Ten year secular declines in the cardiorespiratory fitness of affluent English children are largely independent of changes in body mass index

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ABSTRACT

Secular changes in body mass index (BMI) and cardiorespiratory fitness (20 m shuttle-run test performance) were assessed in 10-year-old children from an affluent area of England in 1998 (n = 303; 158 boys and 145 girls) and 2008 (n = 315; 158 boys and 157 girls). Girls' BMI did not change over the 10 year period. There was a significant increase in boys' BMI (p = 0.02). Cardiorespiratory fitness declined significantly ($p<0.001$) in both boys (7%) and girls (9%).

This study shows a large and worrying decline in cardiorespiratory fitness in children from an affluent area of England.

Children's cardiorespiratory fitness is declining by 4.3% per decade globally[1] and perhaps faster in the UK.[2] Measures of cardiorespiratory fitness correlate negatively with body mass index (BMI) in children and it has been proposed that declining cardiorespiratory fitness in children may be mediated by increases in adiposity.[2] Despite a national obesity epidemic reported in the UK the mean BMI of children from more affluent areas may have remained relatively stable.[3] The aim of the present study was to examine changes in BMI and cardiorespiratory fitness in a sample of 10-year-old children from an affluent area of the UK between 1998 and 2008.

METHODOLOGY

The study was approved by the university ethics committee and parental consent was obtained. Children were recruited from a volunteer sample of six schools in Chelmsford, Essex, UK in 1998 as part of the Chelmsford Fitness and Activity Survey. Schools tested in 2008 were matched for size, type and socioeconomic status. Chelmsford has a low average index of multiple deprivation (8.5) placing the borough in the top 20% most affluent areas in the UK.

Duplicate measures of mass and stature were made (to the nearest 0.1 kg and 0.1 cm, respectively) with participants wearing sports clothing (shorts and T-shirts) and without shoes. Body mass index (BMI) was calculated (kg/m^2) and converted to a z score using the UK 1990 Growth Reference which corrects for age, sex and skewness.[4] The 20 m shuttle-run test was used to asses cardiorespiratory fitness. Children were required to run 20 m shuttles in time with an audible signal until they could no longer maintain the required pace. For comparison with existing UK data,[2] performance was expressed as total number of shuttles completed. For international comparisons[1] running speed (km/h) at final stage was also reported.

Differences in BMI z score and 20 m shuttle run test (km/h[1]) were assessed separately in boys and girls using independent t tests. As number of shuttles completed represents ordinal data, Mann-Whitney U tests were used to assess changes in this variable.

RESULTS

A total of 303 and 315 children (age 10 to 10.9 years) were tested in 1998 and 2008, respectively (see table 1). There was a significant increase in boys' mean BMI (z score) over the 10 year period (p = 0.02) but girls' BMI remained similar (p = 0.4).

There was a significant decline in 20 m shuttle run test performance of both sexes when expressed as number of shuttles completed (Mann-Whitney U test; $p<0.001$). When expressed as running speed at final stage, 20 m shuttle run test performance was also significantly lower in 2008 compared with 1998 for both sexes (independent t test; $p<0.001$).

DISCUSSION

Our aim was to determine changes in BMI and cardiorespiratory fitness in English 10-year-olds from an affluent area between 1998 and 2008. Nationally, over this period there has been a significant increase in the number of English children classified as overweight and obese.[5]

Previous observations from an affluent English population between 1986–1996[3] showed a reduction in girls' (10–16-years-old) mean BMI. The present data showed no change in the BMI of 10-year-olds from a similarly affluent area and, therefore, support the notion that mean BMI and the incidence of obesity in girls from more affluent areas may not follow national trends.

There are no comparable BMI data from boys in affluent areas of the UK. Contrary to the findings reported in girls, there was a small increase in boys' mean BMI (0.7 kg/m^2). When expressed as a z score, the mean change in BMI over the 10-year-period (z = 0.33) was statistically significant. This may suggest that boys from affluent areas are not insulated from the obesity epidemic in the way that girls appear to be.

