Rising Obesity and Expanding Waistlines In School Children: A Cohort Study

Mary C J Rudolf, Darren C Greenwood, Tim J Cole, Ronnie Levine, Pinki Sahota, Jenny Walker, Philip Holland,John Truscott Janet Cade, John Truscott.

Mary C J Rudolf
Ronnie Levine
Leeds Community and Mental Health Trust

Darren C Greenwood
Janet Cade
Nuffield Institute of Health
University of Leeds

Tim J Cole
Institute of Child Health
London

Pinki Sahota
Leeds Metropolitan University

Jenny Walker
Philip Holland
Leeds Teaching Hospitals Trust

John Truscott
School of Health Care Studies
University of Leeds

Address for correspondence:
Dr Mary Rudolf
Community paediatrics
Belmont House
3-5, Belmont Grove
Leeds, LS2 9DE

Tel: 0113 392 6352
Eml: Mary.rudolf@leedsth.nhs.uk
FAX: 0113 392 5169

ABSTRACT
A cohort of school-children was followed-up over six years from 1996 to 2001. In the final year 315 of 500 targeted children were measured. BMI increased substantially over time ($p<0.001$) indicating a further rise in obesity into the secondary school years. Two new indicators of obesity were also measured. Waist circumference scores rose as substantially as BMI ($p<0.001$), and may be of particular significance, given the association between abdominal girth in adults and cardiovascular morbidity. International Obesity Task Force measures were found to be more stringent than previous criteria with no significant change noted over the time period.

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In 2001 we reported an alarming increase in the prevalence of obesity in Leeds primary school children[1]. Our data were collected during a trial of APPLES[2], a primary school health promotion programme designed to improve children's diets and lifestyle. Over the course of 3 years we found a steady increase in the numbers of overweight and obese children so that by the age of eleven, 30% of children were overweight (>85th centile) and 17% obese (>95th centile).

In 2001, six years after the start of APPLES we obtained funding to follow up the children in to secondary school in order to determine whether this trend had persisted, and how this might relate to the new international criteria for obesity defined by the International Obesity Task Force[3]. In addition, as childhood waist circumference standards had been published for the first time[4], we were interested to see if waist measurements were a useful measure during this current "epidemic" of obesity.

Methods
694 children (378 boys and 316 girls) had participated in the original longitudinal study, with measurements in 1996, 1997 and 1998. 608 of these children were tracked from school leaving lists and the local Education Authority database to 32 secondary schools. We excluded 14 schools on the basis that they had fewer than 5 study pupils and were distantly located. The remaining 18 schools had 500 pupils who were targeted for follow up. Written consent to participate was obtained from both the pupils and their parents.

Data were collected in March-June 2001. Height was measured to 0.1cm with a freestanding magnimeter stadiometer (Raven Dunmow). Weight was recorded to 0.1kg without shoes or jumpers. The mean of three triceps measurements was taken[5]. Waist circumference was measured 4 cm above the umbilicus. Body mass index (weight(kg)/height^2(m^2)) was calculated. Data were converted to SD scores using the UK 1990 growth references for height, weight and BMI[6], the 1975 Tanner references for triceps measurements[5] and the 2001 McCarthy references for waist circumference[4]. Puberty was staged by self report[7]. The

International Obesity Task Force criteria[3] were used to calculate the numbers of obese and overweight children (see table 1).

The following statistical tests were employed: SD scores of participants and nonparticipants were compared by unpaired t test. The percentage of overweight and obese children in each year were compared using McNemar's test. Random effects regression was used to test for trends over the 6 years of the study.

Results

348 children, now aged 12-14 years, agreed to participate in the study. Complete growth measures were obtained from 315 (63% of 500) of whom 174 were boys and 141 were girls. As there was concern that children who did not consent might be more obese, participants' and nonparticipants' growth data from 1998 were compared (see Table 2). There was no significant difference for any measure, suggesting that this was not the case.

Figure 1 shows the mean SD scores for growth. There was a substantial increase in weight throughout the period 1996-2001. Mean height SD scores also increased in the final year. As expected, all subjects were in puberty. Only 39 of the girls were premenarchal. The mean age for menarche was 12.6 (sd 0.7) years.

Obesity measures are shown in Figure 2. Mean BMI and waist circumference SDscore increased substantially, indicating a rise in obesity. The triceps measures did not change significantly. Results did not change for any measure when boys and girls were analysed separately.

Overweight and obesity rates using the International Obesity Task Force criteria (see Table 1) are shown in Table 3. Numbers of overweight and obese children were higher than expected from the 1990 growth references. There was no significant trend over time, but there appeared to be a tendency towards girls being more overweight and obese than boys, with an increase over the years.

Discussion

Over six years the population showed a substantial increase in height and weight, although the former was restricted to the final year. The most likely explanation for this rise in height is an earlier onset of puberty. However, we were unable to demonstrate this as the subjects were already in puberty. The mean age for menarche was 3.5 months younger than that found in a survey of British girls from the early 1980s[8], which provides little support for this suggestion. Pubertal status was ascertained by self report rather than examination, with somewhat inconsistent findings, so this relationship could not be explored further.

Despite the increase in height, BMI scores continued to increase substantially, indicating a further rise in obesity for the population as a whole. This was probably caused by children becoming more overweight as they got older[6], although we could not disentangle the secular trend from the age trend because of their collinearity. The triceps measures were not consistent with other measures, as previously noted[6].

In addition to providing further epidemiological data on the rise in children's weight, this report provides information on waist circumference measurements. Waist circumferences were significantly larger in 1996-8 than in the late 1970s and 1980s when the references were obtained[4], and were also larger than BMI. They continued to rise through the course of the study so that by 2001 children's waists were on average 4 cm (two clothing sizes) larger than they had been 20 years ago. This figure is all the more disturbing when one reflects on how many notches on a belt this represents, and is consistent with the cross sectional survey of waist measurements recently reported in the BMJ[9]. Waist circumference as a measure of obesity may be of particular significance, given the association between abdominal girth in adults and cardiovascular morbidity.

