nation vs adjusted dose warfarin for stroke prevention in atrial fibrillation. *Arch Intern Med* 1998;158:1513-21.
17 Stroke Prevention in Atrial Fibrillation Investigators. Warfarin versus aspirin for prevention of thromboembolism in atrial fibrillation: stroke prevention in atrial fibrillation II study. *Lancet* 1994;343:687-91.
18 Morocutti C, Amabile G, Fattaposta F, Nicolosi A, Matteoli S, Trappolini M, et al. Indobufen versus warfarin in the secondary prevention of major vascular events in non-rheumatic atrial fibrillation. *Stroke* 1997;28:1015-21.
19 Hellemons B, Langenberg M, Lodder J, Vermeer F, Schouten H, Lemmens T, et al. Primary prevention of arterial thromboembolism in non-rheumatic atrial fibrillation in primary care: randomised control trial comparing two intensities of coumarin with aspirin. *BMJ* 1999;319:958-64.
20 Jüni P, Altman DG, Egger M. Assessing the quality of controlled clinical trials. In: Egger M, Davey Smith G, Altman DG, eds. *Systematic reviews in health care: meta-analysis in context*. 2nd ed. London: BMJ Publishing, 2000.
21 British Society for Haematology; Haemostasis and Thrombosis Task Force. Guidelines on oral anticoagulation: third edition. *Br J Haem* 1998;101:374-87.
22 Atrial Fibrillation Investigators. The efficacy of aspirin in patients with atrial fibrillation. *Arch Intern Med* 1997;157:1237-40.
23 Cleland J, Cowburn P, Falk R. Should all patients with atrial fibrillation receive warfarin? *Euro Heart J* 1996;17:674-81.
24 Albers G. Atrial fibrillation and stroke. Three new studies, three remaining questions. *Arch Intern Med* 1994;154:1443-7.
25 Cairns J, Connolly S. Non-rheumatic atrial fibrillation. *Circulation* 1991;84:469-8.
26 European Atrial Fibrillation Study Group. Secondary prevention in non-rheumatic atrial fibrillation after transient ischaemic attack or minor stroke. *Lancet* 1993;342:1255-62.
27 Taylor FC, Gaminara L, Cohen H, Ramsay M, Miller D. Evaluation of a nurse specialist anticoagulant nurse specialist service. *Clin Lab Haem* 1997:19:267-72.
28 Poller L, Shiach C, MacCallum P, Johansen A, Munster A, Magelhaes A, et al. Multicentre randomised study of computerised anticoagulant dosage. *Lancet* 1998;352:1505-9.
29 Fitzmaurice D, Hobbs F, Delaney B, Wilson S, McManus R. Review of computerised decision support systems for oral anticoagulation management. *Br J Haem* 1998;102:907-9.
30 Taylor FC, Gray A, Cohen H, Gaminara L, Ramsay M, Miller D. Costs and effectiveness of a nurse specialist anticoagulant service. *J Clin Pathol* 1997;50;823-8.
31 Gustafsson C, Asplund K, Britton M, Norving B, Olsson B, Marke L. Cost-effectiveness of primary stroke prevention in atrial fibrillation: a Swedish national perspective. *BMJ* 1992;305:1457-60.
32 Protheroe J, Fahey T, Montgomery A, Peters T. The impact of patients' preferences on the treatment of atrial fibrillation: an observational study of patients bases decision analysis. *BMJ* 2000:320;1380-4.

(Accepted 9 November 2000)

Prevalence of overweight and obese children between 1989 and 1998: population based series of cross sectional studies

Peter Bundred, Denise Kitchiner, Iain Buchan

Editorial by Dietz

University of Liverpool, Liverpool L69 3GB
Peter Bundred *reader in primary care*

Royal Liverpool Children's NHS Trust, Liverpool L12 7AP
Denise Kitchiner *consultant paediatric cardiologist*

West Hertfordshire Health Authority, St Albans, Hertfordshire AL1 3ER
Iain Buchan *specialist registrar in public health*

Correspondence to:
P Bundred
peterb@liv.ac.uk

BMJ 2001;322:326–8

Abstract

Objective To determine trends in weight, height, and body mass index in children between 1989 and 1998.
Design Retrospective series of cross sectional studies of routinely collected data.
Setting Primary care in the Wirral Health Authority.
Participants 35 662 infants aged 1-3 months (representing 88% of live births) and 28 768 children aged 2.9-4.0 years. 21 582 infants and children (25.1%) were excluded because of missing or inaccurate data.
Main outcome measures Weight, height, sex, and age routinely recorded by health visitors. Height, weight, and body mass index standardised for age and sex. SD score >1.04 for body mass index (>85th centile) was defined as overweight and >1.64 (>95th centile) as obese. Body mass index was not calculated in infants as it is difficult to interpret.
Results From 1989 to 1998 there was a highly significant increasing trend in the proportion of overweight children (14.7% to 23.6%; $P<0.001$) and obese children (5.4% to 9.2%; $P<0.001$). There was also a highly significant increasing trend in the mean SD score for weight (0.05 to 0.29; $P<0.001$) and body mass index (-0.15 to 0.31; $P<0.001$) but not height. Infants showed a small but significantly increasing trend in mean SD score for weight (-0.17 to -0.05; $P=0.005$).
Conclusions From 1989 to 1998 there was a highly significant increase in weight and body mass index in children under 4 years of age. Routinely collected data are valuable in identifying anthropometric trends in populations.

