fact that previous studies evaluated the outcome of adolescent rather than childhood obesity, they evaluated young adults in the 1980s, and assessed outcomes at 21[2] and 23,[3] whereas we assessed outcome at 30 years (see bmj.com).

Conclusions

These data suggest that the long term social and psychological impact of the apparent epidemic of childhood obesity less than previously thought, particularly in those in whom obesity resolves after childhood. Efforts to reduce the socioeconomic and psychosocial burden of obesity in adult life should focus on prevention of the persistence of obesity from childhood into adulthood.

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Early life risk factors for obesity in childhood: cohort study

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Abstract

Objective To identify risk factors in early life (up to 3 years of age) for obesity in children in the United Kingdom.

Design Prospective cohort study.

Setting Avon longitudinal study of parents and children, United Kingdom.

Participants 8234 children in cohort aged 7 years and a subsample of 909 children (children in focus) with data on additional early growth related risk factors for obesity.

Main outcome measures Obesity at age 7 years, defined as a body mass index ≥95th centile relative to reference data for the UK population in 1990.

Results Eight of 25 putative risk factors were associated with a risk of obesity in the final models: parental obesity (both parents: adjusted odds ratio, 10.44, 95% confidence interval 5.11 to 21.32), very early (by 43 months) body mass index or adiposity rebound (15.00, 5.32 to 42.30), more than eight hours spent watching television per week at age 3 years (1.55, 1.13 to 2.12), catch-up growth (2.60, 1.09 to 6.16), standard deviation score for weight at age 8 months (3.13, 1.43 to 6.85) and 18 months (2.65, 1.25 to 5.59); weight gain in first year (1.06, 1.02 to 1.10 per 100 g increase); birth weight, per 100 g (1.05, 1.03 to 1.07); and short (<10.5 hours) sleep duration at age 3 years (1.45, 1.10 to 1.89).

Conclusion Eight factors in early life are associated with an increased risk of obesity in childhood.

Introduction

Evidence on risk factors for obesity in childhood is limited.[1 2] We identified and quantified risk factors for obesity at age 7 years in children who were participating in the Avon longitudinal study of parents and children (ALSPAC), in which confounding variables are being considered and potential risk factors are being tested simultaneously. For our study, we took into account only risk factors supported by a priori hypotheses.

Methods

The Avon longitudinal study of parents and children is described in detail elsewhere.[3] Briefly, 14 541 pregnant women with an expected date of delivery between April 1991 and December 1992 were enrolled, and 13 971 children formed the original cohort. Data have been

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collected from questionnaires completed by the parents, medical records, and biological samples. We randomly selected a subsample of children from the last six months of recruitment (children in focus group), aged from 4 months to 5 years, and invited their parents to bring them in for regular physical examinations.

We measured height to 0.1 cm and weight to 0.1 kg. From these values we calculated the body mass index (weight (kg)/(height (m)^2). The indices were converted to standard deviation scores relative to UK reference data in 1990.[4] We defined obesity as a body mass index equal to or greater than the 95th centile, equivalent to a standard deviation score of 1.64 or more.

We chose putative risk factors on the basis of previously reported associations with obesity, or plausible prior hypotheses. Overall, we identified 31 potential risk factors. Measures for 21 of these risk factors were available for the entire cohort. A further four factors relating to growth in infancy and early childhood were available for the children in focus subsample (see bmj.com).

Statistical analyses

We carried out a multivariable analysis in three stages using multivariable binary logistic regression models. Firstly, we assessed whether the effect of potential risk factors was confounded by the mother's education. Secondly, we analysed putative risk factors for childhood obesity simultaneously within each of the four risk factor groups (intrauterine and perinatal factors; infant feeding and complementary feeding (weaning) practice; family characteristics and demography; and lifestyle in early childhood). Finally, risk factors that were independently statistically significant ($P<0.10$) at the within group stage were then entered into a final model in which we analysed all variables simultaneously. We further adjusted the variables for sex, maternal education, and the child's estimated energy intake at age 3 years for the food group variables. We used χ^2 tests for linear trend for ordered categorical variables and Fisher's exact test in contingency tables when the expected frequency in any cell was less than 5.

To assess the effect of the four growth related risk factors (measured in the children in focus subsample only) on obesity, we used multivariable binary logistic regression models, while controlling for all other statistically significant risk factors obtained from the analysis of the whole cohort. Size in early life was measured at age 8 and 18 months.

Results

In total, 8234 children attended the clinic at age 7. Measures for height and weight were available for 7758 children (3934 boys and 3824 girls; 55.5% of the original 13 971 children). The prevalence of obesity did not differ significantly between the sexes (boys, 9.2% (n=362); girls, 8.1% (n=309): P=0.08). Overall, 5493 children (70.8% of those with measures for height and weight who attended at age 7, 39.3% of the original cohort) had complete data for the multivariable analyses.

Risk factors in entire cohort

Intrauterine and perinatal factors

Increasing birth weight was independently and linearly associated with increasing prevalence of obesity at age 7 (see bmj.com). Obesity at age 7 was also significantly associated with maternal smoking between 28 and 32 weeks' gestation.

