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ORIGINAL ARTICLE

School-based physical activity and changes in adiposity

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Objective: School-based physical education (PE) is often proposed as a strategy for obesity prevention, but many trials have found non-significant effects on body mass index (BMI). We examined the impact of school PE on adiposity in adolescents, using an ecological analysis to relate the number of PE sessions to changes in BMI and waist circumference.
Research methods and procedures: Five-year, longitudinal, school-based study involving 34 secondary schools in London, England. Students were aged 11–12 years at baseline. Twenty-five schools reported one weekly session of PE, seven schools reported two sessions and two boys' schools reported three sessions. Weights, heights and waist circumferences were measured annually, and complete data from the first and fifth years of the study were available on 2727 students. Analyses compared anthropometric changes between students in schools with higher or lower amounts of PE time. In boys, the comparisons were between those receiving 1, 2 or 3 weekly sessions. In girls, comparisons were between those receiving one and two sessions.
Results: There were no differences in BMI changes or the percentage of students classified as obese between schools of higher and lower frequency of PE. However, using unadjusted data, there were lower gains in waist circumference in boys and girls from the higher PE schools. Controlling for baseline demographic and anthropometric characteristics, boys in schools providing 3 weekly PE sessions gained on average approximately 3 cm less than boys in schools providing one or two sessions ($P<0.001$). Differences in girls were in the same direction but not significant.
Discussion: Higher levels of school PE were associated with lower gains in adiposity in boys. This strengthens the case for including recommendations on school PE time as part of population strategies to control adolescent obesity.
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Introduction

The declining levels of physical activity that have characterized late twentieth century lifestyles are widely believed to have contributed to the worldwide epidemic of childhood obesity. Many countries are developing policy initiatives to promote physical activity through a combination of health education and improvement of leisure amenities. School-based physical activity is a popular target because of its potential to reach almost all children in the population.

The evidence to date on the impact of school-based physical activity interventions has been disappointing. Campbell *et al.*[1] reviewed longer-term trials that incorporated a physical activity component. Effects on adiposity were seen only in the *Planet Health* program,[2] and then only among girls. Reviewing an additional eight trials, Wareham *et al.*[3] also found heterogeneous results: two trials achieved effects for boys but not girls,[4,5] while the others, including the elaborate *Pathways* program that ran for 3 years,[6] were unsuccessful in modifying adiposity. The US Task Force on Community Preventive Services concluded that the evidence on school-based interventions was not adequate to recommend them for obesity prevention.[7] One explanation for the mixed results could be variability in implementation of the physical activity program in the trial context. When fitness-orientated PE classes were delivered under intensive supervision – thereby ensuring student participation – significant reductions in body fat as well as improvements in insulin sensitivity were achieved.[8]

An alternative approach to evaluating the impact of school activity is to take advantage of variation between schools in the amount of physical education (PE) in the curriculum and compare changes in adiposity in pupils at schools with

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higher or lower PE time. This approach lacks the scientific rigor of a controlled trial but has the advantage of ecological validity. Data from a large longitudinal study in the United States were used to examine changes in body mass index (BMI) in kindergarten and first grade in relation to differences in timetabled PE at each stage.[9] Modeling the association between PE time and weight gain, the results suggested that an hour a week more PE from kindergarten to first grade was associated with a smaller BMI gain in overweight girls, although there was no significant effect in boys or in normal-weight children of either sex. However, this study could have underestimated the effect of school PE by using BMI because it is relatively insensitive to changes in adiposity achieved through physical activity in view of increases in muscle mass. This was highlighted in Carrel *et al.*[8] intervention, which achieved substantial changes in percentage body fat, while BMI differences were non-significant with a trend towards higher BMI in the intervention group.

We examined changes in waist circumference and BMI over 5 years in relation to the number of scheduled PE classes in students attending schools in London, England, as part of the Health and Behaviour in Teenagers (HABITS) study.

Methods

Setting and participants

The HABITS study is a 5-year cohort study of students attending 36 secondary schools in London, England (see Wardle *et al.*[10,11] for details) designed to investigate trajectories of smoking and adiposity during adolescence. Eleven of the schools admitted boys and girls and the others were single sex, which is characteristic of the British school system. Data collection started in 1999 with 4320 students in year 7 (age 11–12) and continued annually to year 11 (age 15–16). Two schools withdrew after year 10 because of staff changes at the school. All students registered in the designated school year at the time of data collection were eligible to take part. Parents were informed about the study and given the option to exclude their child. Students were given individual consent forms and informed of their right to withdraw from the study. The study was approved by the University College London/University College London Hospital Medical Ethics Committee.

Measures

Anthropometric data were collected by trained researchers who visited the schools annually at the same time of year. Weights and heights were measured to the nearest 0.1 kg and 0.1 cm respectively using TANITA scales and a Leicester freestanding stadiometer, with students wearing light clothing without shoes. Waist measurements were taken under clothes, to the nearest 0.5 cm, as described by McCarthy *et al.*[12] BMI (kg/m^2) was calculated and overweight and obesity status established from IOTF criteria.[13] BMI standard deviation (s.d.) scores were calculated using the Excel Growth Macro for the British 1990 growth reference curves.[14] Waist-for-height was calculated as the ratio of waist divided by height.