Introduction

The increased number of overweight and obese children has been highlighted in a cohort study of British children examined at 24, 49, and 61 months of age.[1] We describe similar findings in a large population based study, in which data were obtained from measurements routinely performed by health visitors as part of the 6 week and preschool assessment. We examined trends in weight, height, and body mass index in a defined population between 1989 and 1998.

Participants and methods

Health visitors in the Wirral Health Authority of the North West region review children regularly, and routinely collected data are stored on computer. These data include weight (in grams), height (in centimetres), date of birth, and date of the examination. We analysed data from the 6 week and preschool assessments for the years 1989 to 1998. For the 6 week assessment we included only infants aged between 28 and 90 days. For the preschool assessment we included children aged between 2 years 11 months and 4 years.

The study population consisted of 35 662 infants and 28 768 children. Records of 21 582 infants and children (25%) were removed because of missing or inaccurate data.

We calculated the body mass index (weight (kg)/height $(m)^2$) for preschool children. This was not done for infants aged 1 to 3 months as it is difficult to interpret body mass index at this age. The height, weight, and body mass index were standardised for age and sex with the British growth reference charts.[2–4] The resulting standard deviation (SD) scores were used in all calculations. An SD score of 0 represents the 50th centile, 1.04 represents the 85th centile, and 1.64 the 95th centile. An SD score >1.04 for body mass index[1 5] was defined as overweight and >1.64 as obese.

Statistical analysis

StatsDirect software was used for all statistical calculations.[6] We examined trends in weight, height,

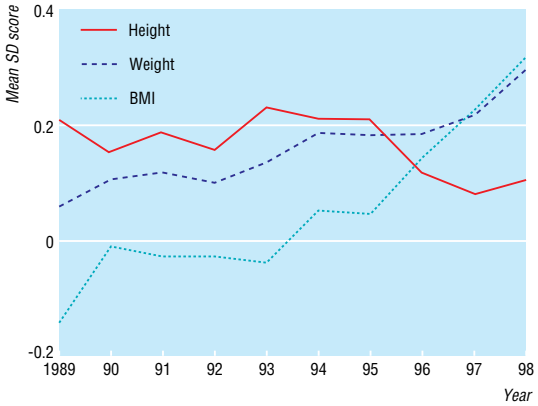

Fig 1 Mean SD scores for weight, height, and body mass index plotted against year of measurement for children aged 2.9 to 4 years. Increasing trend in scores significant for weight and body mass index but not for height (Pearson's correlation (95% CI) and P for r=0 (weighted): 0.94 (0.77 to 0.99), P<0.001; 0.93 (0.71 to 0.98), P<0.001; and 0.61 (–0.03 to 0.90), P=0.059)

and body mass index with weighted Pearson's product moment correlation for mean SD scores. We analysed categorical data using a χ^2 trend.

Results

Preschool children

If the distribution of weights in the study and reference populations is similar, the mean SD score from a large sample should be close to zero. We observed a significantly increasing trend in mean SD score for weight and body mass index between 1989 and 1998 (fig 1).

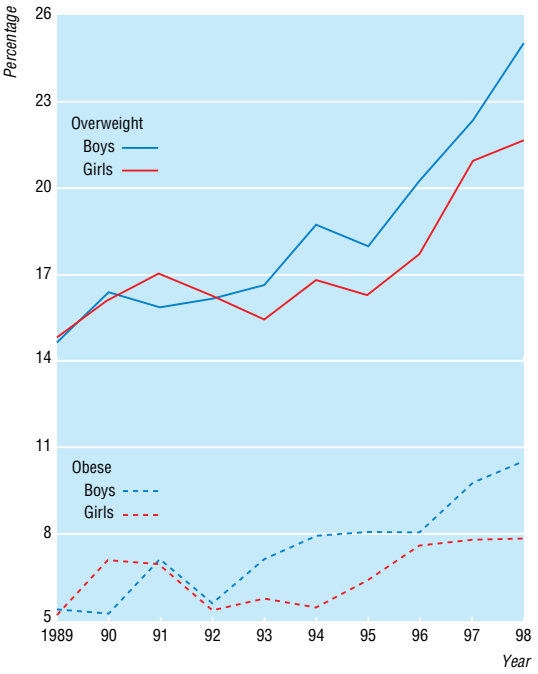

Fig 2 Annual increase in proportion of overweight and obese children; χ^2 for trend in overweight 71.1 (P<0.001) for boys and 33.1 (P<0.001) for girls, for trend in obesity 48.3 (P<0.001) for boys and 7.3 (P=0.007) for girls. Proportion of overweight and obese boys becomes greater than girls in early 1990s and remains so

