Overweight and obesity in 6- to 14-year-old Czech children in 1991: Protective effect of breast-feeding

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Objective: To assess the impact of breast-feeding on childhood overweight/obesity in an Eastern European socialist society with relatively homogeneous lifestyles.

Study design: Cross-sectional survey data collected in 1991 on 33,768 school-children aged 6 to 14 years in the Czech Republic were analyzed by using multiple logistic regression analyses (main outcome body mass index [BMI] >90th percentile [overweight] and BMI >97th percentile [obesity]).

Results: Overall prevalence of overweight (obesity) was lower in breast-fed children: ever breast-fed (9.3%; 95% CI, 8.9-9.6 [3.2%; 95% CI, 3.0-3.4]) compared with never breast-fed (12.4%; 95% CI, 11.3-13.6 [4.4%; 95% CI, 3.7-5.2]). The effect of breast-feeding on overweight/obesity did not diminish with age in children 6 to 14 years old and could not be explained by parental education, parental obesity, maternal smoking, high birth weight, watching television, number of siblings, and physical activity. Adjusted odds ratios for breast-feeding were for overweight 0.80 (95% CI, 0.71-0.90) and for obesity 0.80 (95% CI, 0.66-0.96).

Conclusions: A reduced prevalence of overweight/obesity was associated with breast-feeding in a setting where socioeconomic status was homogeneous. This suggests that the effect of breast-feeding on the prevalence of obesity is not confounded by socioeconomic status. (J Pediatr 2002;141:764-9)

Overweight and obesity are the most common nutritional disorders in industrialized countries, and they continue to increase in prevalence.[1] Childhood obesity is related to obesity in adulthood[2-4] and to later cardiovascular disease.[5-7]

See editorial, p 749 and related article, p 770.

Effective prevention strategies against childhood obesity are needed because therapeutic interventions are expensive and tend to have poor long-term results.[8] Breast-feeding would be an inexpensive preventive intervention. Several studies in Western societies have reported the protective effects of breast-feeding[9-12] but not all studies.[13] The protective effects have been questioned on the grounds of potential confounding factors by maternal overweight[14] and insufficient adjustment for social class.[13] The impact of social class might be operative by different associated lifestyles. Studies in relatively homogeneous populations regarding social class might therefore allow to control for confounding factors by different associated lifestyles.

BMI	Body mass index
OR	Odds ratio
CI	Confidence interval
TV	Television

In socialist societies such as Czechoslovakia in the 1970s and 1980s, living conditions of children and their families were widely homogeneous[15] and limited with regard to the available food items. The 5th Nationwide Anthropometric Survey of Children and Adolescents in the for-

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mer Czechoslovakia/ Czech regions performed in 1991 in which extensive data of sociodemographic and other risk factors for childhood obesity had been collected, allowed us to study the impact of breast-feeding on overweight and obesity. Because there were data on children aged 6 to 14 years, we could also assess the consistency of the breast-feeding effects in different age groups.

METHODS

Data Source and Study Population

The 5th Nationwide Anthropometric Survey of Children and Adolescents 1991 in the Czech Republic consisted of a parents' questionnaire and an anthropometric examination of the children. There were 1,371,910 children aged 6 to 14 years living in the Czech Republic in 1991.[16] To receive a representative sample, schools throughout the Czech Republic were chosen by random selection and weighted with respect to population density.

The parents completed the questionnaires at home. The anthropometric examinations were done by teachers during physical education classes. The overall return rate of the questionnaires was 97.7%. The analysis was based on data of 33,768 schoolchildren aged 6 to 14 years, with complete information on body mass index (BMI) and breast-feeding (716 incomplete questionnaires for either the outcome or the explanatory variables in the entire dataset of n = 34,484).

Questionnaire and Measurements

Stature and weight were measured by the physical education teachers in a standardized manner (same types of scales for weight and height in all schools, consistent instruction). The BMI was calculated and dichotomized at age- and gender-specific percentiles in overweight (>90th percentile) and obesity (>97th percentile) based on the examined population sample, which serves as a reference sample for the Czech population. Percentile curves were fitted by the moving average method.