PE in the school timetable was established from teachers' and students' reports of the number of PE and games classes a week in year 11. Where available (29 schools) teacher's reports of the number of sessions of PE and games lessons were used to classify the schools; in the remaining five schools the modal student report was used to classify the school. Teacher's reports were only available from year 11, but pupils' reports were available for all years. The correlation across years (from 7 to 11) for pupils' reports was 0.58.

Ethnicity (White, Black or mixed Black; Asian or mixed Asian; other) was based on students' self-report. Students also reported their postcodes, which were matched to enumeration districts to derive an area-based measure of family socioeconomic deprivation, the Townsend index.[15]

Statistical analysis

Descriptive analyses were carried out on data obtained from years 7 and 11. Linear mixed models were used for the analyses of association of school PE with measures of adiposity. The models took account of the effect of students' clustering within schools and adjusted for baseline values and confounding factors. Statistical packages SPSS and MLwiN were used.

Results

In year 7, 84% ($n=4320$) of students registered in the participating schools, took part; 10% of students were absent on the day of data collection and 6% of parents or students declined participation. Of students registered in year 11, 78% completed the data collection with 3% declining and 19% absent on the day of data collection (absences were higher because students were on 'work experience'). A small number declined the anthropometric measurements or had outlying values at one or both time points ($n=60$). Complete anthropometric data for years 7 and 11 were available for 2727 students (1580 boys and 1147 girls) for the analysis of change, representing 67% of students in the 34 schools who were registered in year 7 and still registered in year 11.

Twenty-five schools reported 1 weekly sessions of PE, nine schools reported two sessions, and two boys' schools reported 3 weekly PE sessions. Sociodemographic characteristics of students in higher, medium and lower PE schools are shown in Table 1. There were differences in the ethnic distributions between schools according to levels of PE (boys and girls, $P<0.001$), although these were greater among girls. Boys at higher PE schools came from slightly less socioeconomically deprived backgrounds ($P<0.001$) but there was no significant SES difference between school types

Table 1 Demographic characteristics for pupils completing both years of data collection

	Boys (N = 1583)			*Girls (N = 1147)*	
	PE = 1 session (N = 1185)	*PE = 2 sessions (N = 231)*	*PE = 3 sessions (N = 167)*	*PE = 1 session (N = 1004)*	*PE = 2 sessions (N = 143)*
Age in year 7					
Mean	11.76	11.96	11.85	11.83	11.96
s.d.	0.36	0.32	0.35	0.32	0.33
Townsend index quintiles					
Mean	2.90	2.45	2.96	3.15	3.18
s.d.	1.46	1.29	1.26	1.55	1.55
Ethnicity (%)					
White	66.9	72.3	57.5	59.5	46.9
Black	20.3	14.7	19.2	26.1	46.2
Asian	10.7	9.5	19.2	11.3	4.9
Other	2.0	3.5	4.2	3.1	2.1

for girls. Boys and girls attending the higher PE schools were about a month older ($P < 0.001$), because of slight differences in the timing of the visits in the school year.

Baseline (year 7) values of age, waist circumference, BMI and the proportion of pupils obese are shown in Table 2. Boys attending schools providing 3 weekly PE sessions had larger waist circumferences ($P < 0.001$). Mean BMI and the proportions obese in year 7 did not differ between the types of school for either boys or girls.

Unadjusted anthropometric values for year 11 (Table 2) indicate that mean waist circumference increases were 0.97 cm smaller in boys in schools with two PE sessions compared to schools with one session and 4.35 cm smaller in schools with three PE sessions; while the difference for girls was 1.07 cm less in schools with two PE sessions rather than one. BMI increases from years 7 to 11 were very slightly, but non-significantly, lower in the low PE schools. The analyses were repeated using BMI s.d. scores, with the same pattern of results (data not shown). The proportion of students with BMI in the IOTF overweight or obese categories were slightly lower in boys from high exercise schools, but the pattern was reversed in girls and effects were not significant in either group.

Final values for mean waist circumference in year 11 were calculated after adjustment for age, initial values of waist circumference, SES (for boys) and ethnic group (for girls). Adjusted figures show that boys attending schools with one, two or three sessions of PE a week achieved waist circumferences of 78.79 cm (s.e. = 0.30), 78.07 cm (s.e. = 0.63) and 75.05 cm (s.e. = 0.81) respectively. After adjustment, boys from the three-session schools had significantly smaller waists than boys from other schools ($P = 0.001$). After adjustment, the difference for girls for one compared to two sessions of PE was not significant; adjusted means were 74.47 cm (s.e. = 0.35) vs 73.38 cm (s.e. = 0.76) respectively ($P = 0.235$). Analyses using waist-for-height gave a similar pattern of results with similar levels of statistical significance for boys and girls. The effect of school PE was the same for students initially above or below the 85th centile for waist circumference and similar for normal-weight pupils compared with those who were overweight or obese, although power was limited for these subgroup analyses.

