SECULAR INCREASES IN WEIGHT, HEIGHT AND BODY MASS INDEX AMONG SCHOOL CHILDREN OF HAT YAI, THAILAND: A 5 YEARS FOLLOW-UP STUDY

Rassamee Sungthong[1], Ladda Mo-suwan [2], Virasakdi Chongsuvivatwong[1] and Chaon Junjana [2]

[1]Epidemiology Unit and [2] Department of Pediatrics, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand

Abstract. Upward trend of growth and overweight has been reported from developed countries. As Thailand has been undergoing rapid economic transition over the previous decade, we conducted an analysis to demonstrate the secular changes of growth over five years follow-up. Subjects were a cohort of 2,252 primary school children recruited in 1992 for the Hat Yai childhood obesity study. Baseline demographic and family data were collected by a questionnaire completed by parents. To quantify the cohort effect, a generalized estimating equations analysis for a cross sectional time series data was undertaken with weight, height, and body mass index (BMI, kg/m^2) as a dependent variable and containing a quadratic term of age, sex, year of birth and family variables. One thousond and ninety-four (48.5%) children completed 6 anthropometric measurements. Graphs of median weight, height, BMI and overweight prevalence of each birth cohort against age showed secular increases of growth and overweight, and an age effect. For each one-year younger cohort, the median weight, median height and median BMI increased by 1.22 kg, 1.25 cm and 0.23 kg/m^2, respectively. An increasing trend of childhood overweight reported here may signify a need for preventing overweight and reducing weight in childhood adolescence in the future.

INTRODUCTION

Child growth and nutrition has been suggested as a good indicator of health as well as socioeconomic well being of a country. Over the previous decades, upward change in growth and increasing prevalence of obesity have been observed in developed countries. Hughes *et al* (1997) reported an average increase of 1 to 3 cm in English and Scottish primary school children from 1972 to 1994. During the same period, the adjusted increase in height of children aged 5 to 14 years old of the Bogalusa heart study was 1.6 cm (Freedman *et al*, 1997). Among inner city children and ethnic minorities of Britain, height increased approximately 1.5 cm over the period from 1983-1993 (Chinn *et al*, 1998). While growing taller, these children were getting fatter too. The US national health and nutritional surveys showed that the prevalence of overweight based on the 85th percentile cutoff point for body mass index increased from 15% to 22% during 1963 to 1991 (Troiano *et al*, 1995). This trend of increasing prevalence of obesity found in developed countries was also documented in lower income countries, *eg* China, Brazil, Cuba, Vietnam and Thailand (Popkin *et al*, 1998). From a longitudinal study of school children in Hat Yai, Thailand, obesity prevalence was reported to increase from 12% to 15.6% in two years (Mo-suwan *et al*, 1994) Among school children in China, obesity rates, associated with stunting, were reaching a level comparable to those in the United States (Popkin *et al*, 1996).

Most growth studies, however, were carried out in cross-sectional samples. Investigations of birth cohort or secular trend effects on growth and obesity are limited in such design. With the longitudinal data from a cohort of school children residing in Hat Yai in the southern part of Thailand, we conducted the analysis to demonstrate the secular changes of weight, height and body mass index over the five years.

MATERIALS AND METHODS

Study site

Hat Yai, a city in Songkhla Province, is the center of economy of the southernmost part of Thailand. It is about 1,000 km from Bangkok the capital city, and 100 km from the Malaysian border. Rubber, sea-food, wood furniture and tourism industry are its main business. Population was about 290,000 in 1997, 53.5% residing in the municipality.

Correspondence: Dr Rassamee Sungthong, Epidemiology Unit, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.
E-mail: mladda@ratree.psu.ac.th

Subjects

A cohort of 2,252 primary school children was recruited in 1992 for the Hat Yai childhood obesity study using two stage sampling. Six schools (two municipality-operated and four private) were randomly selected from 13 primary schools in the Hat Yai municipality area, then one or two classes of each grade were randomly selected from each school. The study was approved by the Committee for Research in Humans, Faculty of Medicine, Prince of Songkla University and parental consent was obtained.

Collection of data

Subjects were weighed wearing school uniforms without belts and shoes and with empty pockets. Weight and height were measured annually (in January) from 1992-1997 with a beam balance Detecto scale and stadiometer (Dectecto Scales, Inc, Brooklyn, NY, USA) to the nearest 0.1 kg and 0.5 cm, respectively. We used the same and careful quality control of measurement techniques over time. Incomplete data was due to either children move to other schools or to other places where we could not follow them. Baseline demographic and family data were collected by a questionnaire completed by parents as described in the previous report (Mosuwan and Geater, 1996).

