, respectively, to achieve a healthy weight if they maintained fitness compared with those who lost fitness (girls: OR = 2.46, 95%CI = 1.04, 5.83; boys: OR = 11.99, 95% CI = 2.18, 65.89).

Table 3 shows the impact of maintaining, achieving, or losing fitness in initially healthy-weight boys and girls who were either fit or underfit at baseline. Girls initially at a healthy weight who maintained fitness were over four times as likely to maintain a healthy weight than those who lost fitness (OR = 4.14; 95%CI = 1.95, 8.78). Similarly, in boys, those who maintained fitness were >3.5 times as likely to maintain a healthy weight than those who lost fitness (OR = 3.70; 95%CI = 1.40, 9.78). However, the impact of achieving overall fitness in initially underfit, healthy-weight children had no significant effect on maintaining weight status in either boys or girls.

Of the different fitness domains, endurance appears to be the most consistent predictor of the impact of various fitness tests on weight status in all children. In initially overweight/obese children, each incremental increase in the endurance score (e.g., from Participation, to Attainment, to Outstanding) was associated with 1.75–5.73 greater odds of achieving a healthy weight. Similarly, among those initially at a healthy weight, each incremental increase in the endurance score was associated with 1.82–4.57 greater odds of maintaining a healthy weight. In boys, in addition to endurance, the upper body strength score also appeared to be consistently predictive of maintaining or achieving a healthy weight. There were no other consistent results for girls with respect to fitness domains.

Analyses of repeated measures identified similar trends in the protective effects of maintaining or improving fitness (data not shown). On average, for every increase in the number of fitness tests passed between two successive years, there was a statistically significant decrease in the subsequent year BMI *Z* score ($\beta = -0.019$, $P < 0.0001$), after controlling for prior year BMI *Z* score, age, gender, race/ethnicity, and family SES, and accounting for between-student and within-school correlations.

DISCUSSION

Our analyses suggest that elementary- and middle-school-aged children who maintain or improve their fitness status are significantly more likely to maintain healthy weight or experience a remission of overweight/obesity over 1–4 years. Comparable studies are scarce. We identified two studies that examine this question in American schoolchildren (18,20), and one study in Canadian schoolchildren (23), which somewhat echo our results, and thus our findings add to the evidence supporting physical fitness promotion and the utility of school-based surveillance of fitness measures.

In a study of energy expenditure, aerobic fitness, and adiposity in 95 white and black children aged 4–11 years in Birmingham, Alabama, Johnson *et al*. (20) reported that even after accounting for baseline adiposity, increasing aerobic capacity by just 8% would result in a reduced rate of increasing adiposity and a decrease of 1.3% body fat over a 3- to 5-year study period. In an earlier study of Cambridge public school-children, Kim *et al.* investigated the risk of becoming obese (≥95th BMI percentile) in over two 1-year periods (2001–2002 and 2002–2003; the two school years immediately preceding those used in this study). The authors found that unfit boys, as compared with fit boys, were 80% more likely to become obese in a 1-year period, while unfit girls, as compared with fit girls, were more than three times as likely to become obese in a 1-year period (18). Here, we have examined the role of fitness in these children across a longer follow-up, and have closely examined the remission of overweight/obesity as well as the likelihood of maintenance of healthy weight. Consistent with other studies employing multiple fitness measures (10–11,16), our results show that cardiorespiratory fitness—measured here with the 20-yard shuttle run—is the fitness measure most strongly associated with weight status.

It is evident that children can become more fit over time regardless of weight status. Over a quarter of initially underfit students in our population went on to achieve fitness within 1–4 years. In addition, nearly 60% of children who were initially fit were able to maintain a similarly high level of fitness. As noted, the longitudinal study population was drawn from a school system engaged in implementing extensive obesity prevention activities (2004/2005–2006/2007 school years), including "Health (BMI) and fitness report cards," physical education reform with an emphasis on developing lifelong daily physical activity skills, equipment and gymnasium upgrades, professional development for physical education teachers, and increased opportunities for physical activity before and after school (25,34). Forty-five-minute physical education classes were offered twice a week and recess was included daily. These fitness results, achieved concurrently with the Cambridge obesity prevention intervention, suggest that investments in school-based physical education and physical activity improvements support changes in fitness, which may translate into obesity prevention and reduction.

