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Breastfeeding and obesity in school-age children from families of high socioeconomic status

ABSTRACT

OBJECTIVE: To examine the association between breastfeeding and obesity in school-age children from Brazilian families of high socioeconomic status.

METHODS: A cross-sectional study was conducted including 555 students aged six to 14 years from a private school in the city of Sao Paulo. Obesity – the outcome variable – was defined as body mass index at or above the 85th centile plus sub scapular and triceps skin folds at or above the 90th centile using the sex and age specific standards of the US National Center for Health Statistics. Exposure was the frequency and duration of breastfeeding. Potential confounders, controlled for using multiple logistic regression, included child sex, age, birthweight, and dietary and physical activity patterns, and maternal age, body mass index, schooling, and practice of sports or physical exercise.

RESULTS: Prevalence of obesity in the studied population was 26%. After confounder adjustment, the risk of obesity in children that had never been breastfed was twice that of other children (OR=2.06; 95% CI: 1.02; 4.16). There was no dose-response effect of duration of breastfeeding on prevalence of child obesity.

CONCLUSIONS: Children who were never breastfed showed greater prevalence of obesity at school age. The absence of a dose-response effect in the relationship between duration of breastfeeding and prevalence of obesity and the still controversial findings regarding this association reported by other authors indicate a need for further studies on the subject, in particular studies with longitudinal design.

KEYWORDS: Obesity. Child. Adolescent. Breast feeding. Social class. Body mass index. Cross-Sectional Studies.

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INTRODUCTION

Obesity is considered a global epidemic, and its prevalence among children and adolescents has been on the rise in the last decades in both developed and developing countries, with substantial negative impact on public health. In addition to its association with risk factors for cardiovascular, respiratory, and metabolic disease, obesity in children and adolescents also contributes to low self-esteem and social discrimination, leading to emotional complications.[4,15] Moreover, child obesity is also a predictive factor for obesity in adult age.[17]

Considering the difficulty of treating child and adolescent obesity and the high rate of failure associated with such treatment, it is essential to identify effective strategies – preferably simple and without side effects – for the prevention of obesity among this population. In this context, breastfeeding emerges as a potential strategy for the prevention of child obesity, the protective effect of which is acknowledged by the World Health Organization (OMS).[23]

Epidemiological studies suggest that breastfeeding may be a protective factor against obesity in childhood and adolescence.[1,5,7,9,12,19,21] A cross-sectional study conducted by Von Kries et al[21] shows lower risk of obesity among breastfed children at age five to six years (OR=0.75; 95% CI: 0.57; 0.98). Likewise, Gilman[5] found a protective effect for breastfeeding against overweight among 9-14 year-olds (OR=0.78; 95% CI: 0.66; 0.91). However, other studies have failed to detect similar effects.[11,20,25]

The discrepant results obtained in studies evaluating the association between breastfeeding and child/adolescent obesity may be due to differences in study design, sample size, and adjustment – or lack of such – for potential confounders, especially birthweight, maternal obesity, and socioeconomic status.

Different hypotheses have been proposed for the protective effects of breastfeeding. Putative mechanisms range from the specific and unique composition of human milk to the influence of environmental and behavioral factors, such as socioeconomic level, maternal schooling, dietary patterns, and physical activity.[2,3,16,18]

In the present study, we analyze the association between frequency and duration of breastfeeding in infancy and obesity during school age among families of high socioeconomic level.

METHODS

The study evaluated all children and adolescents aged six to 14 years enrolled in elementary school (first to eighth grades) in a private institution located in an upper middle-class neighborhood in the municipality of Sao Paulo, Brazil. This school was selected because its students were exclusively from families with high purchase power.

The first stage of the study consisted of measuring weight, height, and skinfolds (tricipital and subscapular) of all children enrolled in elementary school (n=742). Anthropometric evaluation was carried out at the beginning of the 2004 school year, during physical education classes. Measurements were performed by one of the authors (RS) and by the school's physical education teachers, who were previously trained. Students were weighed and measured wearing light clothing and no shoes using an electronic solar-powered scale with 200 g precision and a stadiometer with 0.1 cm precision. Skinfolds were measured twice using a calibrator with 0.1 mm precision by one of the authors (RS), and the mean of the two measurements was used.

