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Abstract

Objective To assess the impact of breast feeding on the risk of obesity and risk of being overweight in children at the time of entry to school.

Design Cross sectional survey

Setting Bavaria, southern Germany.

Methods Routine data were collected on the height and weight of 134 577 children participating in the obligatory health examination at the time of school entry in Bavaria. In a subsample of 13 345 children, early feeding, diet, and lifestyle factors were assessed using responses to a questionnaire completed by parents.

Subjects 9357 children aged 5 and 6 who had German nationality.

Main outcome measures Being overweight was defined as having a body mass index above the 90th centile and obesity was defined as body mass index above the 97th centile of all enrolled German children. Exclusive breast feeding was defined as the child being fed no food other than breast milk.

Results The prevalence of obesity in children who had never been breast fed was 4.5% as compared with 2.8% in breastfed children. A clear dose-response effect was identified for the duration of breast feeding on the prevalence of obesity: the prevalence was 3.8% for 2 months of exclusive breast feeding, 2.3% for 3-5 months, 1.7% for 6-12 months, and 0.8% for more than 12 months. Similar relations were found with the prevalence of being overweight. The protective effect of breast feeding was not attributable to differences in social class or lifestyle. After adjusting for potential confounding factors, breast feeding remained a significant protective factor against the development of obesity (odds ratio 0.75, 95% CI 0.57 to 0.98) and being overweight (0.79, 0.68 to 0.93).

Conclusions In industrialised countries promoting prolonged breast feeding may help decrease the prevalence of obesity in childhood. Since obese children have a high risk of becoming obese adults, such preventive measures may eventually result in a reduction in the prevalence of cardiovascular diseases and other diseases related to obesity.

Introduction

In industrialised countries obesity and being overweight are the most frequent nutritional disorders in

children and adolescents, and there is a continuing increase in their prevalence.¹ Overweight children have a high risk of being overweight in adulthood²⁻⁴ and therefore are also at risk from the associated health complications such as hypertension and coronary heart disease.⁵ Since therapeutic interventions aimed at encouraging weight loss in obese children are costly and have long term success rates that are less than satisfactory,⁶ the identification of strategies for the effective prevention of obesity is particularly attractive.

Simple strategies without potential side effects are the most appealing. Breast feeding would fulfil these criteria. However, the impact of breast feeding on obesity has only been studied in comparatively small cohorts.⁷⁻⁹ These small studies failed to find a protective effect possibly due to a lack of statistical power, whereas a protective effect has been reported in a Canadian cross sectional study of 1320 adolescents born in the late 1960s.¹⁰ The rates of breast feeding were low in Canada at that time, and lifestyles in industrialised countries have changed considerably over the past three decades. We have therefore studied the impact of breast feeding on the prevalence of being overweight or obese in children born in the early 1990s.

Subjects and methods

Study population and data sources

The 1997 obligatory health examination before school entry evaluated 134 577 children in Bavaria, southern Germany. At the examination, the parents of 13 345 children seen in two rural regions were asked to complete a questionnaire about risk factors for atopic diseases.¹¹ Data collected by this questionnaire were linked with the data from the school health examination. Our analysis was confined to children aged 5 and 6 who had German nationality.

The children's height and weight were measured as part of the routine examination. Body mass index was calculated as weight (kg)/(height (m)²). The age specific and sex specific distribution of the body mass index among all children with German nationality in Bavaria, which had been investigated during the 1997 school health examination, was used as the reference for being overweight (defined as body mass index above the 90th centile) or obese (defined as body mass index above the 97th centile) because these centiles were higher than other European reference values.¹²

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Table 1 Duration of breast feeding and prevalence (95% confidence interval) of being overweight (body mass index above the 90th centile) or obese (body mass index above the 97th centile) among 5 and 6 year olds living in rural Bavaria

Duration of breast feeding	Prevalence (%) of:	
	Being overweight	Being obese
Never breast fed (n=4022)	12.6 (12.4 to 12.9)	4.5 (4.4 to 4.6)
Ever breast fed (n=5184*)	9.2 (9.0 to 9.3)	2.8 (2.7 to 2.8)
Exclusively breast fed for:		
≤2 months (n=2084)	11.1 (10.6 to 11.6)	3.8 (3.6 to 4.0)
3-5 months (n=2052)	8.4 (8.1 to 8.8)	2.3 (2.2 to 2.4)
6-12 months (n=863)	6.8 (6.1 to 7.6)	1.7 (1.6 to 1.9)
>12 months (n=121)	5.0 (1.1 to 8.8)	0.8 (0.2 to 1.5)

*Duration of breast feeding was not reported for 64 children who had ever been breast fed.