Data analysis

Only subjects with complete 6 anthropometric measurements were included in the analysis. To

Table 1
Baseline characteristics of the selected and non-selected subjects.

Variables	Selected (%)	Non-selected (%)	Chi-square [a]
Overweight at entry	1,094 (18.1)	1,155 (14.6)	11.7
Sex = male	456 (41.7)	643 (55.7)	44.0
Father's education	887	892	17.7
no	16 (1.8)	26 (2.9)	
primary	195 (22.0)	263 (29.5)	
secondary	278 (31.3)	265 (29.7)	
higher than secondary	398 (44.9)	338 (37.9)	
Mother's education	916	926	19.0
no	29 (3.2)	52 (5.6)	
primary	332 (36.2)	398 (43.0)	
secondary	193 (21.1)	176 (19.0)	
higher than secondary	362 (39.5)	300 (32.4)	
Father's occupation	889	905	28.2
no	4 (0.5)	6 (0.7)	
casual	191 (21.5)	230 (25.4)	
farmer	12 (1.4)	43 (4.8)	
trader	405 (45.6)	348 (38.5)	
government officer	201 (22.6)	218 (24.1)	
office worker	76 (8.6)	60 (6.6)	
Mother's occupation	918	933	23.5
no	176 (19.2)	161 (17.3)	
casual	129 (14.1)	161 (17.3)	
farmer	10 (1.1)	33 (3.5)	
trader	402 (43.8)	390 (42.0)	
government officer	158 (17.2)	166 (17.8)	
office worker	43 (4.68)	22 (2.4)	
Parent monthly income [b]	936	930	24.8
<5,000 baht	141 (15.1)	211 (22.7)	
5-10,000 baht	319 (34.1)	337 (36.2)	
1-<30,000 baht	360 (38.5)	293 (31.5)	
≥30,000 baht	116 (12.4)	89 (9.6)	

[a] All were significant at p level less than 0.05.
[b] Parental monthly income, 1 baht = 0.04 US dollar at the time of data collection.

Table 2
Birth cohort effect on weight, height and BMI by generalized estimation equations analysis.

Variables	Weight (kg)		Height (cm)		Body mass index (kg/m²)	
	Coefficient	p	Coefficient	p	Coefficient	p
Age[a]	6.16	<0.001	10.93	<0.001	1.20	<0.001
Age^2	-0.09	<0.001	-0.26	<0.001	-0.03	<0.001
Birth year	1.22	<0.001	1.25	<0.001	0.23	0.001
Sex = female	-0.35	0.023	-0.52	<0.001	-0.002	NS [b]
Parental income	2.69	0.001	1.41	0.019	0.92	0.001

[a] Age = age in year at the time of data collection.
[b] NS = non significant

examine for possibility of selection bias, a chi-square test was used to detect differences between selected and non-selected groups. Due to its high correlation with total body fat (Roche *et al*, 1981), we used the body mass index [BMI, body weight (kg) divided by height (m) squared] to define obesity in our study. A child with a BMI value above the US First National Health and Nutrition Examination Survey (NHANES-I) 85th percentile for age and sex was considered overweighted (Must *et al*, 1991).

Secular changes of growth and overweight and age effect were demonstrated by plotting median weight, median height, median BMI and overweight prevalence of each birth cohort against age. To quantify the cohort effect, a generalized estimating equations analysis for a cross sectional time series data was undertaken with weight, height, or BMI as a dependent variable and containing sex, year of birth, and quadratic term of age (age and age^2). Quadratic term of age is used instead of linear term because we expected that the age effect on weight, height and BMI will decrease as children grow into adolescence and adulthood. Family variables including parental education and occupation, and parental income was retained in the models only if it was statistically significant at the 5% level. All analysis were done using the STATA statistical software version 5 (StataCorp, 1997).

RESULTS

Of 2,252 subjects followed from 1992 to 1997, 1,094 (48.5%) had 6 complete anthropometric measurements and hence were included in this report. Comparison of characteristics of the selected group and the rest is presented in Table 1. The selected group contained more females and had higher socioeconomic status.

