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ORIGINAL ARTICLE

Breastfeeding duration, mixed feeding and health risk in Costa Rican children and adolescents

Duración de la lactancia materna, alimentación combinada y riesgo para la salud en jóvenes costarricenses

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What do we know about the subject matter of this study?

There is no clear consensus between the duration of breastfeeding, infant feeding, and obesity in later childhood. Most studies have focused on studying this relationship in children under 6 years of age.

What does this study contribute to what is already known?

We found evidence of the protection of breastfeeding against obesity in a young population in Costa Rica, observing that those fed only with formula are at higher risk of obesity. It is important to advise on healthy complementary feeding and physical activity during the first stages of life.

Abstract

Objective: to analyze the associations between breastfeeding duration and mixed feeding (breast milk and formula) with obesity, cardiometabolic risk (WHtR), body fat, and dietary and physical activity risk behaviors in children and adolescents. **Subjects and Method:** cross-sectional study carried out with 1,467 students in Costa Rica. An interview was conducted with parents and children to gather information on socioeconomic status, education, dietary and physical activity risk behaviors of the youth, including breastfeeding duration and mixed feeding. Body mass index, waist circumference, and body fat were assessed by bioelectrical impedance analysis and cardiometabolic risk was measured with the waist-to-height ratio (WHtR ≥ 0.5) by trained personnel. Descriptive statistics and logistic regression models were applied. **Results:** the average age was 11.4 ± 2.6 years and 50.9% were male. 55.5% of the population was middle class; 60% were sedentary, and 16% presented obesity. Around 20% were breastfed without the introduction of formula before 6 months, 13% were never breastfed, and more than 60% were breastfed for ≥ 6 months. Those children who were fed only with breast milk or in combination with formula for ≥ 6 months presented a lower percentage of obesity

Keywords:
Breastfeeding;
Obesity;
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than those who received formula feeding only (60.8 vs 39.2; p < 0.005). Children with cardiometabolic risk (WHtR ≥ 0.50), unhealthy diet, sedentary lifestyle, and who were fed only with formula are at higher risk of developing obesity (OR = 18.8, 95% CI 13.2-26.0). **Conclusions:** these results are consistent with other studies and reinforce the evident protection of breastfeeding against the development of obesity.

Introduction

Breastfeeding (BF) is associated with improved health status and is one of the protective factors that has been rigorously studied in relation to the prevention of childhood obesity and chronic non-communicable diseases (NCDs). Likewise, there are several physical and psychological benefits of BF for infants and mothers which have been widely described[1,2]. These benefits of BF over the use of formula are known, however, there is no clear consensus in the literature on the relationship between duration of breastfeeding, infant feeding, and obesity in later childhood[3] and most studies have focused on studying this relationship in children younger than 6 years[4].

The World Health Organization states that BF should be initiated within the first hour after birth and continued exclusively until at least six months of age, where complementary foods can be gradually introduced. In addition, it is recommended to continue BF until the child is two years of age or older[5]. However, few studies have drawn strong conclusions regarding the duration of BF and mixed feeding (breast milk and formula) and its association with obesity, cardiometabolic risk, and body fat (infant adiposity)[3,5,6], and the existing studies have focused on the risk of early obesity in children aged two to six years. The dose-response relationship between the duration of BF and the obesity risk reduction of the risk of obesity has been studied mainly in early childhood, excluding the adolescent population[4].

Likewise, factors such as diet and physical activity, along with BF duration, have not been analyzed as risks for obesity in school-aged children and adolescents. The objective of this study is to analyze the association between the duration of BF and mixed feeding with obesity, cardiometabolic risk (WHtR), body fat, and dietary and physical activity risk behaviors in school children.

Subjects and Method

Type of study and population selection

A cross-sectional study was carried out with 1,467 students in 40 public schools and 24 private schools in Costa Rica. The proportion estimation formula was used with a 95% confidence interval and 3% of standard error. The calculation was performed considering maximum variance (p = 0.5) and with an estimated design effect of two. In each educational center, approximately 23 children and adolescents were randomly selected considering age (7 to 15 years) as the only inclusion criterion. Exclusion criteria included incomplete participant information and inability to read and write.

A parental interview guide was applied to collect information on the child's education and habits, including duration of BF and mixed feeding. Demographic and socioeconomic variables were also recorded. Children in the first, second, and third years of school were interviewed.

Breastfeeding and infant feeding

Data on the duration of BF were obtained from mothers or caregivers. They were asked for retrospective information on infant feeding practices. 53 mothers who answered "not sure" or "prefer not to say" were excluded from the analysis.