Questionnaire

Parents were asked: "Was your child breast fed?" If they answered yes they were then asked: "For how long was your child exclusively breast fed: (a) 2 months or less, (b) 3 to 5 months, (c) 6 to 12 months or (d) more than a year?" Exclusive breast feeding was defined as the child being fed no food other than breast milk.

To assess potential confounders additional questions were asked about the number of older siblings the child had and the parents' ages, the child's health (for example, was the child born prematurely or at low birth weight?), early feeding (for example, when solid foods were introduced), and the actual frequency of eating selected foods. The highest level of education attained by either parent was used as a marker for social class.

Statistical analyses

The prevalences of overweight and obese children were calculated according to the duration of breast feeding. The appropriate χ^2 tests were used to compare several items in breastfed and non-breastfed children and their association with the child being overweight or obese. Logistic regression models were used to assess the impact of variables that were significantly associated ($P < 0.05$) with both breast feeding and being overweight or obese. Confounding was assumed to have occurred if the odds ratio changed by $\geq 10\%$. Confounders and independent risk factors were included in the final logistic regression model. All

calculations were carried out with the SAS software package, version 6.12.

Results

The overall response rate to the questionnaire was 76.7% (10 240/13 345). Parents whose children had been examined before 1 February did not receive questionnaires and were classed as non-responders. We could not differentiate between true non-responders and children whose parents had not been given questionnaires so both were included as non-responders for calculations of well baby visits and immunisations because similar results had been obtained when these calculations were confined to those offices where all parents had received questionnaires.

A total of 9357 questionnaires were completed for 5 and 6 year old German children. Information on breast feeding and its duration was available for 9206 children. A total of 4022 children had never been breast fed and 5184 had ever been breast fed. The duration of breast feeding was not reported for 64 children.

Responders were more likely than non-responders to have attended all well baby visits (70.6% (6524/9238) *v* 64% (4511/7044)) and to have had their children vaccinated against measles and Haemophilus influenzae type b (72.3% (6764/9357) *v* 64% (4596/7178)), but mean body mass index and the 90th and 97th centiles for body mass index were similar between the groups (mean 15.36 *v* 15.34; 90th centile 17.70 *v* 17.75; and 97th centile 20.12 *v* 20.07).

There was a clear dose dependent effect of the duration of breast feeding on the prevalence of being overweight or obese in children at the time of entry to school (table 1). Similar effects of the duration of breast feeding on the prevalence of being overweight or obese were observed when different definitions of being overweight or obese were used (that is, above the 90th centile or above the 97th centile for weight; above 110% or above 120% of the median weight for height categories in the total population (data not shown)).

Several indicators of the family's lifestyle and make up (for example, whether the child had his or her own bedroom, the amount of time spent playing outside in winter and summer, whether the mother smoked during

Table 2 Prevalence of independent risk factors associated with breast feeding and being overweight or obese in 5 and 6 year old children in rural Bavaria

	Prevalence (%)		Odds ratio (90% CI) for:	
	Non-breast fed children (n=4022)	Breast fed children (n=5184)	Being overweight	Being obese
High level of parental education (≥ 10 years)*	41.4	66.7	0.77 (0.67 to 0.89)	0.62 (0.49 to 0.79)
Maternal smoking during pregnancy	12.8	4.2	1.51 (1.20 to 1.89)	1.82 (1.28 to 2.58)
Prematurity	13.8	9.0	0.78 (0.62 to 0.98)	0.69 (0.46 to 1.03)
Birth weight <2500 g	10.4	6.6	0.69 (0.48 to 0.84)	0.78 (0.54 to 1.10)
Own bedroom	45.6	54.4	1.19 (1.03 to 1.37)	1.22 (0.96 to 1.56)
Consumes margarine ≥ 3 times/week	35.3	32.4	1.22 (1.05 to 1.41)	1.21 (0.94 to 1.56)
Consumes butter ≥ 3 times/week	60.5	69.2	0.73 (0.63 to 0.83)	0.70 (0.56 to 0.88)
Consumes full fat milk ≥ 3 times/week	50.8	59.6	0.69 (0.60 to 0.80)	0.54 (0.42 to 0.68)
Consumes low fat milk ≥ 3 times/week	31.9	28.8	1.72 (1.49 to 1.99)	1.77 (1.38 to 2.25)
Consumes full fat quark or yogurt ≥ 3 times/week	28.8	36.1	0.66 (0.56 to 0.78)	0.52 (0.38 to 0.70)
Consumes low fat quark or yogurt ≥ 3 times/week	25.9	23.8	1.42 (1.22 to 1.66)	1.32 (1.02 to 1.71)
Consumes whipped cream ≥ 1 time/week	18.6	24.7	0.65 (0.54 to 0.79)	0.58 (0.41 to 0.81)
Consumes breakfast cereals ≥ 3 times/week	25.6%	35.3	0.80 (0.68 to 0.93)	0.76 (0.58 to 0.99)
Consumes sweet desserts ≥ 3 times/week	54.4%	57.8	0.84 (0.74 to 0.97)	0.82 (0.66 to 1.03)

*This variable changed the odds ratio for breast feeding and being overweight or obese by at least 10%, so confounding was assumed to have occurred.

