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ORIGINAL RESEARCH

THE EFFECT OF BREASTFEEDING IN BODY COMPOSITION OF YOUNG CHILDREN

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ABSTRACT

Introduction: the effect of breastfeeding over the body mass components still demands analyses aiming to further investigate the body composition evolution in the after-breastfeeding childhood. **Objective:** analyze the influence of breastfeeding (BF) over the body composition of children under 3 years old. **Methods:** 760 children between zero and 3 years old were selected from the data of the longitudinal, home-based study "Saúde das Crianças de São Paulo II" ["São Paulo's Children Health II"] (1995-1997). The outcome variables used were the anthropometric indexes BMI-for-age (Z_{BI}) and triceps skinfold-for-age (Z_{DI}) expressed in Z-scores based on the WHO reference curve. Panel regression models were used in the analyses, with data from the 3 visits, adjusted by: birth weight, mother's educational level and mother's age. **Results:** there was no association between breastfeeding and Z_{BI} after multiple adjustments. There was inverse association between BF duration and the Z_{DI} index. The interaction between the mother educational level and the BF duration revealed the protective effect of higher educational level over Z_{DI} , when isolated. The mean nutritional indexes showed dose-response effect inversely proportional to the BF duration. **Conclusion**: breastfeeding showed protective effect against the mean body fat increase in children younger than 3 years.

Key words: breastfeeding, nutritional status, child growth, child nourishment, nutrition.

INTRODUCTION

The differences in the breastfed children's linear growth, weigh gain and nutritional state patters in relation to those not-breastfed, and its determinants, are being more intensively investigated in the last few years. In addition to several studies trying to demonstrate the relationship between breastfeeding and the future nutritional status[1,2], some researchers are also trying to relate breastfeeding and the first childhood nutritional state, the results, however, are controversial or inconclusive[3-5].

Theories regarding the long-term influences of nutritional and health conditions at first childhood are discussed in many spheres. The World Health Organization (WHO) published, recently, a review regarding the evidences of breastfeeding long-term effects, finding small protective effect for the obesity development[6]. Other researchers[7,8] still discuss if the weight gain and growth velocity in the children early years could also influence the future nutritional and health states.

In Brazil, some studies also tried to demonstrate the role of breastfeeding in the nutritional state or in the growth pattern in childhood. A study[9] performed in 12 cities verified that children breastfed for a longer period showed greater weight gain velocity. Spyrides et al [10], in a longitudinal study, found that, the longer the breastfeeding lasts, the higher is the child weight. Araújo et al [11], however, did not find relationship between the breastfeeding duration and obesity at 4 years old. Nevertheless, those studies considered

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the weight variable as determinant in the nutritional state. None of these studies considered the body fat deposit measurement itself.

Thus, the breastfeeding effect over the body mass components still requires additional analysis, especially to identify the breastfeeding effects over children body fat. The effect of predominant breastfeeding over the mass gain and body fat gain evolution in children up to three years old will be evaluated in this study.

METHODS

The present study used a sample of children with up to 5 years old, living in São Paulo city (Brazil), that have participated in the longitudinal, home-based study "Saúde das Crianças de São Paulo II" ["São Paulo's Children Health II"] (SCSP-II), from 1995 to 1997. The population selection occurred between September 1995 and August 1996, using complex probabilistic sampling. In summary, we performed a stratified multistage sampling, involving the random selection of the geographic areas of the city defined by the Census, household clusters and individual households.

The visit in the 4,560 selected households identified a total of 1,390 children under five years old. Of these children, 54 (3.9%) were not included because they are not found at home after a minimum of three visits (at least one on Saturdays or Sundays) or because parents did not agree to participate in the study, 56 children (4.0%) were studied only partially because they changed residence before the study was completed. So were fully studied 1,280 children aged zero to 59 months old.

To each of these children was applied a factor that represents the sample weight. This factor is given by the inverse of the household sampling fraction where the child lives (how many households in the city are represented by one household) multiplied by the inverse of the research success rate in the sector of the household.

Applying these weights, the sample of 1,280 children studied adequately represent all children under five years who lived in the city of São Paulo in 1995/96 Follow-up[12].