In our study population, for children who were under-fit but at a healthy weight at baseline, achieving fitness was nonsignificant with respect to maintaining a healthy weight. This may suggest that for those students who are initially at a healthy weight, achieving fitness does not appear to be protective against becoming overweight/obese, unlike losing fitness, which is associated with greater risk of becoming overweight/obese in this population. We believe that the impact of being underfit in a healthy-weight subgroup may be better reflected with more sophisticated measures of body composition, which could reveal important differences in body fat and abdominal adiposity that crude measures of adiposity, such as BMI, are not able to capture. This hypothesis is borne out in several studies that have used such measures (14,19–20,35). For example, in a small study of 113 American children, those with moderate or high cardiorespiratory fitness had significantly lower visceral and subcutaneous adipose tissue than those with low cardiorespiratory fitness, even within the same BMI category (35). Therefore, the potential positive impact of improving fitness, even in a healthy-weight child population, should not be underestimated and caution should be used when interpreting the finding presented here.

Strengths of this study include its repeated measures of height, weight, and multiple fitness domains by trained physical education teachers and school nurses during an obesity prevention intervention. Results of our small reliability study suggest that physical education staff, with training and data quality checks, can reliably collect student height and weight for monitoring obesity and evaluating intervention programs (29). The small differences observed in measurements would likely not contribute to significant misclassification of students according to weight- and height-based indexes.

Although no analogous validation studies have been conducted in this population of teachers and students with respect to fitness measurements, the five fitness tests used are widely used in schools and are accepted fitness measures, and our results are consistent with other reports. By adjusting for potential within-school correlations, we expected to additionally account for unmeasured factors associated with the immediate school and community environment, which may include variations in teacher measurements, physical education classes, and so on. We acknowledge that fitness test results and BMI can be influenced by maturation status, and that there may additionally exist within-gender differences in these measures due to maturation status. This is especially true when fitness norms, such as those employed here, are constructed by chronological age and gender without consideration of maturation, which is known to differ by race (36). Despite a stratified analysis and the use of pre-established age- and gender-based fitness score cut points, the differences we observed between boys and girls suggest that there are differences not captured by national norms. These excess differences may be related to maturation, race/ethnicity, or other sociocultural differences. Although most of our study population was of chronologically prepubertal age for the duration of follow-up (i.e., nearly 25% of the study population was 6 or 7 years old at baseline), and again, although we stratified by our analyses by gender, our lack of information on potential confounders such as maturation, growth history, and other nutritional or behavioral factors may limit the interpretation of our findings. In addition, although an interval of up to 4 years of follow-up is likely long enough before the onset of puberty to evaluate the effects of fitness on the incidence of overweight/obesity in the younger members of the study population, 31% of the study population had only a single year of follow-up; this timeframe may be too short to adequately evaluate fitness effects.

This study was conducted using data from schools in a diverse, urban setting, and thus our findings may not generalize to other child populations notably different from this one (e.g., rural). Finally, although we sought to answer the question of whether a change in fitness predicts a change in weight status, we acknowledge the potential for reverse causality—that changes in weight status might drive changes in fitness.

Conclusion

In summary, among initially overweight/obese children, maintaining fitness or improving fitness appears to help them achieve a healthy weight. Among initially fit children at a healthy weight, maintaining fitness appears to help them maintain a healthy weight (or, conversely, protect them from becoming overweight/obese). These promising results suggest that supporting school-based policies and educational initiatives that promote fitness may help children maintain or achieve a healthy weight and thus help them avoid many of the psychosocial and physiological consequences of excess weight in childhood and adulthood.

Further analyses and additional research are needed to expand our understanding of the longitudinal impact of fitness on school-age children, and to evaluate associations between more sophisticated measures of body composition and changing fitness levels. Improved approaches to consistently, inexpensively, and effectively monitor child physical fitness and activity, as well as weight and body composition status at the population level are essential to support this important area of research. Further studies that include experimental designs to investigate the promising relationship of physical education reform and physical activity promotion on fitness and obesity are warranted. Such evidence is necessary to advocate for school-based physical activity and health programming and support educational policies that promote the whole health and whole development of the child.