Subject feeding was defined by the variables duration of BF and time at which formula was introduced, according to the following options: a) < 1 week, b) ≥ 1week to < 3 months, c) ≥ 3 months to < 6 months, d) ≥ 6 months to <9 months, e) ≥ 9 months to < 1 year), and f) ≥ 1 year.

Participants' type of feeding was then categorized by analyzing the response to both variables, defining "breastfed only", "formula only", and "mixed feeding". Participants classified in the "breastfed only" category were those who were breastfed for at least 6 months and never introduced formula, and those classified in the "formula only" category included those who were breastfed for less than 1 week or only with formula.

Regarding mixed feeding, it was classified as follows: a) "Mixed feeding ≥ 6 months" included participants who were breastfed for at least 6 months and then introduced formula and b) "Mixed feeding for < 6 months" included participants who were breastfed for less than 6 months and additionally received formula.

Anthropometric data

Weight (kg) and body fat were measured by bioimpedance analysis with a Tanita SC-331S scale (without

column kit), which has been recommended for use in children and adolescents[7].

Body weight was measured with the subject barefoot and lightly clothed. Height was measured in standing position, with the internal malleoli together and the heels, buttocks, shoulders, and posterior region of the head in contact with the device.

The body mass index of each participant was assessed using the WHO Child Growth Standards[8,9] and the nutritional status was classified according to the percentile obtained into two groups: without obesity (BMI < 95) and with obesity (BMI ≥ 95).

Abdominal circumference was measured at the midpoint between the lower rib and the top of the iliac crest on bare skin. The cardiometabolic risk was measured using the waist-to-height ratio (WHtR ≥ 0.5)[6].

Each participant was measured twice, and then the average was calculated and, if the difference was greater than 0.5 cm, a third measurement was made. Measurements were performed by trained professionals.

Diet quality index (DQI)

The research team applied a validated food frequency survey to study the food and beverage intake habits of the participants in subjects of the same age[10] and was applied individually under the supervision of two nutritionists.

Physical activity

We calculated the total hours of screen time (0-24 hours/day) considering the frequency of four sedentary behaviors during weekdays and weekends such as watching television, playing computer or console games, connecting to the Internet, and chatting daily by cell phone or another media, considering: (a) the recommended maximum daily screen time (2 hours)[11-13], (b) the weekly frequency of physical activity apart from school (mean ≥ 60 minutes/day; 0 = never, 7 = daily)[14,15], and (c) the practice of physical activity at school.

Subjects were classified as "active" if they met the following two conditions: total screen time less than 2 hours per day and weekly frequency of physical activity apart from school (average ≥ 60 minutes/day) more than 3 days per week. The remaining participants were classified as sedentary.

Sociodemographic data (covariance)

Sex and age were recorded, and the socioeconomic level of the students was determined based on an index[16] that considers the access to services and material goods in the home.

General and ethical procedures

Participants signed informed consent or written assent, approved by the INCIENSA Scientific Ethical Committee (IC 2010-05).

Statistical analysis

Descriptive statistics were used to characterize the population by nutritional status (without or without obesity) and proportions were calculated for categorical variables. The Kolmogorov-Smirnov test was used to verify that the variables did not deviate significantly from normal behavior. Differences between groups were explained by parametric or nonparametric tests according to the normal distribution. Data defined by more than two categories were tested by ANOVA or Kruskal-Wallis test according to the distribution.

Logistic models were applied to organize the clustering of student observations using univariate and multivariate regressions. In the univariate regression, the association between BF duration and nutritional status was evaluated, as well as the association between the mixed feeding variable and nutritional status. In the multivariate analysis, associations were adjusted by sex, household income, and parental education. Subsequently, to obtain a comprehensive and final model, we adjusted by the DQI (healthy = 0 and unhealthy = 1), physical activity (sedentary = 1 and active = 0), body fat (kg), and WHtR (≤ 0.5= 0, > 0.5 = 1). Odds ratios (OR) and 95% CI were calculated separately (with and without obesity). To run the models, the method chosen was "backward", so the elimination by contrast was based on the likelihood of the Wald test.

Analyses were performed with the SPSS software for Windows (version 22.0) and a $p \leq 0.05$ value was considered statistically significant.