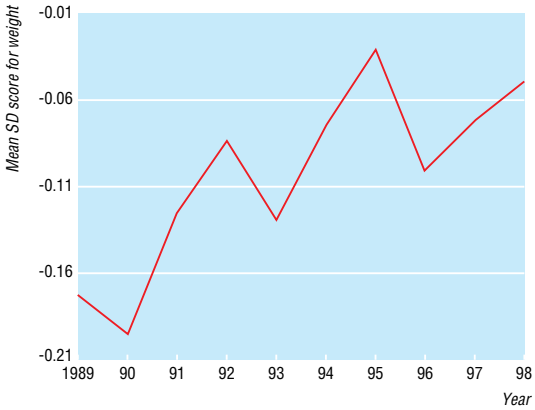

Fig 3 Median SD scores for weight at 6 weeks bounded by interquartile range plotted against year of measurement for infants aged 1 to 3 months (Pearson's correlation (95% CI) 0.80 (0.35 to 0.95), P=0.005 for r=0)

Over the same period there was no increasing trend in the mean SD score for height.

In a population with normally distributed weights, we would expect 15% of children to be overweight (>85th centile; SD score >1.04) and 5% obese (>95th centile; SD score >1.64). This was the case for our study population in 1989, but since then the proportion of overweight and obese boys and girls increased significantly (fig 2).

Infants

Figure 3 shows a slight increase in the mean SD scores for weight of infants during the 10 year period. However, it was close to zero (the 50th centile) and below zero for the whole period. Throughout the study period fewer than 15% of infants weighed above the 85th centile and fewer than 5% above the 95th centile.

Discussion

We have found a highly significant increase in the number of overweight and obese children in the Wirral Health Authority area over the decade to 1998. In 1989 the weight and height of children in this area were similar to those of the reference population underlying the British growth reference charts, compiled in 1990.[2] The increase in weight and body mass index over time has not been accompanied by an increase in height. As such the increase in the number of children with an SD score for weight and body mass index above 1.04 must be recognised for what it is—an increase in the number of overweight and obese children and not a "normal" trend in the population. Kotani et al found that the proportion of obese children in their population had increased from 5% to more than 10% over two decades.[7] In our study, a similar increase occurred in 10 years. The increase in the proportion of children above the 85th and 95th centiles for weight was not present in infants. The excessive weight gain therefore occurred between infancy and preschool age.

In adults body mass index is useful in the assessment of fatness. Concerns have been expressed regarding its use in children because it covaries with height and does not take into account the differences in the timing of growth in height and weight among

What is already known on this topic

The incidence of childhood obesity is increasing and obesity is likely to persist into adult life

Obesity results in considerable morbidity and mortality, of which cardiovascular disease remains one of the principal causes

Interventions aimed at weight reduction must include increased physical activity as well as a reduction in consumption of high fat, high calorie foods

What this study adds

Height and weight measurements taken by health visitors showed a significant increase in overweight and obese children over the decade to 1998

This increase occurred before the age of 4 years and interventions must be targeted at this age group if they are to have an impact

Routinely collected data are valuable in identifying anthropometric trends in populations

various ethnic groups.[8] Nevertheless, it is easy to measure and has been validated against calculations of body density.[9 10] For these reasons it has been recommended by the American Society of Clinical Nutrition and others as a reliable measurement of overweight and obese children.[9] We consider measurement of body mass index to be valid in this study because of the similar ages of the children.[10] In addition, more than 97% of the Wirral population is of white European origin.

Definitions of overweight and obesity

There is no consensus as to the definition of overweight and obese children. The International Obesity Task Force says that children over the 80th centile are overweight, as this corresponds to a body mass index of 25 at the age of 18 years in men and women, which is the adult definition of overweight.[9] Our definition of overweight as being above the 85th centile has been used by others[5] but is arbitrary, and data based on the 80th centile could be calculated easily. We agree with other authors that a consensus figure is required.[9 11]

Effects on later health

There is evidence that obesity is likely to persist into adult life[7 9 12] and to increase the likelihood of morbidity and mortality.[13] Calle et al prospectively examined the risk of death related to body mass index in over a million adults and concluded that heavier men and women in all age groups had an increased risk of death.[14] Cardiovascular disease remains one of the principal causes for this excess mortality. Increased body mass index is also one of the important risk factors associated with the extent of atherosclerotic lesions in the aorta and coronary arteries in people between 2 and 39 years of age.[15] Must and Strauss reviewed the risks and consequences of obesity in childhood and adolescence and concluded that an aggressive approach to prevention and treatment was required.[16] Early intervention, including increased activity and reduction in high fat, high calorie foods, is important,[5] and some success has been shown in such a programme.[17–19] Power et al have emphasised the importance of population based intervention to achieve this.[20] In our study, the increase in the incidence of obesity occurred before the age of 4 years, and interventions should be targeted at this age group if they are to have an impact.