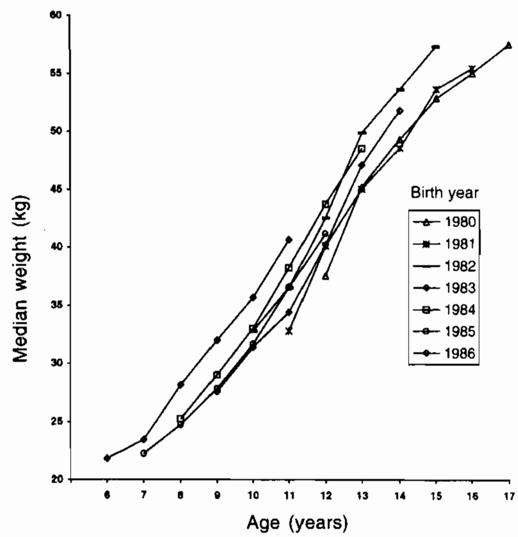

Fig 1–Median weight for age of male birth cohorts from 1992-1997.

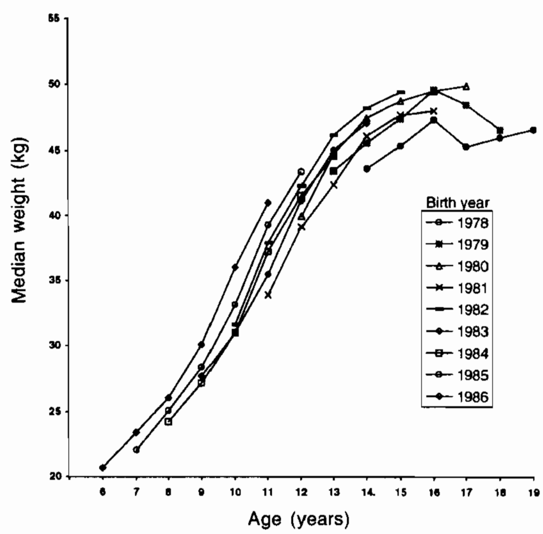

Fig 2–Median weight for age of female birth cohorts from 1992-1997.

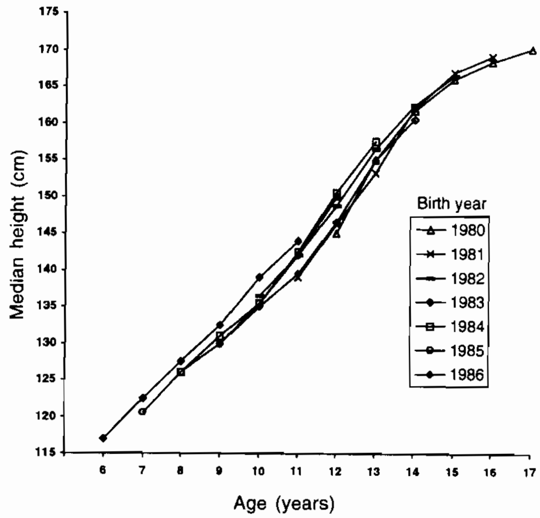

Fig 3–Median height for age of male birth cohorts from 1992-1997.

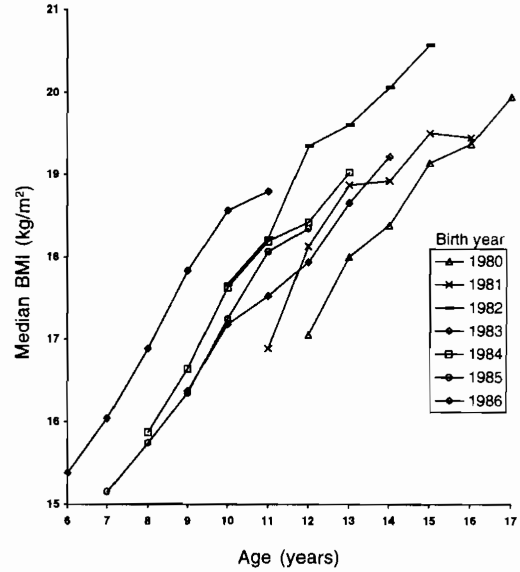

Fig 5–Median BMI for age of male birth cohorts from 1992-1997.