In the self-administered questionnaire, breast-feeding was reported in 5 categories (never, ≤1 month, >1 to ≤3 months, >3 to ≤6 months, and >6 months). No distinction was made between exclusive and partial breast-feeding.

There were data on a wide range of potentially relevant confounding factors. Although several of these were reported on an ordinal or continuous scale, we decided to present the data dichotomized for the sake of better comprehensibility: the impact of parental BMI on the child's risk for overweight and obesity, eg, expressed as a minute increase of the odds ratio by one unit of parental BMI does not describe the effect of parental obesity on childhood overweight/obesity as comprehensively as the odds ratio attributable to an established indicator of parental obesity (BMI ≥30 kg/m^2):

- Educational level: in 5 basic categories, dichotomized at ≥10 years, highest degree of father or mother, respectively.
- Parental BMI: weight and height continuous, dichotomized in BMI ≥30 kg/m^2 of either parent
- Maternal smoking: at date of data collection; in 3 categories (nonsmoker, ≤20 daily cigarettes, >20 cigarettes per day); dichotomized in nonsmoker versus smoker
- High birth weight: continuous, dichotomized at >4000 g
- Watching television (TV): average hours per day at the time of the interview, dichotomized in ≤1 hour versus >1 hour
- Having siblings: discrete number of children per family, dichotomized (yes/no).
- Physical activity: sport activity in 4 categories (inactive, active only at school, at school and recreational, at school and competitive), dichotomized at sports outside school
- Consumption of fruits: in 3 categories (<2 times/week, ≥2 to <7 times/week, ≥7 times/week [daily]), dichotomized in daily versus less

Table I. Duration of breast-feeding and prevalence (95% CI) of overweight (BMI >90th percentile) or obesity (>97th percentile) among Czech children from 6 to 14 years

Duration of breast-feeding	Prevalence (%) of: Overweight*	Prevalence (%) of: Obesity
Never breast-fed (n = 3127; 9.3%)	12.4 (11.3-13.6)	4.4 (3.7-5.2)
Ever breast-fed (n = 30,641; 90.7%)	9.3 (8.9-9.6)	3.2 (3.0-3.4)
Breast-feeding for:		
≤1 mo (n = 9468; 28.0%)	9.7 (9.1-10.3)	3.3 (3.0-3.7)
>1–≤3 mo (n = 14,892; 44.1%)	9.1 (8.6-9.5)	3.0 (2.8-3.3)
>3–≤6 mo (n = 3869; 11.5%)	9.0 (8.1-10.0)	3.2 (2.7-3.8)
>6 mo (n = 2412; 7.1%)	9.0 (7.9-10.3)	3.5 (2.8-4.3)

*Test for trend: $P < .001$.

Statistical Analyses

The prevalence of overweight and obesity were calculated by the duration of breast-feeding. Confidence limits were based on the binomial distribution. Crude odds ratios were estimated with the Mantel-Haenszel χ^2 statistics. We defined confounding factors by a change of at least 10% of the odds ratio for breast-feeding and overweight or obesity. All variables associated with overweight/obesity at a level of $P < .1$ in the bivariate analyses were considered in logistic regression mod-