The second stage consisted of the completion, by student's mothers, of a structured questionnaire comprising 66 questions. The questionnaire was passed on to mothers by the students themselves. About 20% of students (147) did not return a completed questionnaire, 4% returned incomplete questionnaires (34) and in 1% of cases (6) parents did not authorize participation in the study, yielding a total 555 students.

The outcome variable in the analysis was obesity in children and adolescents. For the diagnosis of obesity, we adopted the WHO criteria, which classify as obese children and adolescents with body mass indexes (BMI) and tricipital and subscapular skinfolds higher than a critical value determined by a reference distribution for each age and sex. In the case of BMI, the critical value corresponds to percentile 85 and, in the case of skinfolds, to percentile 90, using as a reference the National Center for Health Statistics distribution.[24]

Explanatory variables in the study refer to the occurrence and duration of breastfeeding. We analyzed the duration of breastfeeding, alone or accompanied by other foods, during the first year of life.

Potential confounders were divided into two groups. The first group was related to the child or adolescent (sex; age; birthweight; dietary pattern; physical activity pattern (sports or physical exercise); and time watching television or using a computer). The second group was related to the mothers (age; BMI - based on self-reported measures; schooling; and sports or physical exercise).

Table 1 - Prevalence (%) of obesity according to breastfeeding indicators in children aged six to 14 years from families of high socioeconomic level. Sao Paulo city, Brazil, 2004.

Indicator	%	OR (95% CI)		p
Child was breastfed				0.11
Yes	25.1	1.00		
No	36.6	1.72	(0.88; 3.35)	
Duration of breastfeeding (in months)				0.20*
≥12	22.1	1.00		
6-11	25.2	1.19	(0.66; 2.16)	
3-5	25.8	1.22	(0.64; 2.32)	
<3	24.3	1.13	(0.54; 2.37)	
0	36.6	2.03	(0.90; 4.59)	
Duration of breastfeeding (in years)				0.12*
≥1	22.1	1.00		
<1	25.2	1.19	(0.68; 2.07)	
0	36.6	2.03	(0.90; 4.59)	

*Linear trend test

Initially, we carried out bivariate analyses of the association between breastfeeding regime in the first year of life and school-age obesity, using Pearson's Chi-square (χ^2) test. The χ^2 test for linear trend was employed when more than two categories of breastfeeding regime were defined and assumed linear trend in the relationship between breastfeeding and obesity. We adopted a 5% significance level for all analyses.

Next, for the selection of potential confounders in the association between breastfeeding regime and obesity, we carried out bivariate analyses between the potential confounders and obesity (simple or linear trend χ^2 test), using as a cutoff point a p-value of 0.2.

Finally, we carried out multiple logistic regression analyses to study the relationship between breastfeeding in the first years of life and school-age obesity with confounder control. Modeling relied on stepwise forward selection, that is, we progressed from a simpler to a more complex model, adding confounder variables in increasing order of p-value, as determined in bivariate analysis. Confounder control was carried out by adding potential confounders one at a time to the logistic regression model, keeping in the final model all confounders that altered the odds ratio of the first category (never breastfed) in at least 10%. This criterion was defined because our initial evaluations showed that the larger difference in prevalence of obesity was seen when the never breastfed category was compared to the remaining categories. Statistical analyses were carried out using Stata 7.0 software.

The study is in compliance with the norms of Resolution n. 196, of 10/10/1996, of the National Health Committee and was approved by the Research Ethics Committee of the Faculdade de Saúde Pública da Universidade de São Paulo.

RESULTS

Prevalence of obesity among the studied population was 26%, and most children and adolescents (92.6%) were breastfed at some point in life, with 78.8% having been breastfed for at least three months.

