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Title   Secular increases in weight, height and body mass index among school children of Hat Yai, Thailand : A 5 years follow-up study.

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Short running title   Secular increases in growth of school children

ABSTRACT

Upward trend of growth and overweight has been reported from developed countries. As Thailand undergoing rapid economic transition over the previous decade, we conducted the analysis to demonstrate the secular changes of growth over the five years follow-up. Subjects were a cohort of 2253 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, or 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. Results : 1094 (48.5%) children had completed 6 anthropometric measurements. Graphs of median weight, height, BMI and overweight prevalence of each birth cohort against age clearly showed secular increases of growth and overweight and age effect. 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. In conclusion, we demonstrated significant birth cohort effect and age effect on growth and overweight prevalence. An increasing trend of childhood overweight reported here signifies an immediate need of intervention aiming at preventing overweight and reducing weight in childhood and adolescence.

Keywords   child, growth, overweight, secular trend, cohort effect.

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) has 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 U.S. 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 e.g. 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,1993) Among school children of China obesity rates, associated with stunting though, were reaching the level comparing 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.

SUBJECTS 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 the capital city (Bangkok) and 100

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km from the Malaysian border. Rubber, sea-food, wood furniture and tourism industry are its main economy. Population was about 290,000 in 1997, 53.5% residing in the municipality. The Faculty of Medicine, Prince of Songkla University situates 6 km from the city center..

Subjects : A cohort of 2253 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. Parental consent was obtained and the study was approved by the Committee for Research in Humans, Faculty of Medicine, Prince of Songkla University.

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) 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. Baseline demographic and family data were collected by a questionnaire completed by parents as described in the previous report (Mo-suwan and Geater, 1996).

Data analysis : Only subjects with complete 6 anthropometric measurements were included in the analysis. To 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 U.S. First National Health and Nutrition Examination Survey (NHANES-I) 85th percentile for age and sex was considered overweight (Must et al, 1991).

Secular changes of growth and overweight and age effect were demonstrated by plotting of 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 2253 subjects followed from 1992 to 1997, 1094 (48.5%) had complete 6 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.

Figures 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. Similar trend was observed for the females. The youngest cohort had a median weight higher than the elder cohorts. In contrast to males, median weights of females appeared to stabilize at mid adolescence.

Median height for age of female cohorts stabilized earlier than those of males (Figs 3 and 4). Similar to weight, younger cohort was taller than the elder ones. Girls born in 1978, the eldest cohort, were approximately 6-10 cm shorter than those born later.

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

Figures 7 and 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 elder 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. 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

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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 noticeable.

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 has been 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 U.S. 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

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difference (Rosner et al, 1998), utilization of NHANES-I reference may underestimate overweight prevalence of our pre-pubertal children.

Concern of overweight in children comes from its long term morbidity and mortality. From the Harvard Growth Study of 508 lean (BMI value below 25th percentile of the NHANES-I reference for age and sex) or overweight (BMI value above 75th 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 y to 14 y 9 mo (Gunnell et al, 1998), the hazard ratio for all cause mortality in those with BMIs above the 75th 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.

Acknowledgment

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Table 1

Baseline characteristics of the selected and non-selected subjects

Variables	Selected (%)	Non-selected (%)	Chi-square [a]
Overweight at entry	1094 (18.1)	1155 (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)	