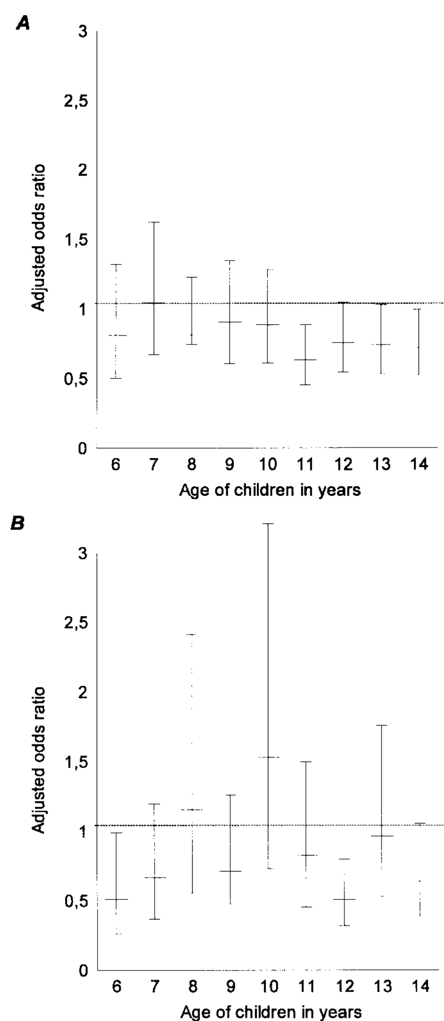

Figure. Adjusted odds ratios for breast-feeding on **(A)** overweight (BMI >90th percentile) and **(B)** obesity (BMI >97th percentile) by age categories. Adjustment for parental education, parental obesity, maternal smoking, high birth weight, watching TV, having siblings, and physical activity.

eling. To account for missing values in the logistic regression model that potentially resulted in selection bias, all missing values for covariates were replaced by the respective means.[17] Confounding was controlled by logistic regression models in which variables were excluded by backward selection via likelihood ratio test ($P < .05$). The potential confounding factors have been dichotomized for the sake of better comprehensibility. To test whether this procedure resulted in residual confounding the model was also calculated with ordinal or continuous covariates as available (see previous). All calculations were carried out with the software package SAS version 6.12 (SAS Institue, Cary, NC).

RESULTS

Breast-feeding was very common in the Czech Republic from 1976 to 1985: 90.7% were ever breast-fed and only 9.3 % were never breast-fed (Table I). The number of children in the breast-feeding category 1 to 3 months was higher (44.1%) than in the other breast-feeding categories (Table I).

The prevalence of obesity was 3.2% (95% CI 3.0–3.4) in breast-fed children compared with 4.4% (95% CI, 3.7–5.2) in nonbreast-fed children (Table I). Although longer duration of breast-feeding was associated with a decreased prevalence of overweight (BMI >90th percentile; $P < .001$, Cochran-Armitage trend test) 12.4% (never breast-fed) to 9.0% (>6 months breast-fed), no such duration dependent effect was seen for obesity (BMI >97th percentile) (Table I).

Nonbreast-fed children had fewer siblings, were more likely to watch TV for longer hours per day and were less likely to eat fruits. Their parents had lower education levels, were more often obese, and their mothers were more likely to smoke (data not shown).

Table II shows uni- and bivariate analyses of the covariates. Higher prevalence for overweight/obesity in the bivariate analyses were observed in case of parental obesity, maternal smoking, high birth weight and >1 hour of daily TV watching, whereas high parental education, sports outside school, and having siblings were associated with a lower prevalence of overweight/obesity. Bivariate analyses showed protective effects for ever breast-feeding with crude odds ratios of 0.72 (95% CI, 0.64-0.81) for overweight (BMI >90th percentile) and 0.70 (95% CI, 0.59-0.84) for obesity (BMI >97th percentile) (Table III). After adjustment for parental education, parental obesity, maternal smoking, high birth weight, daily watching TV >1 hour, having siblings, and physical activity, the effect of ever breast-feeding remained significant with an odds ratio of 0.80 (95% CI, 0.71-0.90) for overweight and 0.80 (95% CI, 0.66-0.96) for obesity (Table III). These odds ratios were recalculated with the original ordinal/continuous covariates to control for residual confounding factors. The estimated odds ratios (0.78 [95% CI, 0.69-0.87] for overweight and 0.78 [95% CI, 0.65-0.94] for obesity) were lower than the estimates by using dichotomized covariates. Parental obesity (either parent BMI ≥ 30 kg/m^2), high birth weight (>4000 g) and daily watching TV >1 hour were significantly associated with an increased risk for overweight and obesity, whereas a high level of parental education (≥10 school years), having siblings, and physical activity appeared protective. Current maternal smoking (yes/no) increased the risk of overweight slightly (adjusted odds ratio of 1.25; 95% CI, 1.15-1.35) but not for obesity (adjusted odds ratio, 1.06; 95% CI, 0.93-1.21).