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Table 1

Baseline characteristics of Cambridge students, by gender, weight status, and fitness level

	All students	All girls	Girls: Overweight/obese N	Girls: Overweight/obese %	Girls: Underfit N	Girls: Underfit %	All boys	Boys: Overweight/obese N	Boys: Overweight/obese %	Boys: Underfit N	Boys: Underfit %
Overall	2,793	1,337	491	36.7	881	65.9	1,456	578	39.7	1,001	68.8
Ethnicity											
White	987	461	128	27.8	279	60.5	526	160	30.4	349	66.3
Black	1,088	533	253	47.5	390	73.2	555	253	45.6	393	70.8
Asian	262	131	31	23.7	79	60.3	131	47	35.9	101	77.1
Latino	425	193	76	39.4	122	63.2	232	111	47.8	149	64.2
Other	31	19	3	15.8	11	57.9	12	7	58.3	9	75.0
Free lunch											
Paid	1,517	728	228	31.3	448	61.5	789	267	33.8	530	67.2
Free/reduced	1,276	609	263	43.2	433	71.1	667	311	46.6	471	70.6
Grade at first test											
1	431	223	57	25.6	132	59.2	208	67	32.2	135	64.9
2	418	187	56	29.9	112	59.9	231	96	41.6	155	67.1
3	407	183	73	39.9	126	68.9	224	96	42.9	148	66.1
4	337	165	70	42.4	104	63.0	172	62	36.0	122	70.9
5	399	197	81	41.1	139	70.6	202	84	41.6	144	71.3
6	379	179	69	38.5	114	63.7	200	77	38.5	147	73.5
7	422	203	85	41.9	154	75.9	219	96	43.8	150	68.5
Baseline weight status											
Underweight	37	18			12	66.7	19			11	57.9
Healthy weight	1,687	828			469	56.6	859			515	60.0
Overweight	497	220	220		161	73.2	277	277		199	71.8
Obese	572	271	271		239	88.2	301	301		276	91.7
Baseline fitness tests passed											
0	51	21	15	71.4	21		30	23	76.7	30	
1	217	96	65	67.7	96		121	75	62.0	121	

	All students	Girls					Boys				
		All girls	Overweight/obese		Underfit		All boys	Overweight/obese		Underfit	
			N	%	*N*	%		*N*	%	*N*	%
2	366	164	94	57.3	164		202	119	58.9	202	
3	578	289	132	45.7	289		289	142	49.1	289	
4	670	311	94	30.2	311		359	116	32.3	359	
5	911	456	91	20.0			455	103	22.6		
Baseline endurance score[a]											
Participation	1,274	551	313	56.8	551	100.0	723	402	55.6	723	100.0
Attainment	1,058	535	148	27.7	228	42.6	523	146	27.9	215	41.1
Outstanding	459	249	29	11.6	100	40.2	210	30	14.3	63	30.0
Baseline agility score[a]											
Participation	760	356	187	52.5	356	100.0	404	223	55.2	404	100.0
Attainment	897	509	185	36.3	297	58.3	388	150	38.7	268	69.1
Outstanding	1,129	467	116	24.8	223	47.8	662	204	30.8	327	49.4
Baseline flexibility score[a]											
Participation	599	347	129	37.2	347	100.0	252	95	37.7	252	100.0
Attainment	1,236	539	210	39.0	313	58.1	697	282	40.5	456	65.4
Outstanding	957	450	151	33.6	220	48.9	507	201	39.6	293	57.8
Baseline abdominal strength score[a]											
Participation	298	88	48	54.5	87	98.9	210	114	54.3	210	100.0
Attainment	796	372	169	45.4	255	68.5	424	191	45.0	296	69.8
Outstanding	1,697	875	273	31.2	529	60.5	822	273	33.2	495	60.2
Baseline upper body strength score[a]											
Participation	827	373	239	64.1	373	100.0	454	291	64.1	454	100.0
Attainment	1,005	454	161	35.5	274	60.4	551	195	35.4	361	65.5
Outstanding	960	509	90	17.7	233	45.8	451	92	20.4	186	41.2
Years of follow-up											
1	865	425	166	39.1	306	72.0	440	187	42.5	315	71.6
2	546	255	95	37.3	165	64.7	291	114	39.2	212	72.9
3	479	210	81	38.6	142	67.6	269	114	42.4	191	71.0

	All students	Girls					Boys				
		All girls	Overweight/obese		Underfit		All boys	Overweight/obese		Underfit	
			N	%	*N*	%		*N*	%	*N*	%
4	903	447	149	33.3	268	60.0	456	163	35.7	283	62.1

Weight status: underweight, <5th BMI percentile; healthy weight, ≥5th and <85th BMI percentile; overweight, ≥85th and <95th percentile; obese, ≥95th percentile. Underfit is defined as failing at least one of the five physical fitness tests.