There are no data regarding changes in the cardiorespiratory fitness of children from affluent English areas. In terms of children's health, cardiorespiratory fitness may be more important than BMI. Good cardiorespiratory fitness attenuates the risk of mortality and morbidity associated

Table 1 Body mass index and cardiorespiratory fitness in 10-year-old English children in 1998 and 2008

	Boys			Girls		
	1998	2008	p Value	1998	2008	p Value
n =	158	145		158	157	
Mean (SD) Age (years)	10.4 (0.3)	10.4 (0.3)		10.5 (0.3)	10.4 (0.3)	
Mean (SD) BMI (kg/m²)	17.6 (3.0)	18.3 (3.1)		18.6 (3.5)	18.4 (2.6)	
Mean (SD) BMI (z score)*	0.32 (1.28)	0.65 (1.16)	0.02	0.48 (1.21)	0.37 (1.02)	0.4
Median (IQR) 20mSRT†	60 (43 to 75)	40 (23 to 58)	<0.001	46 (37 to 56)	29 (21 to 43)	<0.001
Mean (SD) 20mSRT (km/h)*	11.6 (0.9)	10.8 (1.2)	<0.001	11.1 (0.7)	10.2 (0.9)	<0.001

*p Values for independent t test; †p value for Mann-Whitney U test. BMI, body mass index; 20mSRT, 20 m shuttle-run test; BMI z scores are calculated based on the UK 1990 reference data.

with obesity but the converse is not true. It is becoming clear that cardiorespiratory fitness is an important potential interventional target in health promotion. It is worrying, therefore, that the cardiorespiratory fitness of boys and girls in the present study declined significantly. Perhaps more worrying is the rate of this decline.

The 20 m shuttle-run test provides a valid assessment of cardiorespiratory fitness as performance correlates well with measures of maximal oxygen consumption[6] and provokes maximal effort in school-aged children.[7] Based on global 20 m shuttle run test data we expected a 0.4% annual drop in cardiorespiratory fitness.[1] Secular data regarding English children's cardiorespiratory fitness are rare although Stratton *et al*[2] reported a 2.4% annual drop in 20 m shuttle run test performance in 9–11-year-olds between 1998 and 2004. It should be noted that the 0.4% annual decline reported by Tomkinson *et al*[1] was calculated using running speed to represent 20 m shuttle run test performance whereas Stratton *et al*[2] used the number of shuttles completed. By converting the data of Stratton *et al*[2] from shuttles to speed we calculated a second estimate for the annual decline in cardiorespiratory fitness of UK children of 0.8% (mean of both sexes). The present data also showed a 0.8% mean rate of annual decline over the 10 year study period. Two English studies now show that English children's cardiorespiratory fitness is falling at twice the predicted global average rate.

BMI is inversely related to cardiorespiratory fitness. In a sample of 9–11-year-old children from a more deprived area of England (Liverpool), Stratton *et al*[2] found that the observed decrease in cardiorespiratory fitness was mirrored by an increase in BMI from 1998 to 2004. BMI z scores increased in both sexes by an average of $z = 0.07$ per year. The present study found no change in girls' BMI z score and a much lower rate of increase in boys ($z = 0.03$) than previously reported. The current data confirm previous findings that the mean BMI of girls from affluent areas of England may not be changing significantly. The mean BMI of boys from affluent areas may be increasing but at a slower rate than in more deprived areas.

Most importantly, the current findings show remarkable similarity with previous data regarding the worrying rate at which cardiorespiratory fitness is declining in English 10-year-olds.[2] This decline is greater than global data predict[1] and appears largely independent of changes in BMI, at least in girls. Governmental initiatives for the routine measurement of 10-year-olds' BMI are currently in place in English schools. Measurement of BMI alone may not be sufficient to monitor children's future health, as health benefits associated with higher cardiorespiratory fitness are independent of BMI. If further data show declining cardiorespiratory fitness in schoolchildren, then routine monitoring initiatives may be justified.

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