There were no significant effects of school PE on changes in BMI or in BMI s.d. scores, either in boys or girls, or among overweight and obese compared with normal-weight pupils. School PE also had a negligible and non-significant effect on the probability of becoming obese.

Discussion

These results provide some encouragement for promoting school-based physical activity as a means of controlling gains in adiposity in adolescence, at least for boys. A difference of around 4.5 cm in the 4-year waist circumference gain between schools with highest and lowest PE provision emerged for boys in this study and remained significant after controlling for demographic characteristics and initial waist size. While there are no algorithms to translate waist circumference to fat mass in adolescents, there can be no doubt that this is a positive effect and likely to improve health outcomes. Waist circumference has been shown to provide information on coronary artery risk factors in children and adolescents beyond that provided by BMI alone.[16,17]

We found no effects of school activity on BMI or BMI s.d. scores, nor any significant differences in the development of obesity as indexed by the IOTF criteria. The most likely explanation is that exercise increases muscle mass and this offsets the effects of fat loss on weight and BMI; an effect also observed in other studies of physical activity.[8,18]

We analyzed the results separately by gender because of previous findings of stronger effects either in girls[2,9] or

Table 2 Anthropometric data (unadjusted) for pupils completing both years of data collection according to the number of weekly PE sessions

	Boys (N = 1542)			*Girls (N = 1147)*	
	PE = 1 session (N = 1185)	*PE = 2 sessions (N = 231)*	*PE = 3 sessions (N = 167)*	*PE = 1 session (N = 1004)*	*PE = 2 sessions (N = 143)*
Waist year 7					
Mean	66.99	68.69	69.29	67.58	68.57
s.d.	7.87	7.56	7.79	8.27	7.94
Waist year 11					
Mean	78.49	79.21	76.44	74.58	74.55
s.d.	9.59	8.46	8.80	9.10	8.98
Waist change (years 7–11)					
Mean	+11.50	+10.52	+7.14	+7.01	+5.98
s.d.	6.50	6.23	7.14	6.40	6.43
BMI year 7					
Mean	18.80	19.01	19.03	19.73	20.23
s.d.	3.21	3.08	2.93	3.63	3.94
BMI year 11					
Mean	21.74	21.92	21.75	22.58	22.85
s.d.	3.72	3.60	3.50	3.97	4.51
BMI change (years 7–11)					
Mean	+2.94	+2.91	+2.73	+2.85	+2.62
s.d.	2.08	1.96	2.36	2.28	2.43
Weight status year 7 (%)					
Normal	80.6	80.0	77.8	73.6	69.0
Overweight	15.4	16.1	19.2	21.0	23.2
Obese	4.0	3.9	3.0	5.3	7.7
Weight status year 11 (%)					
Normal	79.2	77.8	80.8	72.9	73.9
Overweight	14.7	16.5	15.0	20.5	16.2
Obese	6.1	5.7	4.2	6.5	9.9

boys.[4,5] Our results resemble the M-Span study,[4] which examined the effects of increased opportunities for activity in school and found reduced adiposity in boys but not girls. One explanation for the sex difference could be that many adolescent girls try to avoid PE, so greater opportunities for activity, or even timetabled PE, are not necessarily reflected in higher levels of activity.[19] Unfortunately, we do not have data on compliance with timetabled PE. In the two studies that found stronger effects in girls, one was a multifactorial intervention[2] and the authors attributed the effects to reductions in time spent in sedentary pastimes (TV time) and not increases in physical activity. The other was similar to the present study in examining routine PE provision in schools,[9] but the significant effects were restricted to overweight girls. The authors offered no explanation for the gender difference but hypothesized that overweight children have more scope to benefit because they are more sedentary. The different results of these two studies could be related to age differences: theirs was with 5–7 years old, while ours was in adolescents.

Imputing causal processes from ecological data is difficult. This study, like others that take advantage of naturally occurring differences in exposures, can only contribute circumstantial evidence. In the present dataset, there were differences in the student mix in the high and low PE schools. Black girls and higher SES boys were more likely to attend higher PE schools. There were also small age differences related to the time of year that the schools were visited. Partly related to the age, SES and ethnic differences, students in higher PE schools had slightly larger waists and BMI's at the start of the study. We controlled for these factors in the analysis, but statistical control is an imperfect substitute for random allocation. Nonetheless, in collating evidence to support policy level initiatives for obesity prevention, a range of types of data have to be used, among which ecological data have a contribution to make.

The present results, from a large longitudinal study with good response rates, point to the value for obesity prevention of increasing timetabled physical activity, particularly for boys. The poor results for girls in our study and others highlight the need for new ideas on how to achieve and maintain high levels of activity in adolescents.

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