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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 U.S. 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/m^2)	
	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
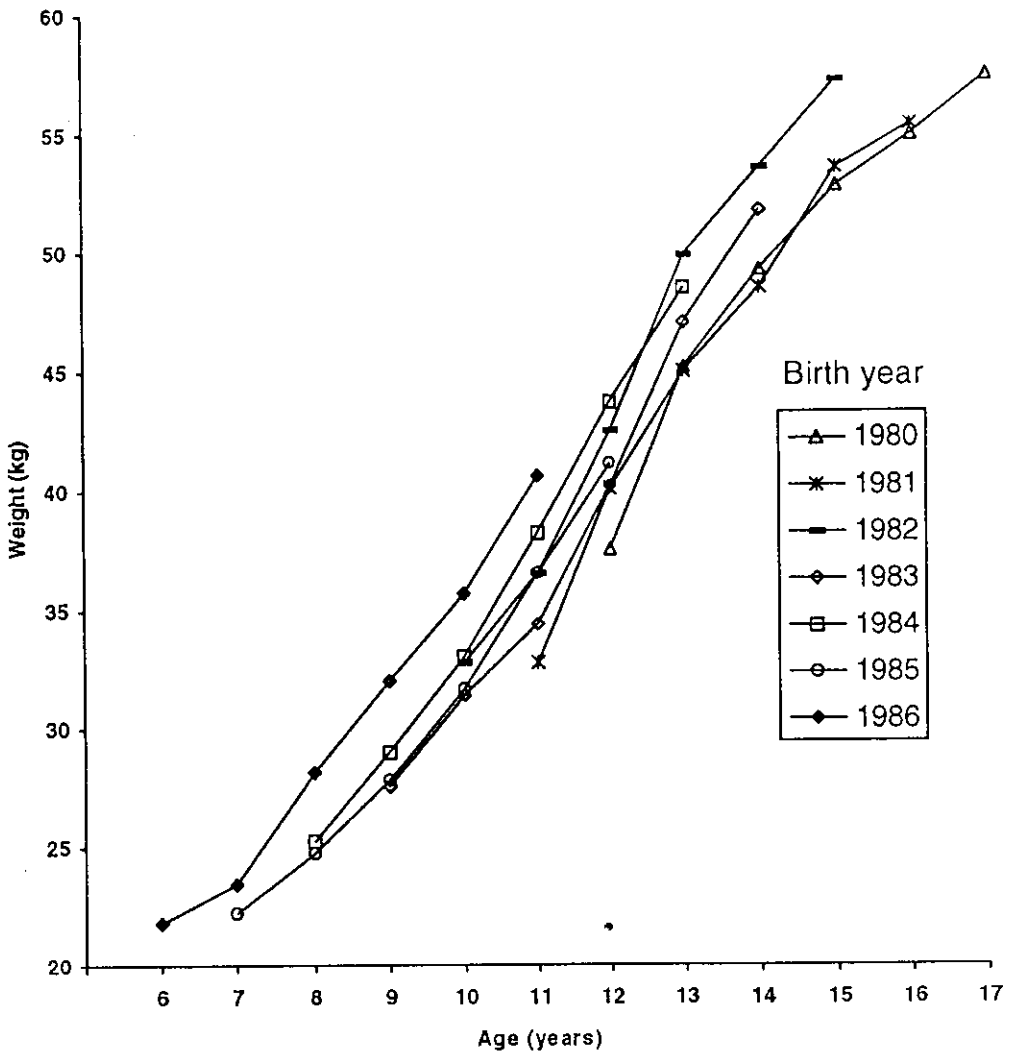
Fig 1 Median weight for age of male birth cohorts from 1992-1997
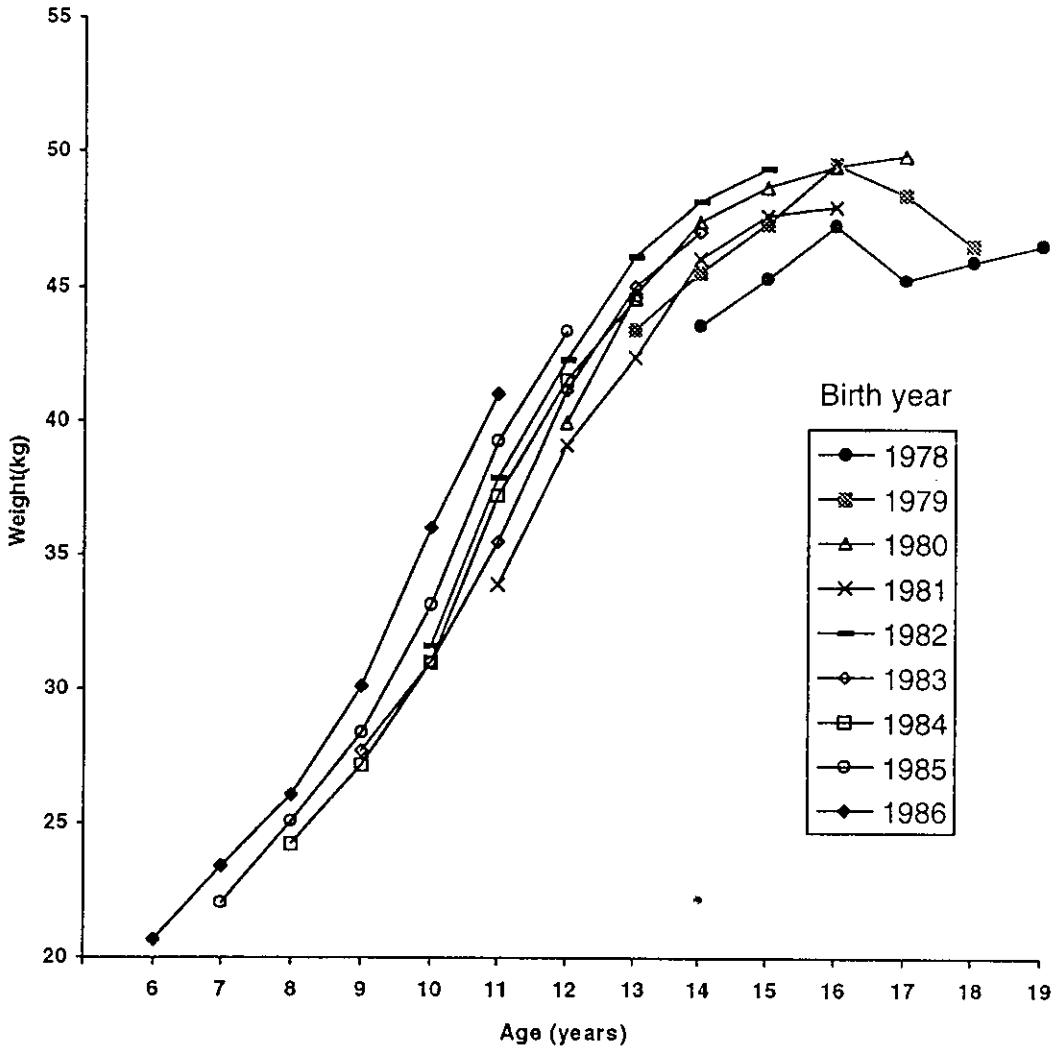