Table 3 Odds ratios for independent risk factors associated with being overweight or obese in the final logistic regression model for 9206 5 and 6 year old children in rural Bavaria

	Odds ratio (90% CI) for:	
	Being overweight	Being obese
Breast feeding	0.79 (0.68 to 0.93)	0.75 (0.57 to 0.98)
High level of parental education (≥ 10 years)*	0.81 (0.70 to 0.95)	0.75 (0.58 to 0.98)
Maternal smoking during pregnancy	1.52 (1.81 to 1.95)	1.85 (1.26 to 2.71)
Birth weight <2500 g	0.68 (0.53 to 0.88)	0.81 (0.54 to 1.20)
Own bedroom	1.24 (1.05 to 1.46)	1.20 (0.91 to 1.59)
Consumes butter ≥ 3 times/week	0.72 (0.62 to 0.84)	0.69 (0.54 to 0.90)

*This variable changed the odds ratio for breast feeding and being overweight or obese by at least 10%, so confounding was assumed to have occurred.

pregnancy, the number of older siblings, and the age of the parents), early feeding habits, and the frequency of the consumption of several products in the child's diet differed significantly between children who had been breast fed and those who had not. The prevalence of variables which were also significantly associated with a child being overweight or obese and which were independent risk factors in a logistic regression model with breast feeding is shown in table 2.

Higher levels of parental education (≥ 10 years), premature birth, and low birth weight were inversely associated with being overweight or obese, whereas maternal smoking during pregnancy and the child having his or her own bedroom were positively correlated. Full fat milk products and sweet desserts were less frequently consumed by overweight children, and the consumption of low fat milk products was higher. Overweight children also ate less butter and breakfast cereals than children who were not overweight.

The level of parental education was the only factor that accounted for a shift of the odds ratio towards unity by at least 10% which related breast feeding to being overweight or obese. In the final logistic regression, which estimated the influence of breast feeding on the dependent variable of being overweight or being obese, the independent risk factors for maternal smoking, low birth weight, own bedroom, and frequent consumption of butter were included in addition to the confounding variable of higher level of parental education (table 3).

Crude and adjusted odds ratios for the dose dependent impact of breast feeding on being overweight or obese are shown in table 4. In children who had been breast fed for at least 6 months or more the risks of being overweight or obese were reduced by >30% and >40%, respectively.

Discussion

Epidemiological evidence for reduced risk

To our knowledge this is the largest epidemiological study on the impact of breast feeding on the risk of school age children being overweight or obese. The most remarkable finding is a consistent, protective, and dose dependent effect of breast feeding on different definitions of obesity or being overweight. Some relevant questions, however, were not asked in our questionnaire because it had been designed originally to identify atopy. The impact of breast feeding on body mass increase ("catch up growth") in low birthweight infants, which is associated with an additional risk of coronary heart disease,¹⁵ could therefore not be analysed. A positive family history of being overweight is an important indicator of the genetic risk for obesity and being overweight,^{9 10} although it is not a confounder of the association between breast feeding and obesity or being overweight as found in a previous study.¹⁰

Breast feeding was associated with family make up and lifestyle, premature birth, low birth weight, and early and current diet. There was an inverse relation between the consumption of butter and margarine and consumption of low fat and full fat dairy products. The inverse relation between the actual consumption of full fat dairy products and obesity or being overweight probably reflects avoidance of these products by children who are overweight. Because of these strong relations and the apparent reverse causation with regard to full fat dairy products, only low birth weight and the consumption of butter were added to the final logistic regression model.

The protective effects of a higher level of parental education and low birth weight accord with the results of other studies.^{9 10 15} Family income or social class might be better indicators of socioeconomic status. Unfortunately, in Germany there is no accepted equivalent to the British categories of social class, and respondents to written questionnaires are reluctant to report income.