Within this sample, the only inclusion criterion for the study was being aged between 0 and 36 months (n = 804). Exclusion criteria were children born from twin pregnancy (n = 18) and those with data provided by anyone other than the mother (n = 26). The final study sample was 760 children (50.4% of boys and 49.6% of girls).

The breastfeeding data were obtained in the first interview and the children's nutritional state was evaluated at this visit and two more times, after 7 and 14 months from the first visit. Socioeconomic background, mother's reproductive state and child birth data were also obtained at the first visit, as control variables.

The present study received approval from the Human Research Ethics Committee at the Faculty of Public Health, University of São Paulo, on February 13, 2008 (protocol No. 1725).

Data Analysis

It was not possible to use the exclusive breastfeeding duration, as it showed the worse statistical tests performances in preliminary analyses, possibly due to the low frequency and duration observed in the sample. For this reason, it was decided to use the "predominant breastfeeding duration in months (PBF)" variable. The PBF occurs when there is concomitant administration of water, teas and juices along with breast milk, with no administration of other types of milks or solid foods.

The anthropometric measurements collected at the 3 visits were: weight (kg), height or lenght (cm) and tricipital skinfold (mm). The Body Mass Index (BMI) was calculated by dividing the weight (kg) by the squared height (m). These variables were converted in the Z_{BI} (BMI-for-age) and Z_{DI} (tricips skinfold-for-age) indexes, expressed in standard deviations (Z-scores) related to the child growth reference pattern proposed by the World Health Organization in 2006[13,14].

The control variables selection was made taking into account factors related to 1) family socioeconomic background such as: family income per capita and mother's educational level (categorized in up to 3 years of study, from 4 to 7 years of study, 8 or more years of study), 2) mother's reproductive factors such as: child birth order and maternal age, 3) environmental factors such as: housing conditions, 4) child biological factors such as: weight at birth (kg), age and sex.

The PBF duration effect over the body mass and body fat anthropometric indexes evolution was estimated by panel analysis (or repeated measurement technique). The models here presented used mixed effects regressions (then, considering the random and fixed effects), with maximum likelihood estimates - MLE. The fixed effect considers both intra-individual characteristics (effect variation if the individual presented different characteristics) and inter-individual characteristics (average effect variation over groups of individuals), the random effect is often attributed to non-observed heterogeneity (residual standard deviation of specific individual non-observed co-variables)[15].

The control variables kept in the final model were child age, weight at birth, the occurrence or non-occurrence of the mother working away from home, and mother's educational level (we selected the ones that presented $p < 0.20$ in univariate regression, and we kept the ones that were significant - $p < 0.05$, or that adjusted in at least 10% any other variable). Interaction terms between mother's educational level and PBF duration variables were included in the models.

Based on the adjusted multiple models, the anthropometric indexes means were estimated for each study phase, as function of PBF duration.

RESULTS

From the 760 children evaluated in the present study, 50.4% were boys and 49.6% were girls. The mean age was 18 months at the first visit (baseline), 24.5 months at the second visit and 31.7 months at the third visit. The mean Z_{BI} index at baseline was 0.26 Z and the prevalence of overweight was 4.7%. The mean Z_{DI} index was 0.24 Z and the prevalence of excess body fat was 3.7% of the sample.

The mean age of the interviewed mothers was 27.8 years at baseline, and the mean study years successfully concluded reached 7.2.

After the independent variables control, it was found an inverse association between the PBF duration and the triceps skinfold-for-age (table 1). The child's weight at birth was not determinant for the Z_{DI} index increase in this model.

Table 1: Mixed linear model (fixed and random effects) for longitudinal evolution of the nutritional indexes Z_{BI} (BMI-for-age) and Z_{DI} (triceps skinfold-for-age) in children under 36 months of the study "SCSP-II". São Paulo, Brazil, 1995-1997

