

ORIGINAL ARTICLE

Tracking of overweight from early childhood to adolescence in cohorts born 1988 and 1994: overweight in a high birth weight population

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Objective: To investigate the prevalence and tracking of overweight and obesity in childhood cohorts born 1988 and 1994 in a population of high birth weight.

Subjects: Icelandic cohorts born in 1988 and 1994.

Materials and methods: Out of 1328, 9- and 15-year-old children from 18 randomly selected schools all over Iceland, 934 participated (71%). Height and mass were measured by the investigators. Also, height and mass at birth, and at age 2.5, 6, 9, and 12 years, were collected from maternity wards and school health registers.

Results: The prevalence of overweight children ranged from 10.1% for 2.5-year-olds to 18.7% for 9-year-olds. No difference was observed between the two cohorts or sex. The prevalence of obesity in the 1994 cohort (4.3%) was significantly higher ($P=0.01$) at age 6 years, compared to the 1988 cohort (1.1%). The children who were overweight at age 2.5 years were more likely to be overweight at age 6 (OR = 12.2) and 9 years (OR = 4.9), but not significantly at age 12 or 15 years, compared with normal weight 2.5-year-olds. Overweight children at age 6 or 9 years were much more likely (OR 10.4 and OR 18.6, respectively) to be overweight at age 15 years compared to their normal weight peers. Of overweight 6-year-olds, 51% were overweight at 15 years, and were about one-third of all overweight children at that age. The children that weighed above the 85th percentile at birth were more likely than the other children to be overweight at the age of 6 years (OR = 1.8), 9 years (OR = 2.1), and 15 (OR = 2.0) years.

Conclusion: The results show high prevalence of overweight and obesity even before the start of compulsory schooling. Approximately, 51% of overweight 6-year-olds were still overweight after puberty. Therefore, preschool overweight prevention, along with prevention at school age, seems to be of uttermost importance.

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Introduction

Trends indicating an increase in the proportion of overweight and obese children and adolescents have been reported in numerous studies from different industrialized countries for the last two decades.^{1–4} Obesity in childhood affects children's health and well-being, and tracks into adulthood leading to serious consequences.^{5–7} Moreover, the most recent studies from various parts of the world indicate

that this trend seems to affect even preschool children aged 2–6 years.^{8–12}

Recently, more attention has been given in epidemiological studies to tracking, which is defined as the maintenance of relative position in the rank of risk factors over time. For example, subjects who rank high for unfavourable risk profiles at a young age are likely to maintain their ranks into adulthood.^{5,13} Several longitudinal observational studies have been conducted to examine the tracking patterns of children's body mass index (BMI).^{1,14,15} However, few studies have focused on tracking of health-related variables such as overweight and BMI from early childhood to adolescence, and studies on tracking within high birth weight populations are scarce. Revealing the degree of tracking and identifying important predictors is critical in designing effective intervention strategies.

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Epidemiological studies have shown an association between small size at birth (<2.5 kg) and impaired adult health, especially at the lower end of the range of birth size.^{16,17} The association between small size at birth and coronary heart disease, hypertension and diabetes mellitus has also been seen in a population of high birth weight (>3.6 kg) in a cohort born in the first third of the last century.^{18–20} Birth weight has been shown to be positively associated with BMI in adulthood, without being a risk factor for severe adult obesity.^{21,22} The association is probably due to larger muscle mass developed in critical periods in foetal life and in childhood leading to higher birth weight and adult BMI in the cohorts from early in last century.^{22,23}

The prevalence of overweight and obesity has increased at all ages during the last decades. More knowledge is needed about the impact of size at birth on the growing generation's BMI. The increasing prevalence of overweight and obesity among preschool children also calls for studies on the development of BMI in cohorts born a few years apart to examine if the overweight epidemic seems to be moving to younger children.