Figs 1, *A* and *B* show a stratification of adjusted odds ratios for breast-feeding on overweight (BMI >90th percentile) and obesity (BMI >97th percentile) by years of age. The data gave no indication for a fading protective effect of breast-feeding on overweight/obesity by increasing age (Fig 1). There are however some differences with respect to the effects of breast-feeding on overweight and obesity. In addition to the fact that the confidence intervals around the effect estimators regarding overweight are narrower, all point estimates but one are clearly below one, whereas 2 of the point estimates for obesity exceed one. Although the age-cumulative estimates for the effect of breast-feeding on overweight and obesity were both significant, these effects were not significant for all age strata.

Table II. Description of study sample (n = 33,768); prevalences of overweight (BMI >90th percentile) and obesity (BMI >97th percentile) with respect to the covariates

		Prevalence (95% CI)			
		Overweight		Obesity	
	Exposed (% Missings)	Exposed	Nonexposed	Exposed	Nonexposed
Parental education (≥10 y of school)*	53.0 (0.0)	8.3 (7.9-8.7)	11.0 (10.5-11.5)	2.7 (2.4-2.9)	4.0 (3.7-4.3)
Parental obesity (either parent BMI ≥30 kg/m²)*	15.7 (5.0)	18.8 (17.8-19.9)	7.7 (7.4-8.0)	7.8 (7.1-8.5)	2.4 (2.2-2.6)
Maternal smoking (yes/no)*	29.4 (1.3)	11.3 (10.7-11.9)	8.8 (8.4-9.2)	3.6 (3.2-4.0)	3.2 (3.0-3.4)
Birth weight >4000g†	7.1(1.1)	14.6 (13.2-16.0)	9.2 (8.8-9.5)	5.8 (4.9-6.8)	3.1 (2.9-3.3)
Daily watching TV >1 h*	42.0 (3.8)	11.3 (10.7-11.8)	8.3 (7.9-8.7)	4.0 (3.7-4.4)	2.7 (2.5-3.0)
Sports outside school†	30.2 (2.1)	7.0 (6.5-7.5)	10.7 (10.3-11.1)	2.1 (1.8-2.4)	3.8 (3.6-4.1)
Siblings (yes/no)*	86.9 (2.2)	9.2 (8.8-9.5)	12.6 (11.5-13.7)	3.1 (2.9-3.3)	4.3 (3.7-5.0)
Daily consumption of fruits‡	71.3 (0.3)	9.4 (9.0-9.8)	9.9 (9.3-10.5)	3.3 (3.0-3.5)	3.4 (3.0-3.7)

*Significantly ($P < .05$) associated with outcome (overweight/obesity) and exposure (breast-feeding).
†Significantly ($P < .05$) associated with outcome (overweight/obesity).
‡Did not enter the starting regression model ($P = .16$).

Table III. Final logistic regression model; crude and adjusted odds ratios for breast-feeding and considered confounding factors on overweight (BMI >90th percentile) and obesity (BMI >97th percentile)

	Overweight		Obesity	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Breast-fed (yes/no)	0.72 (0.64-0.81)	0.80 (0.71-0.90)	0.70 (0.59-0.84)	0.80 (0.66-0.96)
Parental education (≥10 y of school)	0.73 (0.68-0.79)	0.88 (0.81-0.95)	0.66 (0.58-0.74)	0.81 (0.71-0.91)
Parental obesity (either parent BMI 30 kg/m²)*	2.78 (2.58-3.01)	2.61 (2.40-2.84)	3.46 (3.07-3.90)	3.14 (2.76-3.57)
Maternal smoking (yes/no)	1.31 (1.21-1.42)	1.25 (1.15-1.35)	1.13 (1.00-1.29)	1.06 (0.93-1.21)
Birth weight >4000 g*	1.69 (1.51-1.91)	1.61 (1.43-1.82)	1.93 (1.62-2.31)	1.79 (1.49-2.16)
Daily watching TV >1 h	1.40 (1.30-1.51)	1.26 (1.17-1.36)	1.49 (1.32-1.69)	1.33 (1.17-1.51)
Sports outside school	0.63 (0.58-0.69)	0.64 (0.59-0.70)	0.53 (0.46-0.62)	0.55 (0.47-0.64)
Siblings (yes/no)	0.70 (0.63-0.78)	0.69 (0.62-0.77)	0.71 (0.60-0.85)	0.70 (0.59-0.83)

*Changed the estimated odds ratio for breast-feeding and overweight/obesity >10%.