It has been recommended that we should now be utilising new criteria for identification of obesity. These have been developed by the International Obesity Task Force in order to allow for international comparison and consistency. As our numbers show, these criteria are more stringent than the previous 'cutoffs' and the numbers of obese children now appear to be relatively small. Hopefully this will not lull us into a false sense of security about the problem.

Our data are of concern. The previous rise in BMI levels reported through primary school[6] has continued into secondary school and emphasises the need for more rigorous efforts to stem the tide of child obesity. Waist circumference measures provide an extra level of concern. Larger cohort studies specifically designed for the purpose are required to monitor obesity trends, and effective interventions are urgently needed to address this major public health issue.

WORD COUNT 1063 words

Funding
This research was supported by a grant from the Northern and Yorkshire Region Research and Development Unit

Acknowledgements
We would like to thank Carol Levine, APPLES 2 project manager, and Jenny Holland and Sheila Sive, research assistants for their help in this study

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TABLE 1: International Obesity Task Force definitions of obesity giving the approximate relationship of BMI SD score to placement on the UK 1990 growth charts

	BOYS		GIRLS	
	Centile	**BMI sd score**	**Centile**	**BMI sd score**
Normal	<90.4th	<1.30	<88.3	<1.19
Overweight	90.4 – 99.1	1.30 – 2.37	88.3 – 98.8	1.19 – 2.25
Obese	>99.1	>2.37	>98.8	>2.25

TABLE 2: Growth measures from 1998 of children who participated in the APPLES 2 project compared with those who did not. No significant difference was found for any of these measures for the group as a whole or on analysis of boys and girls separately.

	Mean SD score (sd)				Number of children (%)	
	Weight	**Height**	**BMI**	**Triceps**	**Over-weight**	**Obese**
Participants* (n=296)	0.28 (1.04)	0.15 (1.01)	0.25 (1.1)	-0.27 (1.12)	72 (24.2%)	33 (11.2%)
Non participants* (n=277)	0.27 (1.18)	0.07 (1.03)	0.31 (1.22)	-0.30 (1.09)	76 (27.4%)	34 (12.2%)

*19 additional participating children and 2 non-participating children had not been measured in 1998 (but were in 1997 and 1996). They therefore could not be included in this analysis

1.TABLE 3: PERCENTAGE OF CHILDREN WHO WERE OVERWEIGHT AND OBESE OVER THE SIX YEARS OF THE STUDY (using IOTF criteria)

	% OVERWEIGHT		% OBESE	
	Boys	**Girls**	**Boys**	**Girls**
1996	10	13	0	3
1997	10	13	2	4
1998	14	17	2	3
2001	14	16	3	4

FIGURE 1: CHANGES IN GROWTH MEASURES OVER TIME. The trend in mean SD score was assessed by random effects regression.

	1996	1997	1998	2001
Mean age	8.4	9.4	10.4	13.3
n	609	587	575	315

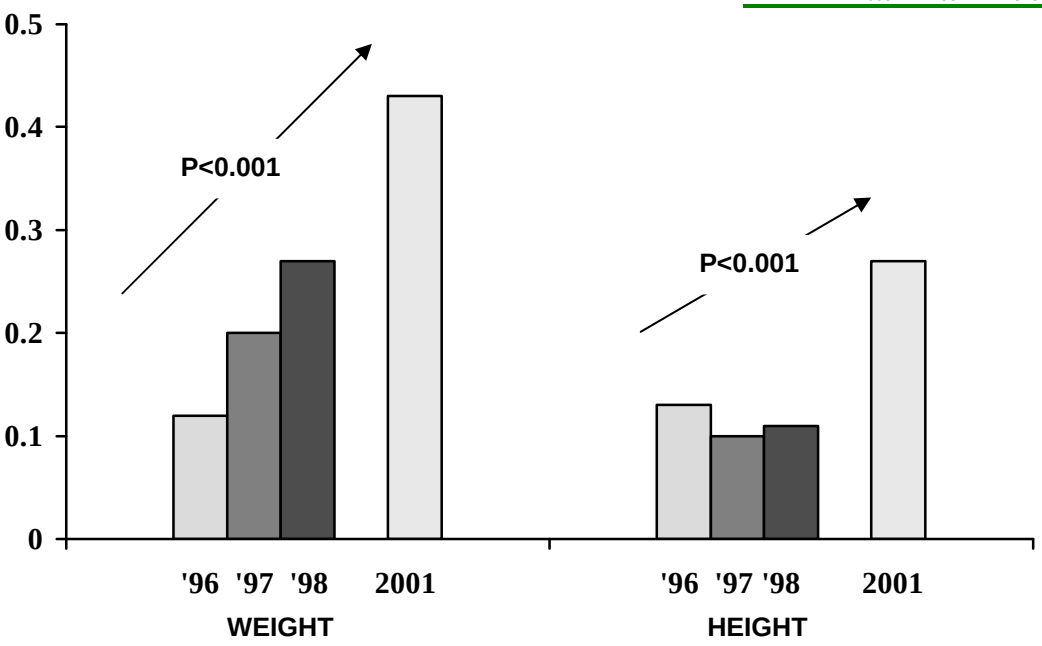

FIGURE 2: CHANGES IN OBESITY MEASURES OVER TIME. The trend in mean SDscore was assessed by random effects regression.

	1996	1997	1998	2001
Mean age	8.4	9.4	10.4	13.3
n	609	587	575	315