Fig 2 Median weight for age of female birth cohorts from 1992-1997
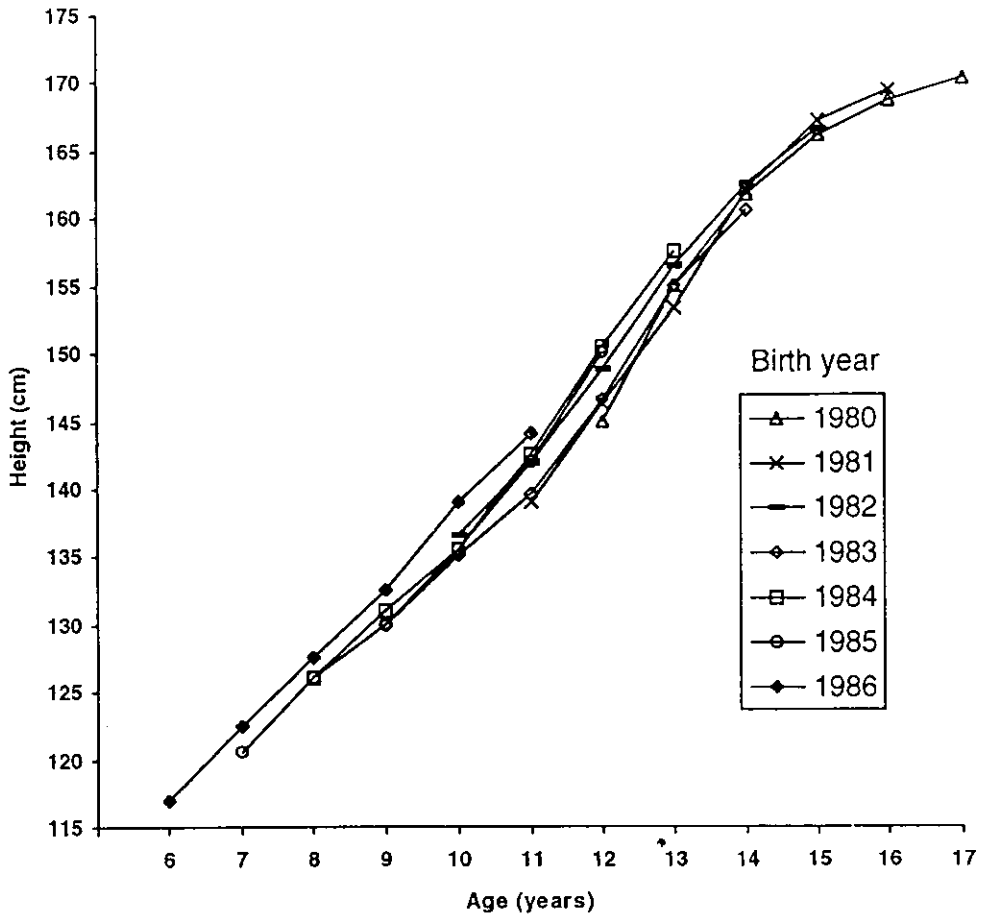
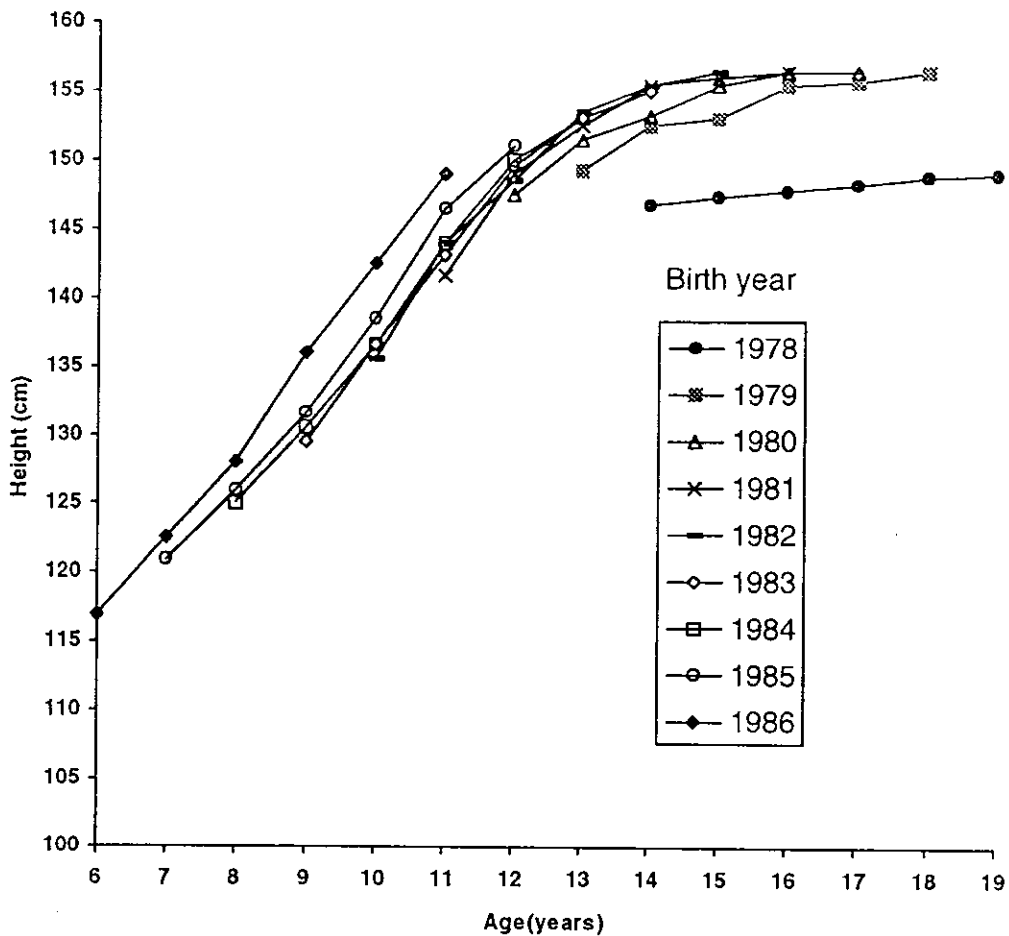Fig 3 Median height for age of male birth cohorts from 1992-1997