Regarding the association between breastfeeding duration and frequency indicators, greater prevalence of obesity was found among children who were never breastfed (36.6%). This proportion was higher than among children who were breastfed for any length of time (25.1%) or for different time periods (22.1% to 25.8%). However, excess obesity did not reach statistical significance in any of these comparisons. To test the association between breastfeeding and obesity using less degrees of freedom, we grouped the variable *duration of breastfeeding* into three categories: *never breastfed*, *breastfed for at less than one year*, and *breastfed for one year or more*. The risk of obesity among children who were never breastfed remained higher after grouping, but its association with obesity was still not significant (p for linear trend=0.12) (Table 1).

Child-related variables with p-values = 0.20 for association with obesity included sex, age group, birthweight, weekly frequency of physical exercise, habit of watching television, and healthy diet score. Frequency of obesity among school children decreased with age ($p<0.05$), was lower among girls than boys ($p<0.01$), and tended to increase with birthweight ($p=0.18$). Frequency of obesity also tended to decrease in the presence of physical exercise ($p=0.10$) and to increase as the number of hours watching television increased ($p=0.13$). There was no consistent association pattern between healthy diet score and frequency of obesity (Table 2).

Frequency of obesity among schoolchildren increased as maternal age decreased ($p=0.07$) and BMI increased ($p<0.01$). We did not find consistent associations between maternal schooling or physical activity and frequency of school-age obesity (Table 3). A noteworthy characteristic of our sample regarding

Table 2 - Prevalence (%) of obesity according to child characteristics in children aged 6 to 14 years from families of high socioeconomic level. Sao Paulo city, Brazil, 2004.

Variable	%	OR (95% CI)		p
Sex				<0.01
Male	31.1	1.00		
Female	19.8	0.47	(0.35; 0.70)	
Age group (years)				0.04
6 to 8	32.3	1.88	(1.16; 3.06)	
9 to 11	26.2	1.40	(0.87; 2.25)	
12 to 14	20.2	1.00		
Birthweight (kg)				
<2.5	29.2	1.00		0.45
2.5-2.99	17.2	0.50	(0.18; 1.42)	
3.0-3.49	25.8	0.85	(0.34; 2.14)	
3.5-3.99	27.1	0.90	(0.35; 2.34)	
>4.0 kg	26.7	0.88	(0.27; 2.92)	
Birthweight (kg)				
<3.0	19.7	1.00		0.18*
3.0-3.49	25.8	1.42	(0.83; 2.44)	
≥3.5	27.0	1.51	(0.86; 2.66)	
Weekly frequency of physical activity (minimum 60 minutes)				0.10*
Never	29.6	2.10	(1.00; 4.39)	
1 to 2 days	25.8	1.74	(0.86; 3.52)	
3 to 4 days	26.5	1.80	(0.89; 3.66)	
≥5 days	16.7	1.00		
Habit of watching television				0.13*
Never or rarely	17.7	1.00		
Up to 2 hours per day	24.5	1.51	(0.42; 5.44)	
Between 3 and 4 hours per day	26.2	1.65	(0.46; 5.96)	
≥5 hours per day	32.9	2.29	(0.60; 8.72)	
Habit of playing computer games				0.88
Never or rarely	25.2	1.00		
Up to 1 hour per day	25.8	1.03	(0.64; 1.65)	
2 or more hours per day	27.7	1.14	(0.69; 1.88)	
Healthy diet score				0.09
1° tercile	31.4	1.39	(0.87; 2.22)	
2° tercile	21.6	0.84	(0.51; 1.31)	
3° tercile	24.7	1.00		

*Linear trend test

maternal schooling is that 63% of mothers had higher education and about 18% had postgraduate degrees.

The results of logistic regression show that the following variables are confounders in the association, that is, variables that are associated with the outcome and that alter the odds ratio of the first breastfeeding category in at least 10%: sex, maternal BMI, maternal age, and birthweight. After control for these variables, we still found greater risk of obesity among children who were never breastfed, but this difference was not statistically significant (OR=2.73; 95% CI: 0.98; 7.76). There was also no dose-response effect in the association between duration of breastfeeding and obesity. An additional logistic regression model was tested which employed a dichotomous breastfeeding variable (never *vs* ever breastfed), without considering duration. In this case, risk of obesity was significantly higher among schoolchildren who were never breastfed (OR=2.06; 95% CI: 1.02; 4.16). Confounders in this last model were maternal age and child birthweight (Table 4).