Although numerous papers have been written about the tracking of overweight and obesity from childhood into adolescence and adulthood, most of these longitudinal investigations come from older cohorts.^{1,6,7,15} Cohort data from contemporary children are lacking, however, and nationwide representative samples of a large proportion of the whole population are not readily available. Therefore, the aim of the present study was to investigate the prevalence and tracking of overweight and obesity in nationwide representative childhood cohorts born 1988 and 1994 in a population of high birth weight.

Methods

A total of 934 healthy Icelandic children participated in this study, born in 1994 (4th grade, 9-year-old; 246 boys and 241 girls) and 1988 (10th grade, 15-year-old; 216 boys and 228 girls). The population for this study were all primary or lower secondary schools in Iceland and 18 schools were randomly selected based on the national and geographical distribution of the Icelandic population. For practical reasons all children born in 1988 and 1994 in these schools served as subjects ($n = 1328$) and informed consent was obtained from their parents (71% participation rate). Approximately, 15% of all children born in 1988 and 1994 in Iceland were sampled and more than 10% of the population participated in the study. All measurements were conducted from September 2003 to February 2004. The National Bioethics Committee in Iceland approved the study (VSN2003060014/03-12/BH/-).

Standing height was measured to the nearest mm with a transportable stadiometer and body mass was determined to the nearest 0.1 kg using standard procedures. The subjects were barefoot or wore socks and light clothing. BMI was calculated as body mass (kg) divided by height (m) squared. In

addition to measuring height and mass at 9 (1994 cohort) and 15 (1988 cohort) years of age, we obtained data on height and mass from prior ages in these cohorts from the school health care register. For decades the health care centres and the school nurses in primary and lower secondary schools in Iceland have measured mass and height/length at regular intervals from birth throughout childhood. When the children begin their schooling, the health care reports for the children are kept and updated by the school health care register. For children born in 1988, we obtained on average six measurements of height and mass between birth and 15 years of age (0, 2.5, 6, 9, 12, and 15) and for children born in 1994, four measurements (0, 2.5, 6, and 9) from birth to 9 years. Some of the children born in 1988 had no measurements at age 6 years, but were measured at ages 5 and 7 years. For these children, we estimated their values at age 6 years by linearly extrapolating between these measurements taking exact age at the time of the measurements into account.

Age and sex specific BMI cutoff points determined by the International Obesity Task Force (IOTF)²⁴ were used to indicate overweight and obesity. Each participant was classified into one of two groups, lean and overweight/obese. The cutoff values were calculated for each child based on exact age at the time of measurements and linear extrapolation between IOTF cutoff points for every half year of age.²⁴

In this study, tracking was defined as the maintenance of a ranking as overweight from age 2.5 to age 15 years and being above the 85th percentile for anthropometric measurements at birth (85th percentile for pooled data, same for both cohorts). Odds ratios (OR) were calculated to indicate tracking of being overweight at different ages. Logistic regression was used to test whether there were differences between the two cohorts and between sex. Neither sex nor year class had significant regression coefficients in any of the models in this study. Therefore, only unadjusted values of OR are presented in this paper. We calculated the predicted OR of being above the 85th percentile based on the observed correlation coefficient and the model presented by Wang and Popkin.¹⁴ The predicted OR was very similar to the observed one and always well within the 95% confidence intervals (CI) of the observed one. Thus, our observed ORs are not significantly different from those predicted by the correlation coefficients and are not presented. In this study, we had on several occasions significant correlation coefficients (data not shown) but not significant OR. Multifactorial ANOVA was used to test the sex and cohort differences of anthropometric measurements or any interaction thereof at birth and at ages 2.5, 6 and 9 years. Statistical analysis was performed with the SAS statistical program (SAS Institute Inc., Version 8.2).

Results

The prevalence of obesity at age of 6 years was higher in the 1994 than in the 1988 cohort but no other differences were

found between sex (within cohort) or between age groups (Tables 1 and 2). The prevalence values of overweight were not different between the cohorts.