Results

The mean age of the study population was 11.44 ± 2.64 years; most were middle class and sedentary, 50.9% were male, and a higher proportion of children aged between 7 and 9 years were obese ($p < 0.002$). Three-quarters of the subjects with obesity received breast milk for less than 6 months, while those without obesity were breastfed for 6 months or more (75.7% vs. 25.9%, respectively; $p < 0.001$), and approximately one-quarter of the participants without obesity never received formula (Table 1).

There were statistically significant differences between the early introduction of formula at 0 to 6 months of age (10.6% no obesity vs. 31.1% obesity; $p < 0.001$) and the introduction of formula at 6 months or more (65.7% no obesity vs. 31.7% obesity; $p < 0.001$) (Table 1).

Compared with the children without obesity, higher proportions of obese children presented WHtR

with risk ($p < 0.001$), unhealthy DQI ($p < 0.001$), aged parents ($p < 0.011$), and parents with completed university education ($p < 0.001$) (Table 1).

Those children and adolescents who were exclusively fed with breast milk ($p < 0.001$) or in combination with formula for 6 months or more ($p < 0.001$) were less likely to be obese; while those who were fed with formula only, were more likely to be obese compared with those who were not obese (60.8 vs. 39.2; $p < 0.005$) (Table 2). There were no statistically significant differences between children and adolescents, regardless of nutritional status, in relation to mixed feeding for less than 6 months (59.0% vs. 41.0%; $p = 0.11$).

Table 3 shows the averages of total fat mass. When comparing exclusive BF with mixed feeding for ≥ 6 months, no statistically significant associations were observed. However, when comparing exclusive BF with mixed feeding for < 6 months, there were statistically significant associations in the three age groups analyzed. Those children and adolescents with less fat were those exclusively breastfed. Concerning the averages of total fat mass, comparing exclusively breastfed with formula-fed children, statistically significant associations were observed in all three age groups, except for children aged 10 to 12 years.

Sociodemographic covariates of the students and their parents were adjusted to determine the associations (OR) between the four BF duration groups analyzed and the nutritional status (no obesity = 0 and obesity = 1) of the students, comparing them with those who were breastfed for less than one week or never. During the periods of BF duration from one week to less than 3 months and 9 months or more, a greater protective factor of BF against obesity can be observed. There was no association in children and adolescents who were breastfed from 6 months to less than 9 months (Table 4).

The associations (OR) in the four BF duration groups analyzed regarding the probability of being obese were significant in the fully adjusted model with sociodemographic variables, WHtR, body fat, DQI, and physical activity status. In all assessed categories of BF duration and mixed feeding, children and adolescents were significantly less likely to be obese compared with those who were breastfed for less than 1 week or never. Despite the full adjustment, the most protective odds ratios of breastfeeding against the likelihood of being obese continued to be the BF duration periods of 1 week to less than 3 months and 9 months or more.

In the three models applied, compared with those who were exclusively breastfed, children and adolescents who were more likely to be obese were those who received formula only, followed by those who received mixed feeding for 6 or more months (Table 4).

Discussion

Considering the OR obtained in the fully adjusted model, which included cardiovascular risk, among other factors, to analyze the association between the BF duration and the probability of obesity, it was observed that any time longer than one week protects the child and adolescent from obesity. Due to the absence in the scientific literature of studies that have analyzed these factors and reported odds ratios during this specific period of BF duration, it is not possible to compare our results with others. One possible explanation is that the addition of formula, either as exclusive or supplemental feeding, leads to the non-physiological weight gain that is associated with obesity[17]. In addition, it is recommended to initiate complementary feeding after 17 weeks of age[18].

Poorolajal et al.[19] reported an OR (95% CI) for BF < 4 months vs. ≥ 4 months of 1.24 (1.16, 1.33), meaning that BF <4 months may increase the risk of childhood obesity by 24% ($p = 0.001$). The trend of BF duration and its protection from obesity in our study is supported by Rito et al.[20] who indicate that the more exclusively and longer the child is breastfed, the greater the protection from obesity. However, in our study, in the BF duration periods analyzed from 3 to 9 months, the protection of BF with respect to the risk of obesity was lower compared with the other periods. This variation could be explained by the different number of participants in each of the BF duration groups analyzed. Despite this, Spatz[21] reports that any length of breastfeeding will help protect the child from obesity.

Although infants should be fed without formula, some mothers in this study did so, which is a practice that is associated with obesity. Several mechanisms could explain this association[21,22] such as that breastfed infants have a lower protein intake and, in general, consume fewer calories and that formula feeding leads to a higher insulin response, which stimulates the deposition of fatty tissue and thus the risk of cardiometabolic risk, obesity, and type 2 diabetes.