DISCUSSION

The present study suggests a protective effect of breastfeeding against school-age obesity among children who were breastfed for any length of time, but does not confirm the dose-response found in some studies[5,9,12,21] but not in others.[1,7,19]

Regarding the limitations of the present study, initially, the proportion of exposed children – children breastfed for at least three months – was only 21.2%, whereas the exposure assumed for sample size calculations was 50%. We found greater risk of obesity among children who were never breastfed, who corresponded to only 7.6% of the sample. Considering this exposure rate, in order to identify an odds ratio of 1.5, as initially planned, a sample size of 1,500 children would be required.

Another potential limitation, important especially for the detection of a dose-response effect in the association between breastfeeding and obesity, is the study's retrospective design. Although the studied population had a high level of schooling, and although a number of studies show evidence of reasonable accuracy for information provided by mothers regarding the length for which their children were breastfed,[6,8,10] it is possible that this information was not sufficiently precise in the present study. Such lack of precision

Table 3 - Prevalence (%) of obesity according to maternal characteristics in children aged six to 14 years from families of high socioeconomic level. Sao Paulo city, Brazil, 2004.

Maternal characteristics	%	OR (95% CI)		p
Schooling				0.63
Secondary or lower	28.2	1.05	(0.57; 1.92)	
Higher education	24.1	0.85	(0.51; 1.41)	
Post-graduate	27.3	1.00		
BMI (kg/m²)				
<25	18.9	1.00		<0.01*
25-29.9	34.8	2.29	(1.44; 3.63)	
≥30	36.7	2.49	(1.13; 5.47)	
Age (years)				0.07*
25-30	42.1	1.00		
>30-35	26.9	0.51	(0.18; 1.43)	
>35-40	27.5	0.52	(0.20; 1.36)	
>40-45	22.9	0.41	(0.15; 1.09)	
>45-50	22.7	0.40	(0.14; 1.19)	
>50	15.8	0.26	(0.56; 1.19)	
Physical activity (minimum 30 minutes)				
Never	27.9	1.33	(0.72; 2.47)	0.35
1 to 2 days	18.8	0.80	(0.37; 1.74)	
3 to 4 days	27.1	1.28	(0.64; 2.55)	
≥5 days	22.5	1.00		

*Linear trend test

would tend to obscure eventual associations between duration of breastfeeding and school-age obesity, driving the odds ratios towards the unit.

Finally, another potential factor that could justify the absence of a dose-response effect would be the fact that the present study did not evaluate the duration of exclusive breastfeeding. With the exception of the study by Kramer,[9] all other studies that found dose-response effects in the association between breastfeeding and childhood obesity considered the duration of exclusive breastfeeding. There is no consensus, however, about the mechanisms behind a dose-response association between exclusive breastfeeding and childhood obesity.[5,12,21]

The control of potential confounders in the association between breastfeeding and obesity was an important feature of the present study. We controlled for the most important confounders identified in the literature, such as birthweight, sex, age group, nutritional status, and mother's schooling, in addition to other potential confounders such as physical activity and dietary patterns. Rigorously speaking, there would be no need for controlling for the child's dietary pattern, since this may be one of the mechanisms thought which breastfeeding would act as a protective factor against school-age obesity. We also highlight the fact that the potential confounder effect of social class was minimized in the present study by the sample's social homogeneity, that is, all subjects come from families of high socioeconomic level. This is evidenced not only by the neighborhood in which the school is located and the high cost of tuition, but also by the parents' high level of schooling.

Our results are consistent with the study by Kramer,[9] carried out in Canada with subjects aged 12 to 18 years. This author reported a crude odds ratio of 2.25 for obesity among children who were never breastfed, and this risk remained significant after control for confounders (race, social class, order of birth, and parents' BMI). Kramer supports the hypothesis that breastfeeding would be particularly important during the first weeks or months of life, since this period would be the most critical for the expression its protective effect. This supposition reinforces the results of the present study, in which we detected a large difference in risk of obes-

Table 4 - Prevalence (%) of obesity and crude and adjusted odds ratios according to breastfeeding indicators in children aged six to 14 years from families of high socioeconomic level. Sao Paulo city, Brazil, 2004.