Variables	Coefficient (SE)	
	BMI-for-age (Z_{BI})	**triceps skinfold-for-age (Z_{DI})**
Fixed Effects		
Birth weight (kg)	0.200 (0.065)[a]	0.097 (0.064)
Maternal age	0.003 (0.006)	-0.003 (0.006)
Maternal educational level		
0-3 years of schooling	-	-
4-7 years of schooling	-0.165 (0.166)	-0.282 (0.135)[a]
> 8 years of schooling	-0.133 (0.136)	-0.212 (0.135)
PBF duration (months)	-0.048 (0.026)	-0.070 (0.026)[a]
Interaction effect		
Education x PBF duration[b]		
0-3 years and PBF_{mean}	-	-
4-7 years and PBF_{mean}	0.032 (0.029)	0.065 (0.028)[a]
> 8 years and PBF_{mean}	0.043 (0.029)	0.075 (0.028)[a]
Constant	-0.229 (0.283)	-0.401 (0.280)
Random effects	**Estimates (SE)**	
SD (age)	0.016 (0.002)	0.004 (0.008)
SD (cons)	0.759 (0.034)	0.794 (0.038)
SD (residual)	0.540 (0.012)	0.641 (0.014)

[a]p<0.05, [b]PBF = predominant breastfeeding duration in months.

The interaction effect between maternal education and AMP duration reversed the isolated negative effect of PBF among mothers with eight or more years of study. Thus, for the same mean PBF duration, more educated mothers presented children with higher body fat indexes.

The duration of PBF did not remain significant in the analysis of the Z_{BI} index after multiple adjustments (Table 1). In this adjusted model, only birth weight was a significant predictor of changes in PBF over follow-up time.

The values for both anthropometric indexes are inversely associated with the PBF duration and theirs means converge to zero (average value expected for this population) as the PBF duration increases, which can be seen in Table 2. The evolution of the average of both anthropometric indexes between periods of follow-up showed a statistically significant linear trend.

DISCUSSION

The predominant breastfeeding showed a protective role over the body fat accumulation in children under 3 year old. Each additional month of PBF was associated to a 0.070 standard deviations reduction in the DCT index-for-age. The duration of AMP did not remain significant in the analysis of the index ZBI after multiple adjustments. Thus, in addition to reinforce the importance of breastfeeding until 6 months, as recommended by WHO [16], these findings highlight the possible preventive role of breastfeeding over obesity.

These results are not commonly found in national studies on the topic, since in general nutritional status is assessed based on the weight and length of the child. In studies performed in Europe and North America, focusing the relationship between breastfeeding and body composition, the

Table 2: Adjusted means of the nutritional indexes Z_{BI} (BMI-for-age) and Z_{DI} (triceps skinfold-for-age), according to the duration of predominant breastfeeding (PBF) in children under 36 months of the study "SCSP-II". Sao Paulo, Brazil, 1995-1997

PBF duration	Visit 1	Visit 2	Visit 3	Complete Follow-up
Z_{BI}				
0 - 1 month	0.364	0.359	0.359	0.361
1 - 4 months	0.324	0.330	0.332	0.328
4 - 6 months	0.303	0.307	0.299	0.303
6 - 24 months	0.208	0.212	0.221	0.213
Z_{DI}				
0 - 1 month	0.407	0.404	0.402	0.404
1 - 4 months	0.375	0.376	0.375	0.375
4 - 6 months	0.356	0.358	0.348	0.354
6 - 24 months	0.299	0.309	0.325	0.311

results found were conflicting: one of them reports a superior quantity of fat in breastfed children[17], others, on the other hand, indicates a superior quantity of fat in children that received formula[18,19].

In a review about this subject, Dewey[19] demonstrates that of 6 studies that showed differences in the adiposity according to the feeding scheme, 5 found that children fed with formula had higher adiposity indexes than the children breastfed, usually after the first 4 months of life. However, four of these studies[20-23] used only indexes such as weight-for-height or BMI-for-height to evaluate adiposity.

Studies with Brazilian population[10,11] also used one of these indexes to evaluate the nutritional state, and not the fat component evaluation itself. To our knowledge, this is the first Brazilian study that focused on the effect of PBF over body fat on children. In the present study, the use of tricipital skinfold information as fat measurement brought the possibility to evaluate adiposity evolution, and not only body mass evolution, according to breastfeeding duration. In the analysis here presented, the BMI was not sensitive to detect the effects identified by the triceps skinfold analysis, which can be more sensitive to show the differences that sometimes cannot be detected only by the child weight measurement.