Exclusive BF is inversely associated with the weight gain rate during the first year of life[23]. Breastfed infants self-regulate intake, regardless of the availability of breast milk; therefore, they will stop feeding when satisfied, whereas bottle-fed infants have poor self-regulation and greater weight gain at the end of infancy[21].

However, our results suggest that mixed feeding is less risky than formula feeding alone (OR = 18.8, 95% CI 13.2-26.0). Breastfed infants initially consume small volumes of colostrum, which allows them to use the brown fat, and the fat digestion of breast milk is better than that of formula because of its content of lipases[21,24].

Duration of BF is associated with healthier food choices from early infancy[24-26]. Children's food prefe-

Table 1. Characteristics of the studied population by nutritional status

Variables	Total n = 1467 (100%)	Nutritional status		p*
		Without obesity n = 1233 (84%)	With obesity n = 234 (16%)	
Gender				
Female	49.1	48.2	53.8	0.29
Male	50.9	51.8	46.2	0.33
Groups of age (years)				
7 - 9	24.7	21.8	39.3	0.002
10 - 12	36.3	38	27.4	0.13
13-15	39.0	40.1	33.3	0.30
Breastfeeding duration				
<1 week	13.2	6.2	50.4	< 0.001
1 week - <3 months	5.6	3.8	15.0	0.16
3 - <6 months	14.9	15.9	10.3	0.67
6 - <9 months	59.9	68.0	17.1	< 0.001
9 months - <1 year	3.2	2.8	5.1	0.58
≥ 1 year	3.1	3.3	2.1	0.22
Introduction to milk formula				
Never	20.5	23.8	3.4	0.35
<1 week	6.13	0.5	3.8	0.47
1 week - 3 months	9.3	8.6	12.8	0.73
3 - < 6 months	3.5	1.5	14.5	0.31
6 - < 9 months	14.6	15.3	10.7	0.75
9 months - <1 year	40.3	44.4	18.4	0.002
≥ 1 year	5.5	6.0	2.6	0.57
Cardio-metabolic risk (waist-to height ratio (WHtrR)				
Without-risk	79.9	90.4	24.4	< 0.001
With risk	20.1	19.6	75.6	< 0.001
Quality of diet				
Healthy	11.3	9.7	11.5	0.94
Non-healthy	88.7	76.6	88.5	< 0.001
Physical activity				
Active	40.5	41.4	35.9	0.40
Sedentary	59.5	58.6	64.1	0.24

p*: statistically significant if p ≤ 0,05; n= number of children and adolescents.

Tabla 2. Feed type by nutritional status

Feed type	Total n = 1467 (100%)	Nutritional status		p*
		Without obesity n = 1233 (84%)	With obesity n = 234 (16%)	
Only breastfed	20,5	97,3	2,7	< 0,001
Combination fed for ≥6 months	59,4	92,3	7,7	< 0,001
Combination fed for <6 months	6,8	59,0	41,0	0,11
Only formula	13,2	39,2	60,8	0,005

p*: statistically significant if p ≤ 0,05; n= number of children and adolescents.

Table 3. Comparation of mean total fat mass[a] (Kg)[b] in children and adolescents who were only breastfed versus combinations of breastfeeding and only formula

Population	Only breastfed	Combination fed for ≥6 months	Combination fed for <6 months	Only formula
Girls				
7-9 years (n = 179)	5,63 (3,60)	5,76 (3,32)	12,10 (4,56)*	9,38 (3,77)*
10-12 years (n = 261)	7,26 (2,96)	7,37 (3,48)	9,87 (4,23)*	8,32 (4,16)
13-15 years (n = 281)	10,51 (4,21)	11,51 (4,22)	13,78 (2,58)*	18,58 (8,59)*
Boys				
7-9 years (n = 182)	4,92 (2,77)	5,03 (2,46)	7,77 (4,36)*	7,51 (4,63)*
10-12 years (n = 272)	5,24 (2,23)	5,64 (3,60)	9,33 (6,03)*	5,31 (3,15)
13-15 years (n = 292)	6,74 (3,95)	6,82 (4,62)	12,3 (6,30)*	17,11 (7,54)*

[a]TaAll values are averages, SD in parenthesis. [b]Measured by bioelectrical impedance analysis in a Tanita SC-331 S (without columna). *Indicate that p value <0,05 (Kruskal-Wallis Test (de William Kruskal-Wallis).