Indicator	%	Crude OR	Adjusted OR* (95%CI)		p
Child was breastfed					0.03
Yes	25.1	1.00	1.00		
No	36.6	1.72	2.06	(1.02; 4.16)	
Duration of breastfeeding (months)					0.43**
≥12	22.1	1.00	1.00		
6-11	25.2	1.19	1.48	(0.71; 3.09)	
3-5	25.8	1.22	1.43	(0.64; 3.19)	
<3	24.3	1.13	1.30	(0.53; 3.18)	
0	36.6	2.03	2.73	(0.98; 7.65)	

*Adjusted for maternal age and birthweight for frequency of breastfeeding and for sex, birthweight and mother's age and BMI for duration of breastfeeding
**Linear trend test

ity among children who were never breastfed. Another supporting study is that of Tosckhe et al,[19] carried out in the Czech Republic. The authors report an odds ratio for obesity at age 6-14 years of 0.80 (95% CI: 0.66; 0.96) for children who were breastfed when compared to those who were not. Tosckhe et al also failed to detect a significant dose-response effect for the association between prevalence of obesity and duration of breastfeeding. On the other hand, Li et al,[11] in a cross-sectional retrospective study carried out in England with children and adolescents aged four to 18 years – a range which includes the ages analyzed in the present study – did not find a significant association between obesity and infant feeding patterns.

In a meta-analysis of 28 articles that reported estimated odds ratios for the association between infant feeding and obesity at later ages, Owen et al[13] found that breastfeeding was associated with lower risk of obesity when compared to artificial feeding (OR=0.87; 95% CI: 0.85; 0.90). These authors also found a weaker inverse association between breastfeeding and obesity in studies that controlled for maternal obesity and smoking and socioeconomic class (OR=0.93; 95% CI: 0.88; 0.99). The protective effect of breastfeeding against obesity was greater in four studies that evaluated exclusive breastfeeding (OR=0.76; 95% CI: 0.70; 0.83).

Owen et al[14] carried out another meta-analysis of studies of infant breastfeeding and BMI at later ages, this time including published and unpublished data and comparing only the mean BMI in different breastfeeding categories. Considering all published and unpublished results, the mean BMI among breastfed children was only slightly lower than that of non-breastfed children (-0.04; 95% CI: -0.05; -0.02). This difference was not statistically significant in studies that controlled for maternal obesity and smoking and for socioeconomic level. The difference in mean BMI between breastfed and non-breastfed children was greater in studies with samples smaller than 1,000 subjects (-0,19; 95% CI: -0.31; -0.08) than in larger studies (-0.03; 95% CI: -0.05; -0.02). In light of these findings, Owen and colleagues suggest that the frequently detected association between infant breastfeeding and obesity later in life may be due to inadequate confounder control and to publication bias (studies with negative results would tend not to be submitted or published).

It seems clear, therefore, that further studies will be necessary in order to clarify the association between breastfeeding and obesity. Prospective studies are especially needed in order to measure the duration of total and exclusive breastfeeding with greater precision. Equally important is the extensive control for confounders in the association between breastfeeding and obesity. In any case, regardless of the demonstration or not of a protective effect of breastfeeding against obesity, the promotion of exclusive breastfeeding for six months and of the continuation of breastfeeding until age two or older is completely justified by the other manners in which breastfeeding inarguably benefits children, mothers, and society.[22]

REFERENCES

1. Bergmann KE, Von Kries R, Bohm O, Ritcher R, Dudenhausen JW, Wahn U. Early determinants of childhood overweight and adiposity in a birth cohort study: role of breast feeding. *Int J Obes.* 2003;27:162-72.

2. Butte NF. The role of breast feeding in obesity. *Pediatr Clin North Am.* 2001;48(1):189-98.

3. Dewey KG, Lonnerdal B. Infant self regulation of breast milk intake. *Acta Paediatr Scand.* 1986;75:893-8.

4. French SA, Story M, Perry CL. Self-steem and obesity in children and adolescents: a literature review. *Obes Res.* 1995;3:479-90.