Birth weight and length were higher for boys (3.7 ± 0.6 kg, 51.9 ± 2.7 cm) than for girls (3.5 ± 0.6 kg, 51.0 ± 2.4 m, $P < 0.0001$), but no cohort differences were found for these variables ($P = 0.29$ mass, $P = 0.68$ height) at birth. No difference in BMI or Ponderal Index was found between sex and cohorts at birth and no sex cohort interaction was observed for any of the birth parameters.

The average mass and height growth curves for both cohorts and both sex are shown in Figures 1 and 2, respectively. The development of BMI from birth and at various ages for both cohorts and both sex are presented in Figure 3. Differences in mass and height between the sexes were found at ages 2.5 ($P < 0.0001$) and 6 years ($P = 0.046$ mass, $P = 0.002$ height) with boys being taller and heavier at both ages. The difference in mass was not significant at age 9 years ($P = 0.13$) but boys remained taller ($P = 0.0006$). Boys also had significantly higher BMI at age 2.5 years ($P = 0.001$). The 1994 cohort was taller (1.382 m) than the 1988 cohort (1.372 m) at age 9 years ($P = 0.02$). No sex cohort interactions were observed.

To demonstrate tracking of overweight in this study, the data for both cohorts were pooled for birth and ages 2.5, 6 and 9 years. When prevalence of overweight was compared between different ages from 2.5 to 15 years, it was found that the overweight children at age 2.5 years were more likely to be overweight at both ages 6 and 9 years than the lean children (Table 3). However, the overweight children at age

2.5 years were not more likely to be overweight at age 12 and 15 years. The children who were overweight at age 6 years were more likely to be overweight at 9, 12 and 15 years (Table 3).

Our results show strong tracking patterns of overweight since about 56% of the children that were overweight at age 2.5 years were overweight at age 6 years. An even higher rate of tracking was noted for the population between ages 6 and 9 years, or 72%. Moreover, similar tracking patterns were found for the children that were overweight at age 9 years; 63% of them remained overweight at age 12 years and 54% at age 15 years.

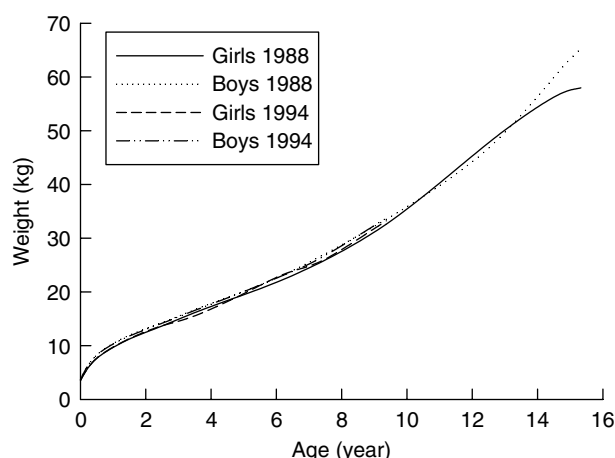


Figure 1 Mass growth of both cohorts and both sex.

Table 1 Prevalence of overweight in the two cohorts in Iceland

Age (years)	1988 cohort				1994 cohort				Total ^a (%)	1994 vs 1988 Fischer exact P
	Male (%)	Female (%)	All (%)	n	Male (%)	Female (%)	All (%)	n		
2.5	9.4	16.4	13.0	108	8.6	9.6	9.1	309	10.1	0.27
6	10.1	11.9	11.0	356	12.3	18.4	15.3	353	13.1	0.10
9	17.5	19.6	18.5	383	18.7	19.0	18.9	488	18.7	0.93
12	18.3	17.9	18.1	364						
15	18.0	12.1	15.1	443						

^aTotal symbolizes the value for both cohorts.