DISCUSSION

The data show a reduced prevalence of overweight and obesity in 6- to 14-year-old breast-fed Czech children, and therefore provide further evidence for metabolic programming during a critical time window early in life.[18-20]

During the years 1976 to 1985, the former Czechoslovakia was one of the socialist countries without major social differences as a whole.[15] A particular strength of the dataset is its size, completeness, and the wide range of risk factors for childhood obesity for which information had been collected.

Most of the Czech children (90.7%) in this dataset were breast-fed at least for a short period. This is comparable to the Nurses Health Study II where 87.7% of the children were ever breast-fed,[11] but much higher than in studies in which only exclusive breast-feeding is recorded (56%).[10,12] In Czechoslovakia, locally produced infant formula was available (Drs Szitanyi and Nevoral, Prague, personal communication).

The nonlinear intake during breast-feeding,[21] a lower energy density of human milk compared with formula milk,[22] and thus a better self control of food consumption in breast-fed chil-

dren, are possible explanations for the observed effect of breast-feeding.

The observed dose effect of human milk consumption on the risk of obesity point to the role of components of human milk.[11] Breast milk contains bioactive factors that may modulate epidermal growth factor and tumor necrosis factor α, both of which are known to inhibit adipocyte differentiation in vitro.[23,24] A lower protein content of human milk could also be instrumental.[25] Moreover, part of the human milk proteins such as immunoglobulins are relatively resistant to low pH and proteolysis and hence are not fully digested and absorbed. A high-protein intake in excess of metabolic requirements may enhance the secretion of insulin and insulin-like growth factor 1.[26] Higher plasma concentrations of insulin were observed in formula compared with breast-fed infants,[27,28] potentially accounting for a higher fat deposition and the early development of adipocytes.[29]

A high-protein intake can also stimulate both longitudinal growth particularly during the first two years of life.[30] A prospective intervention study in infants fed formula with varying amounts of protein showed that growth in the group fed the lowest amount of protein paralleled that of breast-fed infants.[31] Early adiposity rebound was shown to be related to high-protein intakes.[32] In several studies, childhood BMI, corrected for parental BMI, was associated with early protein intakes but not with the intakes of energy, fat, or carbohydrates.[32-34]

The formula used by most families in Czechoslovakia between 1976 and 1985, "Sunar," had a protein content of 5.57 g/100 kcal in the recommended dilution for the first months of life (Drs Szitanyi and Nevoral, Prague, personal communication), which is higher than the protein contents of formula used in Western societies.[31] Therefore, the difference in protein intake between exclusive breast- and formula-fed infants in the former Czechoslovakia was greater compared with the more recent cohorts studied in Bavaria and in the United States.[10-12] The size of the effect of breast-feeding in this dataset, however, was similar to that observed for exclusive or predominant breast-feeding in the Bavarian and US studies.[10-12] This might be explained by the fact that the case definition of breast-feeding in the Czech dataset included partial breast-feeding as well.

A recent study observed a dose-response effect with respect to the duration of breast-feeding,[11] whereas another did not.[12] Duration of breast-feeding might not necessarily reflect a dose-effect if children are partially breast-fed. In addition, there might be a critical period for priming of body composition in the very first months of life.

The effect of breast-feeding did not systematically decrease with age. This is important regarding potential long-term effects of breast-feeding. The failure to confirm significant effects for all age groups studied in particular with respect to obesity may be due to chance. This may also be an explanation for why the effects of breast-feeding were not consistently found in other, smaller studies.[35]

Because information on breast-feeding was obtained retrospectively, nondifferential misclassification is possible. The effect estimates presented in this study might therefore be conservative. Causal inference from observational studies is limited, however, because of potential bias due to nonrandomized exposure. The strength of the effect, the consistency with observations in Western European/American capitalist societies, the coherence, and a number of possible biological mechanisms suggest a causal association between breast-feeding and overweight/obesity.

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