The National Service Framework for Coronary Heart Disease identifies the need to develop, implement, and monitor policies that reduce the prevalence of coronary risk factors in the population.[21] Data that are routinely collected are important in monitoring the health of communities and should be used in the planning of community based interventions. Such data may be less accurate than those collected prospectively in carefully executed studies, but this must be balanced against the large amount of information that is readily available. In our study, valid data were collected on over 64 000 infants and children, which represented 88% of live births in the health authority and thus provided a large sample of the relevant population. The accuracy of routinely collected data must be ensured as they are a valuable source of information on population trends. This information could be the impetus for a national programme to prevent and treat childhood obesity and its long term complications.

Contributors: PB had the original idea for the study and carried out the initial data analysis and is guarantor. DK carried out further analysis and drafted the manuscript. IB was responsible for all the statistical analysis as well as writing the statistical methodology.

Funding: None.

Competing interests: None declared.

1 Reilly JJ, Dorosty AR, Emmett PM. Prevalence of overweight and obesity in British children: cohort study. *BMJ* 1999;319:1039.
2 Freeman JV, Cole TJ, Chinn S, Jones PRM, White EM, Preece MA. Cross sectional stature and weight reference curves for the UK, 1990. *Arch Dis Child* 1995;73:17-24.
3 Cole TJ, Freeman JV, Preece MA. Body mass index reference curves for the UK, 1990. *Arch Dis Child* 1995;73:25-9.
4 Child Growth Foundation. *UK cross-sectional reference data: 1990/1.* London: Child Growth Foundation, 1996.
5 Barlow SE, Dietz WH. Obesity evaluation and treatment: expert committee recommendations. *Pediatrics* 1998;102:e29.
6 StatsDirect. www.statsdirect.com (accessed 15 Dec 2000).
7 Kotani K, Nishida M, Yamashita S, Funahashi T, Fujioka S, Tokunaga K, et al. Two decades of annual medical examinations in Japanese obese children: do obese children grow into obese adults? *Int J Obes Rel Met Dis* 1997:21:912-21.
8 Prentice AM. Body mass index standards for children. *BMJ* 1998;317:1401-2.
9 Bellizzi MC, Deitz WH. Workshop on childhood obesity: summary of the discussion. *Am J Clin Nutr* 1999;70:173-5S.
10 Pietrobelli A, Faith MS, Allison DB, Gallagher D, Chiumello G, Heymsfield SB. Body mass index as a measure of adiposity among children and adolescents: a validation study. *J Paediatr* 1998;132:204-10.
11 Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity: international survey. *BMJ* 2000;320:1240-3.
12 Fredricks AM. Van Buuren S, Wit JM, Verloove-Vanhorick SP. Body index measurement in 1996-7 compared with 1980. *Arch Dis Child* 2000;82:107-12.
13 Dietz WH. Childhood weight affects adult morbidity and mortality. *J Nutr* 1998;128:411-4S.
14 Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW. Body-mass index and mortality in a prospective cohort of US adults. *New Engl J Med* 1999;341:1098-105.
15 Berenson GS, Svinivasan SR, Bao W, Mewman WP 3rd, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. *N Engl J Med* 1998;338:1650-6.
16 Must A, Strauss RS. Risks and consequences of childhood and adolescent obesity. *Int J Obes Rel Met Dis* 1999;23(suppl 2):2-11.
17 Luepker RV, Perry CL, McKinlay SM, Nader PR, Parcel GS, Stone EJ, et al. Outcomes of a field trial to improve children's dietary patterns and physical activity. *JAMA* 1996;275:768-76.
18 Prentice AM, Jebb SA. Obesity in Britain: gluttony or sloth? *BMJ* 1995;311:437-9.
19 Fruhbeck G. Childhood obesity: time for action, not complacency. *BMJ* 2000;320:328-9.
20 Power C, Lake JK, Cole TJ. Body mass index and height from childhood to adulthood in the 1958 British born cohort. *Am J Clin Nutr* 1997;66:1094-101.
21 NHS Executive. *The National Service framework for coronary heart disease.* Leeds: NHS Executive, 2000.

(Accepted 9 November 2000)