Infant feeding and weaning practice

The apparent protective effect of exclusive breastfeeding on obesity at age 7 observed in the univariable analysis remained when breastfeeding was considered together with the other infant feeding and weaning practice variable (adjusted odds ratio 0.70, 95% confidence interval 0.54 to 0.91), but disappeared in the final model (see bmj.com). In the final model, timing of introduction of complementary feeding was not significantly related to the risk of obesity at age 7.

Family characteristics and demographics

When only one parent was obese, the risk of obesity at age 7 was increased. The risk was higher when both parents were obese (adjusted odds ratio 10.44, 5.11 to 21.32; see bmj.com).

Lifestyle in early childhood

Sleep Sleep duration in children aged 30 months was independently associated with prevalence of obesity at age 7 (see bmj.com). Children in the lowest two quarters of sleep duration (<10.5 hours and 10.5-10.9 hours) were more likely to be obese at age 7 than children in the highest quarter (>12 hours; χ^2 test for linear trend 17.8).

Sedentary behaviour The odds ratio for obesity increased linearly as the number of hours of television viewing increased (χ^2 test for linear trend 26.7). For children reported to watch television for 4-8 hours per week at age 3 the adjusted odds ratio for obesity at age 7 was 1.37 (1.02 to 1.83). For those reported to watch more than eight hours per week the adjusted odds ratio was 1.55 (1.13 to 2.12).

Dietary patterns We found no conclusive evidence of an association between dietary patterns at age 3 and risk of obesity at age 7. A junk food dietary pattern at age 3 was significantly associated with obesity at age 7 (see bmj.com).

Risk factors in children in focus subsample

The prevalence of obesity at 7 years in the children in focus subsample was not significantly different from that in the entire cohort (8.7%; 79/909). Children in the highest quarter for weight at age 8 months and 18 months were more likely to be obese at age 7 than children in the lower quarters (see bmj.com). Early adiposity rebound, catch-up growth between birth and two years, and high rates of weight gain in the first 12 months were also independently associated with obesity at age 7 (see bmj.com).

Discussion

We found that eight of 25 putative early life risk factors for obesity in childhood were significantly related to risk of obesity. Our study supports the hypothesis that the environment in early life can determine risk of later obesity, and suggests several influences in early life that might be suitable targets for future obesity prevention interventions. Our study has advantages over previous ones because of its contemporary nature, large sample size, longitudinal design, and the use of multivariable

analysis. We found that the list of potential risk factors for childhood obesity and targets for preventive interventions should be extended.

Putative risk factors for obesity not independently associated with the risk of obesity in childhood were sex, parity, season of birth, gestational age, number of fetuses, timing of introduction of complementary feeding, number of siblings, ethnicity, maternal age, and time spent in the car.

We did not observe an independent protective effect of exclusive breast feeding on obesity in our final model, in contrast to our findings in a different UK cohort.[5] Breast feeding in women who did not smoke during pregnancy was significantly associated with a reduced risk of obesity at age 7 years.

In the entire cohort, birth weight, parental obesity, sleep duration, and television viewing remained independently associated with the risk of obesity in the final model. In the children in focus subsample, size in early life (standard deviation scores for weight at age 8 months and 18 months), weight gain in infancy, catch-up growth, and early adiposity rebound were also significantly associated with the risk of obesity.

Parental obesity may increase the risk of obesity through genetic mechanisms or by shared environmental characteristics.[6] Duration of night time sleep may alter later risk of obesity through growth hormone secretion, or because sleep reduces the child's exposure to factors in the environment that promote obesity. Alternatively, duration of night time sleep may be a marker for some other variable. Television viewing may confer risk through a reduction in energy expenditure or increased food intake.[7 8]

The mechanisms by which the early life growth variables studied in the children in focus subsample might increase the risk of obesity are generally unclear but consistent with an increasing body of evidence that the early life environment is important.[1 5 9–11]

Limitations of the study

We were unable to analyse several factors—notably physical activity and energy expenditure, parental control over feeding in childhood,[12] and maternal diabetes during pregnancy.[13] The use of definitions of obesity based on body mass index is acceptable as an outcome measure but not ideal.[4 14 15]

The Avon longitudinal study of parents and children cohort is broadly representative of the UK population,[3] although ethnic minority groups are slightly under-represented. We cannot rule out underestimation of the effect of some risk factors that are more prevalent in these groups.

Implications

Intrauterine life, infancy, and the preschool period have all been considered as possible critical periods during which the long term regulation of energy balance may be programmed.[16] Our study provides evidence of the role of the early life environment in the later risk of obesity. Prevention strategies for childhood obesity to date have usually been unsuccessful and typically focus on change in lifestyle during childhood or adolescence. Future interventions might focus on environmental changes targeted at periods in early life that are independently related to later risk of obesity.

What is already known on this topic

Obesity is common in children and adolescents and its prevalence is still increasing

Risk factors for childhood obesity are not well established

Existing prevention strategies, focused on late childhood and adolescence, are largely unsuccessful

What this study adds

The early life environment can determine later risk of obesity

Eight factors in early life were independently associated with obesity risk at age 7

Eight evidence based targets for future population based obesity prevention interventions have been identified

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