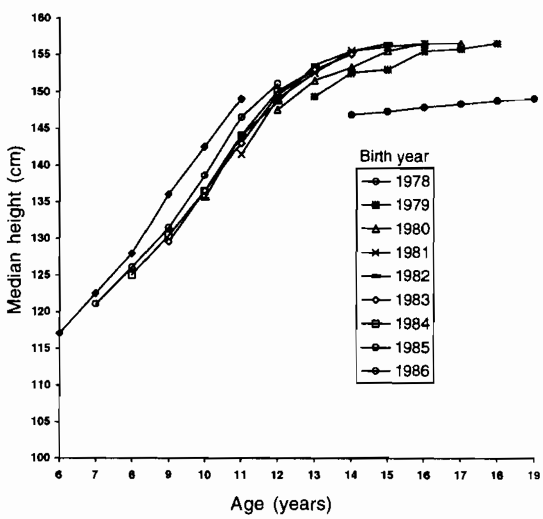

Fig 4–Median height for age of female birth cohorts from 1992-1997.

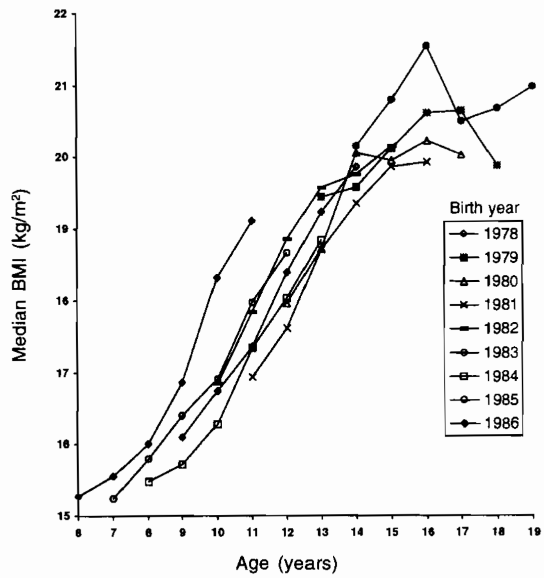

Fig 6–Median BMI for age of female birth cohorts from 1992-1997

Figs 1 and 2 show median weight for age of each cohort of males and females, respectively. For males, at each age point, latter cohort was heavier than the former ones with the youngest cohort being the heaviest. A similar trend was observed for females. The youngest cohort had a median weight higher than the elder cohorts. In contrast to males, median weights of females appeared to be stable at mid adolescence.

Median height for age of female cohorts stabilized earlier than those of males (Figs 3, 4). Similar to weight aspect, younger cohort was taller than the elder ones. At the mid and late adolescence, girls born in 1978 were approximately 6-10 cm shorter than those born 1-5 years later.

Similar to weight and height, median BMI of the younger cohort of both sexes was greater than those of the elders (Figs 5, 6). Because they were

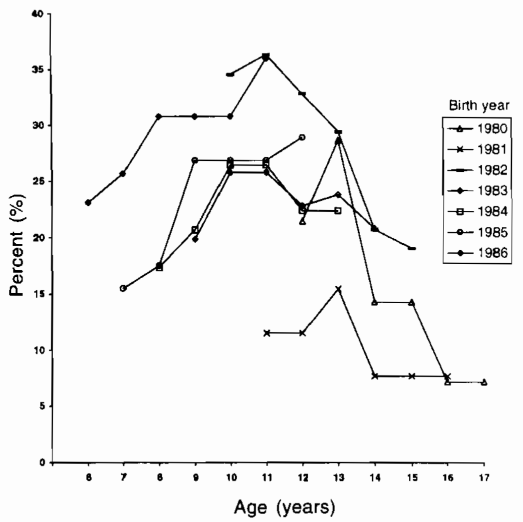

Fig 7–Percent overweight for age of male birth cohorts from 1992-1997.

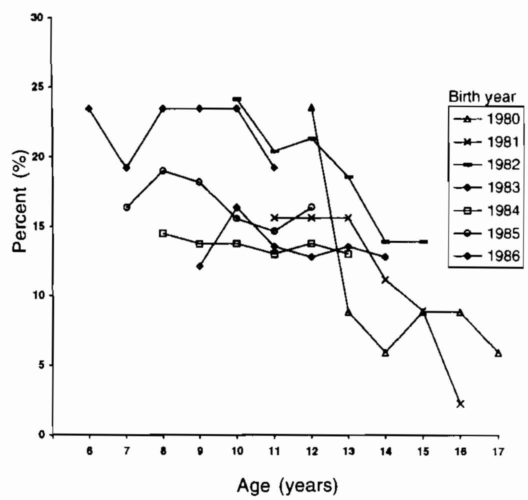

Fig 8–Percent overweight for age of female birth cohorts from 1992-1997.