Table 2 Prevalence of obesity in the two cohorts in Iceland

Age (years)	1988 cohort				1994 cohort				Total ^a (%)	1994 vs 1988 Fischer exact P
	Male (%)	Female (%)	All (%)	n	Male (%)	Female (%)	All (%)	n		
2.5	1.9	0.0	0.9	108	0.7	1.3	1.0	309	1.0	1.00
6	1.1	1.1	1.1	356	3.9	4.6	4.3	353	2.7	0.01 ^b
9	1.6	2.1	1.8	383	4.2	3.6	3.9	488	3.0	0.11
12	1.7	0.5	1.1	364						
15	1.8	1.4	1.6	443						

^aTotal symbolizes average value for both cohorts. ^bA significant difference was found between the cohorts at the age of 6 years for both sex.

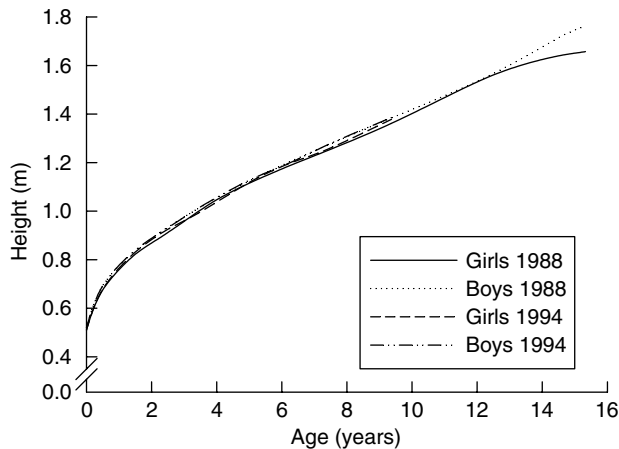


Figure 2 Height growth of both cohorts and both sex.

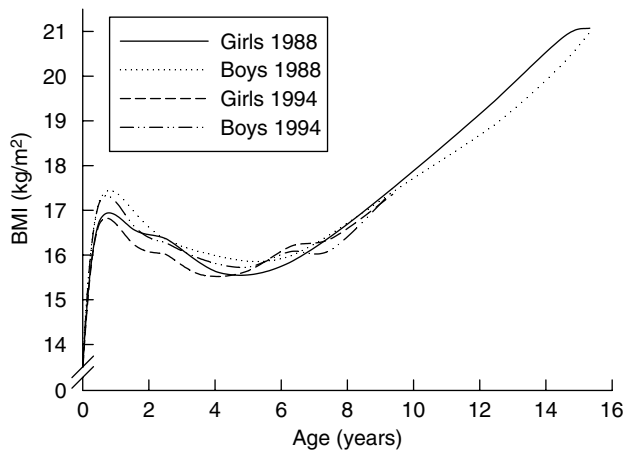


Figure 3 BMI for both cohorts and both sex.

To investigate the implication of size at birth for being overweight later in life, we compared the OR of those above the 85th percentile at birth in our cohorts against those below for mass, length, BMI, and Ponderal Index. The children that weighed above the 85th percentile at birth were more likely than the other children to be overweight at all ages except at age 12 years (Table 4). Also, the children whose length was over the 85th percentile at birth were more likely to be overweight at ages 2.5 and 9 years. Tracking of high mass and length at birth was about 20–30% for all ages between 2.5 and 15 years, although not significant at all ages. On the contrary, the children that were born with BMI or Ponderal Index above the 85th percentile were not more likely to be overweight after age 6 than the children below this percentile.

Discussion

In a representative large proportion sample population study on a high birth weight population strong tracking of overweight ranking from age 6 to age 15 years was found. The magnitude of tracking was higher as the children got older. The rate of obesity in the 1994 cohort was more than twice the rate in the 1988 cohort, but other significant differences between the cohorts were not observed. The results also indicate that of measurements at birth, only high mass can predict overweight in adolescence.