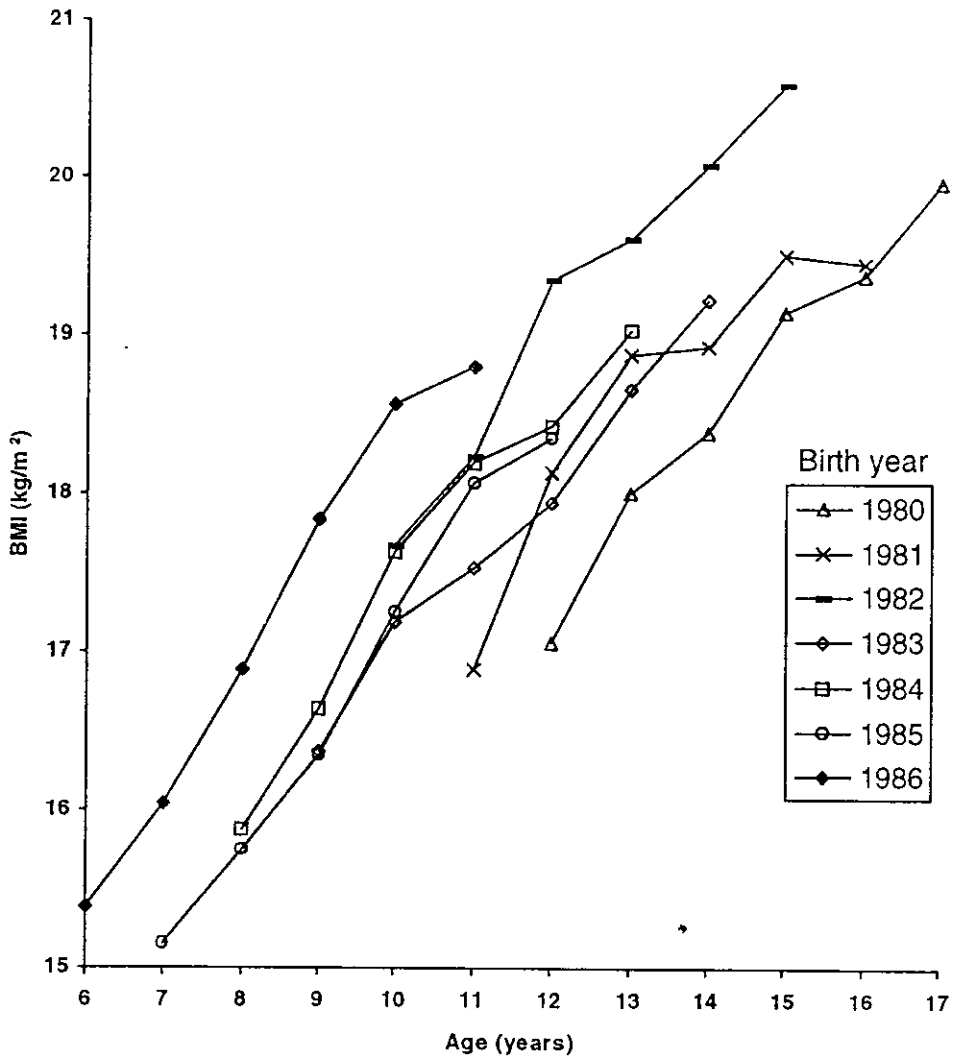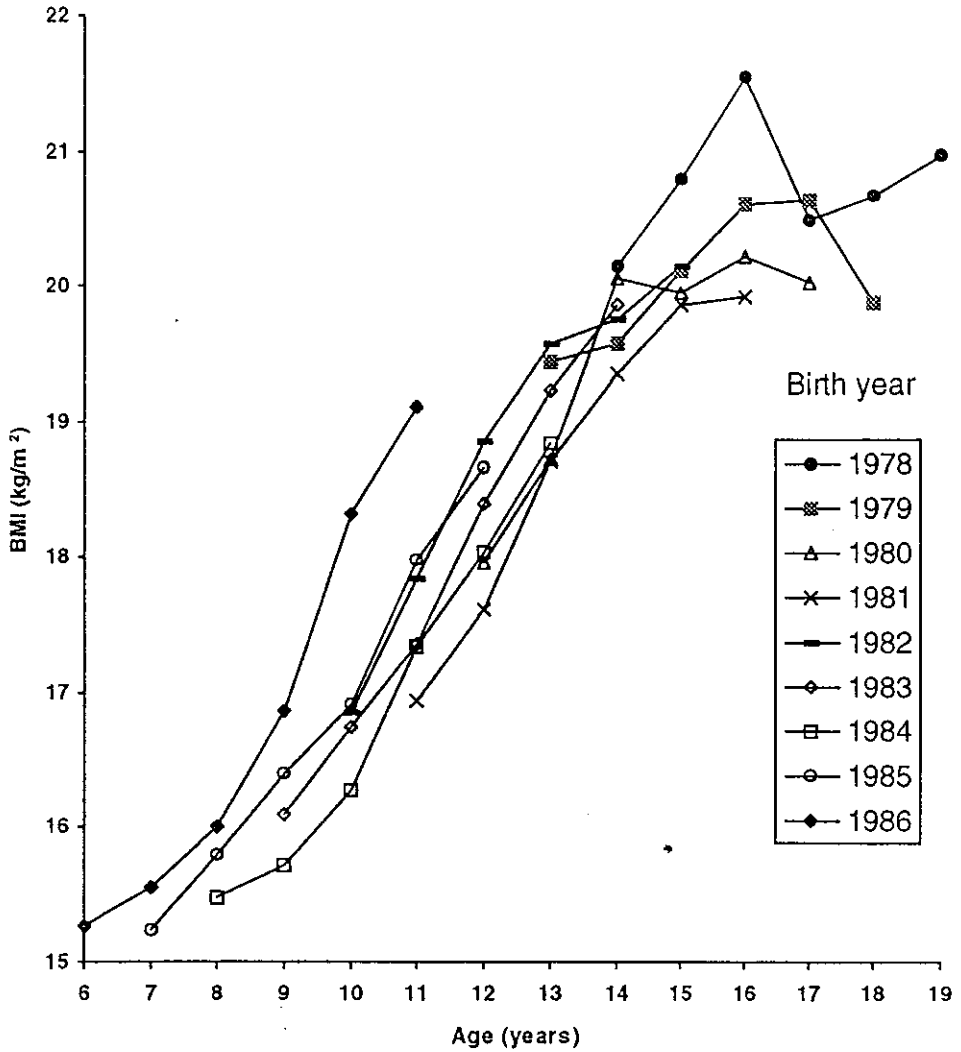Fig 4 Median height for age of female birth cohorts from 1992-1997