6-10 cm shorter but only 2-5 kg lighter than other cohorts, the eldest female cohort exceptionally had the highest BMI. While BMI of males increased linearly with age from 6 to 17 years old, BMI increment in females appeared to slow down after thirteen years of age.

Figs 7, 8 depicted prevalence of overweight for age for males and females, respectively. Females had a lower prevalence than males. With exception of some birth cohorts, the younger cohort tended to have a greater prevalence of overweight than the older ones. However, a decreasing prevalence of overweight was observed in females entering adolescence.

Result of the generalized estimating equations analysis is shown in Table 2. Each model was adjusted with age, sex and a quadratic term of age. Birth cohort effect on weight, height and BMI was significant. Children who were born one year younger weighed 1.22 kg heavier, were 1.25 cm taller, and had a BMI of 0.23 kg/m^2 greater than those being born earlier. Similar findings of a greater value of weight, height and BMI were observed in children of the high income family.

DISCUSSION

The present longitudinal study of school children demonstrated significant birth cohort effect and age effect on growth and overweight prevalence. The new birth cohort had a greater value of weight, height and BMI than the elder cohorts. The difference was mostly noticeable in the youngest group. Prevalence of overweight was also increased with age up to early adolescence then had a downward trend. Males and females had a different pattern of age effect. Anthropometric parameters of females reached plateau earlier than those of males. Prevalence of overweight of females was lower than that of males and decreased when reaching adolescence.

Our findings of secular increases of growth and overweight support previous reports from developed countries (Chinn *et al*,1998; Freedman *et al*, 1997; Hughes *et al*, 1997; Starks *et al*, 1981; Troiano *et al*, 1995). These studies (Chinn *et al*,1998; Freedman *et al*, 1997; Hughes *et al*, 1997) reported height increments of 0.1 to 3.3 cm over the period of 10 to 22 years. Using birth cohort analysis, we demonstrated much greater increase, 1.25 cm per birth year. This enlarged effect probably reflected a wide gap between the actual growth and the growth potential among children of a country undergoing an economic transition like Thailand (Kachondham *et al*, 1993). For children of high-income countries who almost grew to their fullest potential, economic effect on height would then take a longer time to be noticed. Use of different anthropometric index to define obesity renders a direct comparison of prevalence of obesity across studies infeasible. However, no matter which index was utilized, an increasing trend of obesity was documented. BMI was recommended as a screening index of obesity for adolescents (Himes and Dietz, 1994). From the Bogalusa heart study, BMI increased by 1.5 kg/m^2 over the twenty years or 0.075 $kg/m^2/y$ (Freedman *et al*, 1997). Again, we found a greater increase of 0.23 $kg/m^2/$ birth year. From our previous report, a significant trend of increased risk for childhood obesity was associated with higher family income (Mo-suwan and Geater, 1996). The bias of subjects included in our analysis towards upper income groups may partly explain this observation.

Different patterns of overweight by sex were observed. From 9 US surveys (a mix of cross-sectional and cohort studies) including 66,772 children aged 5 to 17 years, mean BMI increased with age and was slightly higher for girls than for boys (Rosner *et al*, 1998). Mean BMI of white female cohort of Bogalusa heart study leveled off around 15 years of age, whereas those of white males did a little later at 20s (Freedman *et al*, 1997). On the contrary, mean BMIs of black cohorts of both sexes showed rather steady increase up to 25 years of age. BMI pattern of our female subjects was similar to that of Bogalusa white female cohort, while that of our male cohorts behaved like Bogalusa black subjects. Consequently we found a higher percentage of overweight for boys than for girls.

The use of NHANES-I BMI data to classify our subjects may need justification. Lack of local BMI reference and upper height limit of 170 cm of the local weight-for-height curves restrict the use of local standard for overweight categorization in our study. Due to notable ethnic difference (Rosner *et al*, 1998), utilization of NHANES-I reference may underestimate overweight prevalence of our prepubertal children.