In the epidemiological literature tracking is used to describe the relative stability of a certain biological variable over time.^{5,25} Studies in the United States and Europe that tracked overweight from childhood to adulthood from the 1960s to the present generally found that about one-third of overweight children remained overweight as adults. The rate varies dramatically, however, because of differences in the

Table 3 Tracking of overweight from age 2.5 to 15 years in pooled data from two cohorts (1994 and 1988)

Younger age (years)	Older age (years)	n	Persistence (%)	Tracking (%)	OR (95%CI)
2.5	6	336	56	5.4	12.2 (5.5–27.0)*
—	9	408	48	4.9	4.9 (2.5–9.6)*
—	12	84	42	6.0	2.7 (0.8–9.8)
—	15	108	29	3.7	2.5 (0.7–9.1)
6	9	690	72	9.4	21.8 (12.8–37.0)*
—	12	307	62	7.5	10.3 (4.9–21.9)*
—	15	354	51	5.7	10.4 (5.0–21.6)*
9	12	333	63	12.0	20.6 (10.5–40.7)*
—	15	380	54	10.0	18.6 (9.6–36.3)*
12	15	361	58	10.5	27.2 (13.2–56.3)*

Persistence = percent of those overweight at the younger age that are still overweight at the older age. Tracking = percent of the total sample that are overweight at both ages. OR = odds ratio = odds of the children who are overweight at the younger age of being overweight at the older age divided by the odds of children who are lean at the younger age of being overweight at the older age. *Significant ($P > 0.05$).

Table 4 Tracking of overweight from size at birth (over the 85th percentile at birth according to Cole *et al.*, 2000) through age 2.5–15 years in pooled data from two cohorts

Birth size parameter	Age (years)	n	Persistence (%)	Tracking (%)	OR (95%CI)
Birth weight	2.5	408	21	2.9	2.9 (1.4–6.1)*
	6	646	19	2.8	1.8 (1.0–3.2)*
	9	772	30	4.5	2.1 (1.4–3.4)*
	12	311	23	3.9	1.4 (0.7–2.9)
	15	361	24	3.9	2.0 (1.0–4.0)*
Birth length	2.5	406	22	2.2	2.9 (1.3–6.7)*
	6	642	18	1.7	1.6 (0.8–3.2)
	9	766	32	3.3	2.3 (1.4–3.8)*
	12	307	23	2.6	1.4 (0.6–3.2)
	15	356	24	2.5	1.9 (0.8–4.2)
Birth BMI	2.5	406	20	3.0	2.8 (1.3–5.9)*
	6	642	19	2.8	1.8 (1.0–3.2)*
	9	766	22	3.3	1.3 (0.8–2.1)
	12	307	15	2.3	0.8 (0.3–1.8)
	15	356	16	2.5	1.1 (0.5–2.4)
Ponderal Index	2.5	406	14	2.0	1.6 (0.7–3.7)
	6	642	18	2.7	1.6 (0.9–2.9)
	9	766	17	2.5	0.9 (0.5–1.4)
	12	307	12	2.0	0.6 (0.2–1.4)
	15	356	17	2.8	1.2 (0.6–2.6)

Persistence = percent of those over the 85th percentile at birth that are overweight at a given age. Tracking = percent of the total sample over the 85th percentile at birth and overweight at a given age. OR = odds ratio = odds of the children who are over the 85th percentile at birth of being overweight at a given age divided by the odds of children who are under the 85th percentile at birth of being overweight at a given age. *Significant ($P < 0.05$).

definition of overweight, the children's initial age, and the length of follow-up.^{6,7,26–28}