There are several mechanisms that may explain this inverse association showed here. There is evidence that the breastfed babies self-regulate the energy consumption in a level inferior to those consumed by children fed with formula, through mechanisms of satiety that are stimulated by breastfeeding[24]. A second possibility refers to blood insulin concentration: formula-fed infants have higher plasma insulin concentration and more prolonged response to insulin. Higher concentrations of insulin stimulate greater fat deposition[25]. Besides, the body temperature and baseline metabolic rate are smaller in breastfed children when compared to formula fed babies and can be part of the expanation[19]. Another hypothesis for this mechanism is that protein consumption a formula fed child is normally higher than the consumption of a child under breastfeeding, which contributes to a higher total amount of energy and also higher insulin concentrations[19,26-29]. A final possibility is also that the leptin concentration may be influenced by breastfeeding. One study found that, after controlling for confounding variables, such as BMI, children who had higher breast milk intake in early life had more favorable leptin concentrations in relation to their fat mass[30]. Therefore, the differences of consumption and metabolism on breastfed children can support the results we found.

Another area in which the evidence of the importance of breastfeeding has shown impact is the analysis of its potential to activate genes that can interfere with the metabolism and the development of non-communicable diseases. Most recently, for example, has been discussed that the Ala12 allele of the peroxisome proliferator-activated receptor 2 (PPAR2) is associated with weight gain in early life and that this association may be influenced by the duration of breastfeeding[31]. Other analyzes have shown that common PPAR2 polymorphisms are associated with adipocyte differentiation, lipid metabolism and insulin sensitivity[32], as well as reporting increased BMI in persons with PPAR2 allele 12[33], which was also seen among children in early childhood[34,35]. In the present study, we do not have this sort of data available, but the type of effect and meaning of the results presented here are consistent with some of the mechanisms proposed in studies on polymorphism and indicate the potential population impact of these mechanisms.

The initial analysis of our data indicated an association between the level of education of mothers and the PBF duration, as well as the effect of both variables on body fat. This analysis suggested, therefore, an exponential effect of these variables on the body composition of children. For this reason, an interaction term between maternal schooling and PBF duration was created in the next step of the analysis to account for possible multiplicative effect for these variables suggested in the previous step. The inclusion of this interaction changed the relationship direction, i.e., showed that mothers with higher educational level tends to have children with superior quantity of body fat.

In developing countries, as Brazil, the prolonged breastfeeding tends to provide greater energy input to children of poorer families and, accordingly, represents the differential to the children weight increase in these social groups. In the populational research that originated the present study sample, it was observed that mothers with higher educational level (11 or more years of study), already had children with higher prevalence of overweight[12]. Thus, it seems that the predominant breastfeeding protective effect was not sufficient to change this condition. In the developing countries, the relationship between mother's educational level and breastfeeding is still not clearly defined, therefore it is difficult to establish a causality model that explains the pattern found. There are studies that show that the Brazilians more educated mothers breastfeed for longer periods[36,37], but other results did not show significant association[38,39] or even the opposite association - more educated mothers breastfeed for less time[40].

In addition to the favorable aspects that these findings suggests to child growth, is also subject for discussion its possible role in the relationship with the nutritional state in adult life[6-8]. Dietz[41,42] proposes 3 critical periods to the future obesity development: pre-natal and first childhood, between 4 to 7 years, known as "*adiposity rebound*", and finally adolescence. During these periods, the excessive fat accumulation is directly related to the future nutritional state, precociously defining the adult obesity risk. Thus, the modulatory effect exerted by breastfeeding over the adipose tissue growth at first childhood can become an important protective factor against adult obesity.

One of this study's limitation is that the body fat data are based on the tricipital skinfold measurement. Some analysis, however, indicates that the tricipital skinfold presents approximately 0.80 correlation with total body fat[43]. The skinfold measurement is not common in younger children in population-based studies, so this is an important advantage for the results here presented in relation to other available studies, even with the limit of analyzing fat based only on measure of one skinfold location.

Moreover, given the study design, the possibility of estimating the relationships analyzed here for a set of children representative of Brazil's largest city makes the results of this study relevant *per se*. Representative longitudinal studies that evaluate the health in children are still scarce in Brazil and this is the third differential of our study.

Thus, the findings on this study indicate that the predominant breastfeeding duration was inversely proportional to body fat in children under 3 years old, offering protective role. The same effect was not observed for BMI-for-age index, because the predominant breastfeeding duration was no longer significant after multiple adjustments.

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