A similar dose dependent reduction in the risk of being overweight or obese as associated with breast feeding was observed in Canadian adolescents born in the 1960s.¹⁰ Only 18.5% of these children had been breast fed exclusively as compared with 56% of those born in Bavaria in the 1990s; this suggests that mothers with different sociodemographic characteristics have chosen to breast feed their children in Bavaria now. If this dose dependent protective effect had been caused by lifestyle factors associated with breast feeding, similar confounding factors should have been operative during different times in different societies. These factors would also have to be closely related to the duration of breast

Table 4 Crude and adjusted odds ratios (95% confidence intervals) of the dose dependent impact of breast feeding on being overweight or obese in children aged 5 or 6 in rural Bavaria

	Being overweight		Being obese	
	Adjusted odds ratio*	Crude odds ratio	Adjusted odds ratio*	Crude odds ratio
Exclusively breast fed for:				
≤ 2 months (n=2084)	0.89 (0.73 to 1.07)	0.87 (0.74 to 1.02)	0.90 (0.65 to 1.24)	0.84 (0.64 to 1.10)
3-5 months (n=2052)	0.87 (0.72 to 1.05)	0.64 (0.53 to 0.76)	0.65 (0.44 to 0.95)	0.50 (0.36 to 0.69)
6-12 months (n=863)	0.67 (0.49 to 0.91)	0.51 (0.38 to 0.67)	0.57 (0.33 to 0.99)	0.38 (0.22 to 0.64)
>12 months (n=121)	0.43 (0.17 to 1.07)	0.36 (0.16 to 0.82)	0.28 (0.04 to 2.04)	0.18 (0.03 to 1.28)
Ever breast fed (n=5184)	0.79 (0.68 to 0.93)	0.70 (0.61 to 0.80)	0.75 (0.57 to 0.98)	0.61 (0.50 to 0.76)

*Odds ratios adjusted for level of parental education, maternal smoking during pregnancy, low birth weight, own bedroom, and frequent consumption of butter.

Key messages

- Obesity is the most frequent nutritional disorder in children, and is an important risk factor for cardiovascular disease in adulthood
- Preventing obesity in children should be a useful strategy in preventing later heart disease because weight loss interventions in obese children are costly and rarely successful
- Data from a cross sectional study in Bavaria suggest that the risk of obesity in children at the time of school entry can be reduced by breast feeding: a 35% reduction occurs if children are breastfed for 3 to 5 months
- Preventing obesity and its consequences may be an important argument in the drive to encourage breast feeding in industrialised countries

feeding for each child in both populations to explain the dose effect related to the duration of breast feeding which was observed both in the Canadian study and our study. The protective effect of breast feeding therefore is more likely to be related to the properties of breast milk or the breastfeeding process than to lifestyle factors associated with breast feeding.

Biological plausibility

In addition, it is plausible that breast feeding might indeed have a programming effect in preventing obesity or becoming overweight in later life. Lucas and colleagues found significantly higher plasma concentrations of insulin in infants who had been bottle fed than in infants who had been breast fed; these higher concentrations would be expected to stimulate fat deposition and the early development of adipocytes.^{14 15} Breast milk also contains bioactive factors which may modulate epidermal growth factor and tumour necrosis factor α , both of which are known to inhibit adipocyte differentiation *in vitro*.^{16 17} The amount of energy metabolised and the protein intake of breastfed children is considerably lower than previously assumed and significantly below the intake of infants who are fed formulas.^{18 19} In longitudinal studies a significant relation was found between dietary protein intake at the age of 10 months and later body mass index and the distribution of body fat²⁰⁻²²; this suggests that a high intake of protein in early childhood might increase the risk of obesity later. Indeed, in animal studies the availability of protein during fetal and postnatal development was found to have long term effects on the metabolic programming of glucose metabolism and body composition in adult life.²³⁻²⁵

Conclusion

Prolonged exclusive breast feeding reduced the risk of being obese or overweight among school age children in Bavaria who were born in the early 1990s. This effect is more likely to be related to the composition of breast milk than to lifestyle factors associated with breast feeding. Preventing childhood obesity and its consequences may be an important argument in the drive to encourage breast feeding in industrialised countries.

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Contributors: RvK coordinated and designed the study, analysed the data, wrote the paper and is guarantor for the paper. BK had the original idea for the study and wrote the nutritional aspects of the discussion. TS contributed to the discussion of the results. EvM designed the questionnaire for the study of atopy and made important suggestions about the epidemiological and statistical analyses and the writing of the paper. DB managed the dataset on all children enrolled in the 1997 school entry health examination. VG checked all statistical procedures and calculations in SAS, and is also a guarantor for the study. HvV initiated the research project in collaboration with the public health offices in Bavaria.

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