5. Gillmann MW, Rifas-Shiman SL, Camargo Jr CA, Berkey CS, Frazier AL, Rockett HR, et al. Risk of overweight among adolescents who were breastfed as infants. *JAMA.* 2001;285(19):2461-7.

6. Haaga J. Reliability of retrospective survey data on infant feeding. *Demography.* 1988;25:307-14.

7. Hediger ML, Overpeck MD, Kuczmarski RJ, Ruan WJ. Association between infant breastfeeding and overweight in young children. *JAMA.* 2001;285(19):2453-60.

8. Kark JD, Troya G, Friedlander Y, Slater PE, Stein Y. Validity of maternal reporting of breastfeeding history and the association with blood lipids in 17 years olds in Jerusalem. *J Epidemiol Community Health.* 1984;38:218-25.

9. Kramer MS. Do breast feeding and delayed introduction of solid foods protect against subsequent obesity? *J Pediatr.* 1981;98:883-7.

10. Launer JL, Forman MR, Hundt GL, Sarov B, Chang D, Berendes HW, et al. Maternal recall of infant feeding events is accurate. *J Epidemiol Community Health.* 1992;46:203-6.

11. Li L, Parsons TJ, Power G. Breast feeding in childhood: cross sectional study. *BMJ.* 2003;327:4-5.

12. Liese AD, Hirsch T, Von Mutius E, Keil U, Leupold W, Weiland SK. Inverse association of overweight and breastfeeding in 9 to 10 year old children in Germany. *Int J Obes.* 2001;25:1644-50.

13. Owen CG, Martin RM, Whincup PH, Smith GD, Cook DG. Effect of infant feeding on the risk of obesity across life course: a quantitative review of published evidence. *Pediatrics.* 2005;115:1367-77.

14. Owen CG, Martin RM, Whincup PH, Smith GD, Gillman MW, Cook DG. The effect of breastfeeding on mean body mass index through life: a quantitative review of published and unpublished observational evidence. *Am J Clin Nutr.* 2005;82:1298-307.

15. Reilly JJ, Methven E, McDowell ZC, Hacking B, Alexander D, Stewart L, et al. Health consequences of obesity. *Arch Dis Child.* 2003;88:748-52.

16. Rolland-Cachera MF, Deheeger M, Akrout M, Bellisle F. Influence of macronutrients on adiposity development: a follow up study of nutrition and growth from 10 months to 8 years of age. *Int J Obes Relat Metab Dirsord.* 1995;19:573-8.

17. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamsson DF, Byers T. Do obese children become obese adults: a review of the literature. *Prev Med.* 1993;22:167-77.

18. Singhal A, Farroqi IS, O'Rahilly S, Cole TH, Fettreell M, Lucas A. Early nutrition and leptin concentrations in later life. *Am J Clin Nutr.* 2002;75:993-9.

19. Toschke AM, Vignerova J, Lhotska L, Osancova K, Koletzo B, Von Kries R. Overweight and obesity in 6-to-14 year-old Czech children in1991: protective effect of breast feeding. *J Pediatr.* 2002;141(6):764-9.

20. Victora C, Barros F, Lima R, Horta B, Wells J. Antropometry in body composition of 18 year old men according to duration of breastfeeding: birth cohort study from Brazil. *BMJ.* 2003;327:901.

21. Von Kries R, Koletzo B, Sauerwald T, Von Mutius E, Barnert D, Grunert V, et al. Breast feeding and obesity: cross sectional study. *BMJ.* 1999;319(17):147-50.

22. World Health Organization. Breast-feeding: the technical basis and recommendations for action. Geneva; 1993.

23. World Health Organization. Diet, nutrition and the prevention of chronic diseases. Geneva; 2003. (WHO Technical Report Series, 916).

24. World Health Organization. Physical status: uses and interpretation of antropometry. Geneva; 1995. (WHO Technical Report Series, 954).

25. Zive MM, McKay H, Frank-Spohrer GC, Broyles SL, Nelson JA, Nader PR. Infant feeding practices and adiposity in 4-y- old Anglo-and Mexican-Americans. *Am J Clin Nutr.* 1992;55:1104-8.

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