Concern of overweight in children comes from its long term effects on morbidity and mortality. From the Harvard growth study of 508 lean (BMI value below 25^{th} percentile of the NHANES-I reference for age and sex) or overweight (BMI value above 75^{th} percentile of the NHANES-I reference) adolescents 13 to 18 years old, after 55 years of follow-up overweight was associated with an increased risk of mortality among men (Must *et al*, 1992). The relative risks were 1.8 [95% confidence interval (CI), 1.2 - 2.7] for mortality from all causes and 2.3 (95% CI, 1.4 to 4.1) for mortality from coronary heart disease. Another report of 57 years follow-up of the Boyd Orr cohort of children aged 2 years to 14 years 9 months (Gunnell *et al*, 1998), the hazard ratio for all cause mortality in those with BMIs above the 75^{th} percentile for age and sex was 1.5 (95% CI, 1.1 -2.2) and for ischemic heart disease it was 2.0 (95% CI, 1.0-3.9). Providing an observed increasing trend of childhood overweight, there is an immediate need of intervention aiming at preventing overweight and reducing weight in childhood and adolescence.

ACKNOWLEDGEMENTS

This project was supported by the Songklanagarind Hospital Foundation and the National Research Council of Thailand. Data analysis was supported by the Thailand Research Fund.

REFERENCES

Chinn S, Hughes JM, Rona RJ. Trends in growth and obesity in ethnic groups in Britain. *Arch Dis Child* 1998; 78: 513-7.

Gunnell DJ, Frankel SJ, Nanchahal K, Peters TJ, Smith GD. Childhood obesity and adult cardiovascular mortality: a 57-y-follow-up study based on the Boyd Orr cohort. *Am J Clin Nutr* 1998; 67: 1111-8.

Himes JH, Dietz WH. Guidelines for overweight for adolescent preventive services: recommendation from an expert committee. *Am J Clin Nutr* 1994; 59: 307-16.

Hughes JM, Li L, Chinn S, Rona RJ. Trends in growth in England and Scotland, 1972 to 1994. *Arch Dis Child* 1997; 76: 182-9.

Freedman DS, Srinivasan SR, Valdez RA, Williamson DF, Berenson GS. Secular increases in relative weight and adiposity among children over two decades: the Bogalusa Heart Study. *Pediatrics* 1997; 99: 420-6.

Kachondham Y, Winichagoon P, Tontisirin K. Nutrition and health in Thailand : trends and actions. UN ACC/SCN Country Case Study supported by UNICEF United Nation Children Fund. A case study for the XV Congress of the International Union of Nutrition Sciences, September 26-October 1, Adelaide 1993.

Mo-suwan L, Junjana C, Puetpaiboon A. Increasing obesity in school children in a transitional society and the effect of the weight control program. *Southeast Asian J Trop Med Public Health* 1993; 24: 590-4. (*Erratum : Southeast Asian J Trop Med Public Health* 1994; 25: 224).

Mo-suwan L, Geater AF. Risk factors for childhood obesity in a transitional society in Thailand. *Int J Obesity* 1996; 20: 697.

Must A, Dallal G, Dietz W. Reference data for obesity:85th and 95th percentiles of body mass insex (wt/ht^2) and triceps skinfold thickness. *Am J Clin Nutr* 1991; 53: 839-46.

Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents. A follow-up of the Harvard Growth Study of 1922 to 1935. *N Engl J Med* 1992; 327: 1350-5.

Popkin BM, Doak CM. The obesity epidemic is a world-wide phenomenon. *Nutr Rev* 1998; 56: 106-14.

Popkin BM, Richards MK, Monteiro CA. Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. *J Nutr* 1996; 126: 309-16.

Roche AF, Siervogel RM, Chumlea WC, Webb P. Grading body fatness from limited anthropometric data. *Am J Clin Nutr* 1981; 34: 2831-8.

Rosner B, Prineas R, Loggie J, Daniels SR. Percentiles for body mass index in US children 5 to 17 years of age. *J Pediatr* 1998; 132: 211-22.

Stark O, Atkins E, Wolff OH, Douglas JWB. Longitudinal study of obesity in the National Survey of Health and Development. *Br Med J* 1981; 283: 13-7.

StataCorp. Stata statistical software: release 5.0. College Station, TX: Stata Corporation, 1997.

Troiano RP, Flegal KM, Kuczmarski RJ, Campbell SM, Johnson CL. Overweight prevalence and trends for children and adolescents. The National Health and Nutrition Examination Surveys, 1963 to 1991. *Arch Pediatr Adolesc Med* 1995; 149: 1085-91.