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

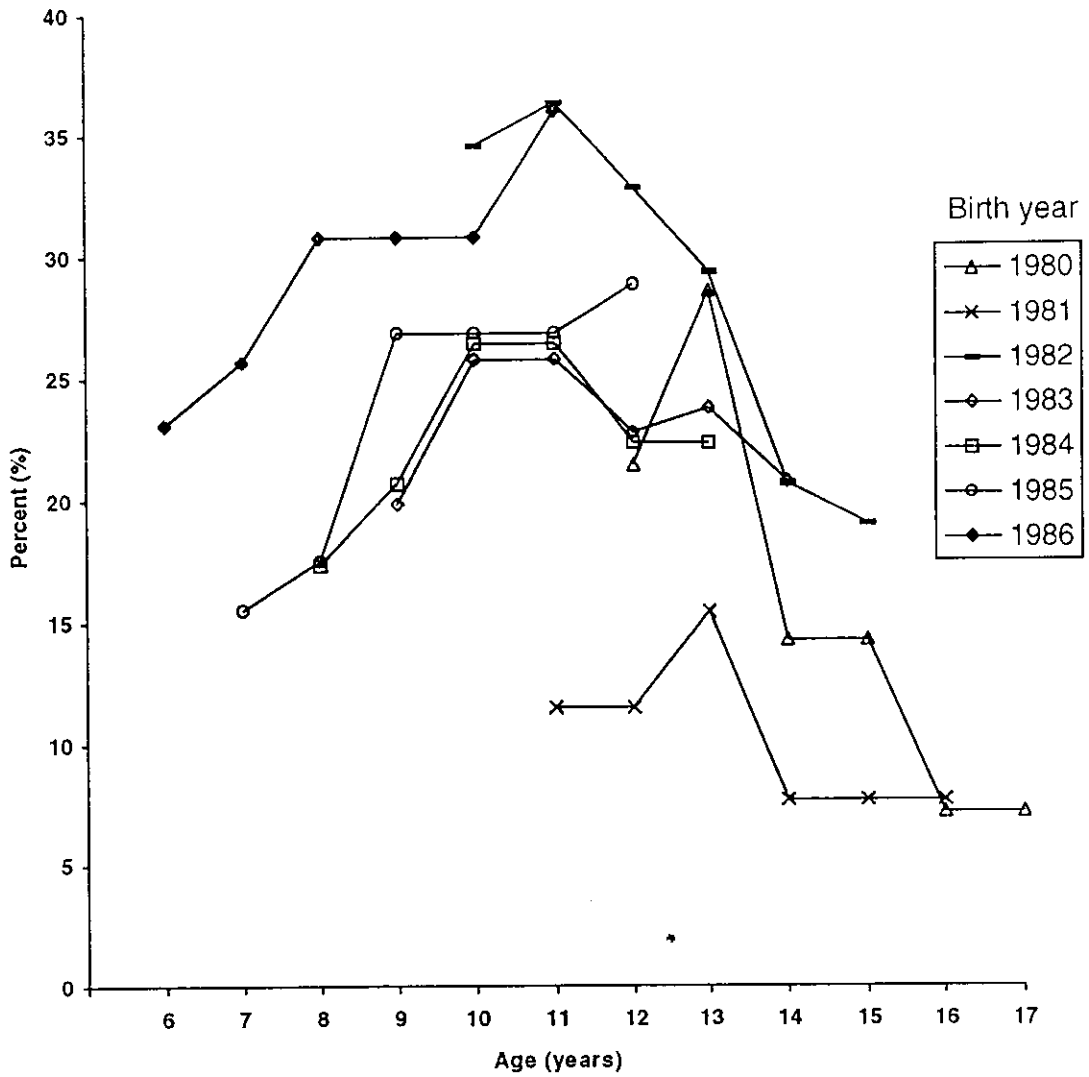Fig 6 Median BMI for age of female birth cohorts from 1992-1997