Tracking of BMI from early childhood to mid-20s was estimated in Australian children born in the mid-1970s¹ and in Finnish children born in the early 1980s.¹⁵ In the Finnish study the relative risk (RR) was used as the tracking coefficient and was 3.6 (2.0–6.3, 95% CI) of being of high level BMI at 15 years of age if one had been at high level BMI at the age of 7.¹⁵ Similarly, the RR of being overweight at the age of 20 if one had been overweight at 11 years of age was 3.47 (2.41–5.01, 95% CI) among Australian children.¹ In the present study, the OR of being overweight at age 15 years if overweight at age 6 years was 10.4 (5.0–21.6, 95% CI). As OR values are not directly comparable to RR values, we transformed this value into an RR value. The RR of being overweight at age 15 years if overweight at age 6 years was 5.6 (3.5–8.9, 95% CI). Therefore, although the CIs in these studies overlap, the tracking coefficient is slightly higher in the present study than in the other studies. One reason for higher tracking coefficients in the present study could be the rise in the prevalence in overweight and obesity in industrialized countries^{2–4} and better tracking of extreme groups.¹⁴ The data in the present study are more recent than

in the earlier ones, and the rate of overweight slightly greater.¹

Similar, to our findings, these earlier studies found that tracking of overweight was stronger for shorter age intervals and was weakest from early childhood (0.5–2 years) to adolescence and early adulthood.^{1,15} As in the present study, the magnitude of the tracking coefficient was higher as the children got older.^{1,15} One of the reasons for nonsignificant tracking for longer age intervals (i.e., 2.5–12 or 2.5–15) in the current study was reduced statistical power, which is due to the low number of subjects that had data at both ages. This reduction in number of subjects is in part because at 12 and 15 years of age we only have data from the 1988 cohort and in part due to imperfect recording systems in the schools and factors such as children moving between schools. This was considerably worse for the 1988 cohort at the age of 2.5 year because around this time (1990–1991) it was very variable whether children were measured at 2, 2.5 or 3 years of age.

Our study confirmed previous findings of higher tracking of extreme groups, like the overweight or underweight classifications, than for the middle groups (normal weight) for a given correlation coefficient.¹⁴ In many studies a correlation coefficient is used to predict tracking.^{25,29} However, as shown in this study, a significant correlation coefficient does not necessarily reveal significant OR. This shows that caution is needed when methods to demonstrate tracking are chosen. By using OR, we can demonstrate how strong the IOTF cutoff points are in predicting overweight at later age without the influence of tracking in ranking within the lean group.

Our results show that 51% of the children that were overweight at age 6 years were still overweight at age 15 years, which constitutes 5–6% of the total research population or about one-third of those overweight at age 15 years. This finding suggests that overweight prevention strategies could be implemented before children start their compulsory schooling. The corollary is that 49% of the children went from being overweight to being normal weight between the ages of 6 and 15 years and identifying the factors that are linked to this loss of overweight is also of great importance. Furthermore, twice as many children moved into the overweight category between the ages of 6 and 15 years as moved out of that category during the same period. Therefore, the value of intervention in late childhood and adolescence must not be underestimated. Despite the possibility of losing weight during compulsory schooling, several studies both from US and Europe have shown that one-third of childhood overweight/obesity tracks into adulthood.^{6,7,26–28} This indicates that childhood overweight or obesity is a strong predictor for increased risk of obesity and its complication such as cardiovascular disease in later life.³⁰

The prevalence of overweight at the highest comparative age of the cohorts, age 9 was 18.5% and 18.9% in the 1988 and 1994 cohorts respectively, and in general the prevalence of overweight was similar in the cohorts. Our prevalence

rates for overweight are slightly higher than prevalence rates in studies from Australia,¹ Britain,² US,³ and Europe.⁴ That does not necessarily reflect greater prevalence of overweight in Iceland. Our prevalence rate is sampled a few years later than in the studies mentioned above and the rapid increase in overweight prevalence rate worldwide³⁰ could explain this difference.