[a] Sample sizes vary slightly due to missing data.

Table 2

Odds of achieving healthy weight in 1–4 years of follow-up, by overall fitness and individual fitness domains

	Girls			Boys		
	OR (95% CI)			OR (95% CI)		
Initially underfit	48/400 initially overweight/obese girls achieved healthy weight			76/475 initially overweight/obese boys achieved healthy weight		
Overall fitness[a]						
Achieved fitness	4.67	(2.09	10.45)	2.68	(1.24	5.77)
Remained underfit	Reference			Reference		
Fitness domains[b]						
Endurance	1.78	1.15	2.77	1.75	1.16	2.64
Agility	1.72	1.13	2.61	1.48	0.99	2.22
Flexibility	0.63	0.38	1.06	0.67	0.43	1.05
Upper body strength	1.36	0.99	1.87	2.26	1.53	3.34
Abdominal strength	1.79	1.00	3.20	1.15	0.69	1.94
Initially fit	26/91 initially overweight/obese girls achieved healthy weight			30/103 initially overweight/obese boys achieved healthy weight		
Overall fitness[a]						
Maintained fitness	2.46	(1.04	5.83)	11.99	(2.18	65.89)
Lost fitness	Reference			Reference		
Fitness domains[b]						
Endurance	2.73	1.40	5.33	5.73	1.88	17.48
Agility	0.77	0.42	1.42	0.58	0.23	1.45
Flexibility	0.45	0.25	0.83	1.13	0.45	2.82
Upper body strength	1.55	0.83	2.88	4.61	1.59	13.36
Abdominal strength	2.01	0.66	6.11	2.80	0.88	8.89

CI, confidence interval; OR, odds ratio; SES, socioeconomic status.

[a]The OR represents the odds of achieving a healthy weight (remission of overweight/obesity) for students who achieved (initially underfit) or maintained (initially fit) fitness. For overall fitness, models were adjusted for age, race/ethnicity, family SES, follow-up time, and within-school correlation structure.

[b]The OR represents the odds of achieving a healthy weight (remission of overweight/obesity) for each incremental increase in score (i.e., from Participation to Attainment to Outstanding). For fitness domains, models were adjusted for age, race/ethnicity, family SES, follow-up time, and within-school correlation structure, and all other domains were included in each model.

Table 3

Odds of maintaining healthy weight in 1–4 years of follow-up, by overall fitness and individual fitness domains

	Girls			Boys		
	OR (95% CI)			OR (95% CI)		
Initially underfit	456/481 initially healthy weight girls maintained healthy weight			487/526 initially healthy weight boys maintained healthy weight		
Overall fitness[a]						
Achieved fitness	1.89	(0.74	4.83)	1.31	(0.55	3.14)
Remained underfit	Reference			Reference		
Fitness domains[b]						
Endurance	1.82	0.94	3.51	1.85	1.21	2.82
Agility	0.97	0.55	1.71	0.82	0.63	1.07
Flexibility	0.57	0.29	1.13	0.93	0.66	1.31
Upper body strength	1.57	0.81	3.04	1.73	1.17	2.57
Abdominal strength	2.79	1.41	5.51	1.20	0.87	1.67
Initially fit	339/365 initially healthy weight girls maintained healthy weight			334/352 initially healthy weight boys maintained healthy weight		
Overall fitness[a]						
Maintained fitness	4.14	(1.95	8.78)	3.70	(1.40	9.78)
Lost fitness	Reference			Reference		
Fitness domains[b]						
Endurance	4.57	2.68	7.80	3.03	1.40	6.56
Agility	1.23	0.72	2.07	0.74	0.18	3.05
Flexibility	1.95	1.18	3.22	0.41	0.14	1.23
Upper body strength	1.34	0.74	2.42	1.96	0.80	4.82
Abdominal strength	1.44	0.62	3.38	0.33	0.06	1.73

CI, confidence interval; OR, odds ratio; SES, socioeconomic status.

[a]The OR represents the odds of maintaining a healthy weight for students who achieved (initially underfit) or maintained (initially fit) fitness. For overall fitness, models were adjusted for age, race/ethnicity, family SES, follow-up time, and within-school correlation structure.

[b]The OR represents the odds of maintaining a healthy weight for each incremental increase in score (i.e., from Participation to Attainment to Outstanding). For fitness domains, models were adjusted for age, race/ethnicity, family SES, follow-up time, and within-school correlation structure, and all other domains were included in each model.