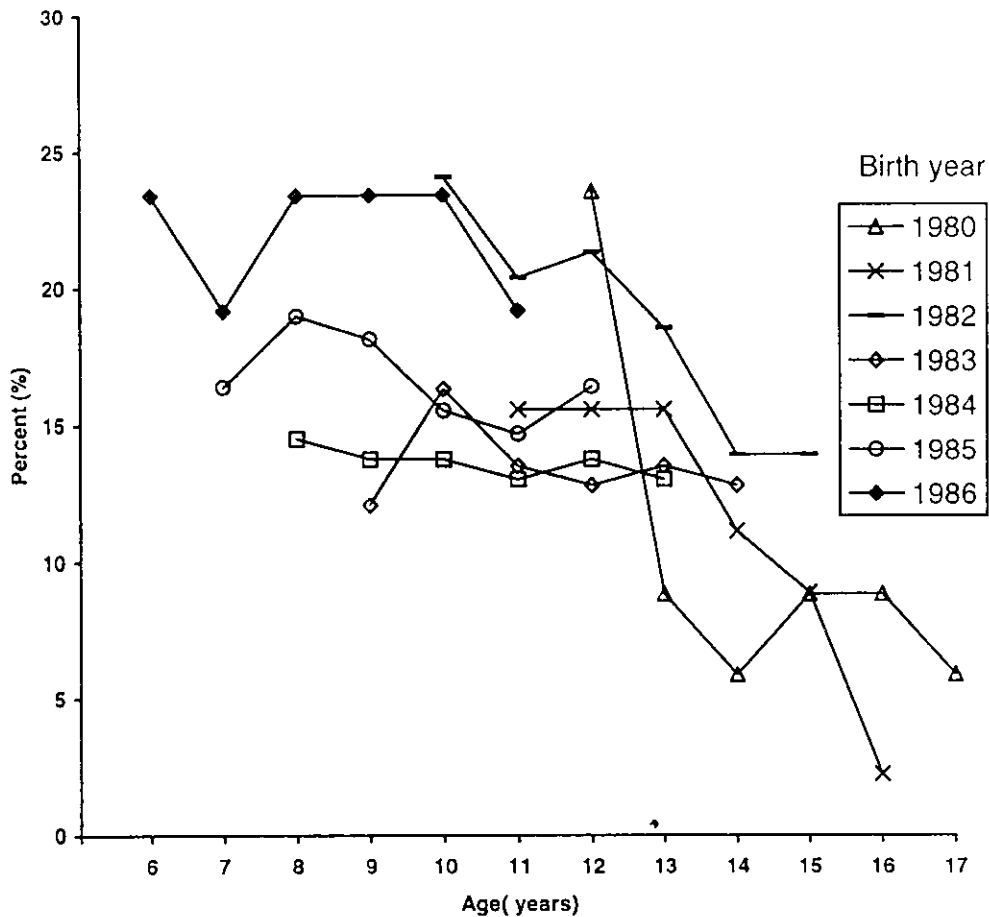Fig 7 Percent overweight for age of male birth cohorts from 1992-1997

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