Despite the fact that only 6 years separate the birth of the cohorts in this studies, the prevalence of obesity was significantly higher in the 1994 cohort compared to the 1988 cohort at age 6 years. At age 9 years, this difference was not significant despite the prevalence of obesity in the 1994 cohort being double that of the 1988 cohort. There could be several reasons why prevalence of overweight/obesity might differ between the cohorts and it is difficult to find simple explanations. In a recent review paper written by Lobstein *et al.*³⁰ for the International Obesity Task Forces, there is a comprehensive list of possible reasons for the increase in the prevalence of overweight/obesity over the last decade. From this review, it can be speculated that rapid changes in lifestyles, such as in physical inactivity, television viewing and diet could explain the differences between the two cohorts.

A rising prevalence of overweight and obesity in preschool children has been reported in repeated cross-sectional studies and longitudinal studies from other countries.^{2,3,8,10–12} Numerous studies have also shown that increased energy intake and sedentary lifestyle are the two characteristics that are most strongly associated with the increased prevalence of overweight worldwide.³⁰ Another important reason for this tendency is also the lack of physical activity in children's lives.³¹

The increase in the prevalence of overweight in most Western countries during the twentieth century could indicate that boys and girls are getting taller and weigh more at the same age compared to earlier time points. In the current study, the children born in 1994 were significantly taller at age 9 years than children born in 1988, but no such difference was found in body mass at this age despite the average body mass being 0.5 kg higher in the 1994 cohort. These results are interesting because the two cohorts are only separated by 6 years, and to our knowledge, different size at comparable age has not been found previously in two cohorts so close in year of birth and in the same population. These differences in height and mass may indicate that the younger cohort is growing at a faster rate from age 6 to 9 years.

High birth weight, above the 85th percentile, increased the risk of overweight at ages 2.5, 6, 9 and 15 years. The prediction was smaller though (OR = 2.0 for age 15 years overweight) than the effect of overweight at higher age. One-fourth of those in the highest 15% at birth were overweight at 15 years compared to more than half of those overweight at age 6 years. The tracking was 5.7 and 3.9% of the study population and comprised almost 40 versus 25% of those overweight at age 15 years. The tracking from birth weight cannot be disregarded. The association between the birth weight of children today and later health might be different

from that of the cohorts from early in the last century, where there was a protecting effect of high birth weight against several chronic diseases in adulthood.^{16,17} Icelandic women or mothers of the study population in the present study are tall³² and their newborns are among the largest worldwide, which has been related to high fish intake in prepregnancy normal weight women.^{33–35} Maternal weight gain in pregnancy is associated with birth weight and a very recent paper showed that overweight Icelandic women are more likely to gain excessive weight during pregnancy than other women and excessive weight gain is related to higher energy intake and high intake of sweets during early pregnancy.³⁶ This indicates the importance of guidance in diet during pregnancy. It has been suggested that the association between birth weight and BMI in cohorts older than those studied in the present study could be related to more muscle mass developed at a critical period in foetal life close to week 30 *in utero* as well as during childhood.²³ That theory is supported by an association between birth weight and fat-free mass in adulthood at any adult BMI,²³ and an inverse relation between birth weight and adult truncal fat.²² This indicates the weakness of BMI as a measure of body composition or body fatness. In more recent cohorts, the highest birth weight might be related to high fat mass and obesity, however. This remains to be investigated.

Our findings support the need for practical prevention strategies. It appears that there is a need to target children very early in life. Many of the stated strategies indicate alternatives in dietary education, healthy food provided at school and increases in physical education.³⁷ Nevertheless, most of these approaches target mainly school-aged children, but our results demonstrate that overweight and obesity are problematic before school enrolment with up to one in eight young children being affected.

In conclusion, overweight and obesity are a health problem even before children begin compulsory school. Approximately, 51% of the children that were overweight at age 6 years are still overweight after puberty, and are about 40% of those overweight at that time. Of less impact but considerable importance for overweight among 15-year-olds is mass at an even younger age, 2.5 years and birth. Therefore, preschool overweight prevention, along with maternal care and prevention at school age, seems to be of uttermost importance.

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