Table 4. Adjusted and non-adjusted associations between breastfeeding duration / combined feeding and nutritional status (without obesity=0 vs. obesity=1) among 1,467 children and adolescents of Costa Rica

Breastfeeding duration/ Combination fed	Non-adjusted OR (95% CI)	OR adjusted for sociodemographic variables of students and their parents[a]	OR adjusted additionally for body fat (Kg), DQI, physical activity status and WHtrR[b]
<1 week	1	1	1
1 week - <3 months	0,71 (0,69-0,74)*	0,70 (0,67-0,73) *	0,74 (0,72-0,81) *
3 - < 6 months	0,83 (0,80-0,86)*	0,92 (0,88-0,96) *	0,81 (0,77-0,86) *
6 - < 9 months	1,06 (1,02-1,09)*	0,95 (0, 99-1,03)	0,95 (0,90 -0,99) *
9 months - <1 year	0,74 (0,71-0,77)*	0,73 (0,70-0,76) *	0,69 (0,64-0,74) *
≥ 1 year	0,76 (0,73-0,79)*	0,76 (0,73-0,79) *	0,77 (0,72 -0,82) *
Only breastfed	1	1	1
Combined feeding for ≥6 months	7,12 (5,88-11,78)**	7,00 (5,22-10,81) *	7,09 (5,24-10,89) *
Combined feeding for <6 months	2,19 (1,30-3,71)*	2,16 (1,21-3,60) *	2,18 (1,22-3,69) *
Only formula	18,86 (13,50-26,61)*	17,46 (13,10-25.83) *	18,80 (13,20-26,00) *

*Indicate that p value < 0,05 (Wald test). [a]Adjusted for gender (1= female and 0= male) and age (years, continue variable) of the child/adolescent; family socioeconomic status (index, continue variable) and parent´s education (years of study, continue variable). [b]Adjusted for gender (1= female and 0= male), age (years, continue variable), WHtrR (1= > 0,50 and 0= ≤ 0,50), body fat (Kg, continue variable), DQI (1 = no healthy and 0= healthy) and physical activity status (1 = sedentary and 0 = active) of the child/adolescent; family socioeconomic status (index, continue variable) and parent´s education (years of study, continue variable).

rences seem to be determined by exposure to foods and flavors in the mother's diet through the amniotic fluid and breast milk[25]. Trabulsi et al.[27] report that every day an infant is breastfed, her/his palate and taste buds are exposed to new flavors, whereas formula always tastes the same. Research in the Netherlands found that 7-year-olds breastfed for more than 16 weeks had a higher intake of fruits and vegetables and were less likely to consume white bread, soft drinks, chocolate bars, and fried foods than those who were never breastfed[28].

Regarding the introduction of solid foods and other liquids other than breast milk and formula analyzed in this cross-sectional study and considering recall bias[29], it would be hasty to suggest that infants who received mixed feeding for less than 6 months versus exclusive BF had lower ORs than those who received mixed feeding for more than 6 months since the former ones are less exposed to formula.

For these reasons, at the time of introducing solid foods, infants who have been exclusively breastfed or

received mixed feeding mainly with breast milk will have been exposed to more tastes compared with those non-breastfed or those who received mixed feeding mainly with formula. Therefore, it is recommended to follow dietary guidelines from early childhood to promote the construction of healthy eating habits in children and prevent the development of risk behaviors and, consequently, obesity[30]. In contrast, the association of BF duration for less than 6 months and health risk leads to unhealthy eating and a sedentary lifestyle.

Evidence indicates that eating while watching TV is associated with poor diet quality and obesity, due to frequent consumption of sugary drinks and foods rich in fats and sugars and fewer fruits and vegetables[31]. Studies have reported that watching television for more than 2 hours/day can increase the risk of obesity by 42% ($p = 0.001$)[19] and that BF shows beneficial effects on children's physical fitness[32].

In developing countries, it has been observed that BF duration is associated with a greater increase in cardiorespiratory fitness in infancy[33]. Other studies have reported that BF in early infancy positively influences walking skills during childhood and later years, which could be explained by the active ingredients, enzymes, and adipokines present in breast milk[34]. Levels of insulin-like growth factor type 1 (IGF-1) may be playing a key role in muscle and strength in breastfed infants[35] since these IGF-1 levels are positively associated with neonatal energy and protein intake, and muscle and bone growth[36,37]. Protein intake in early infancy may contribute to preparing lean mass and IGF-I around puberty[37-40].

The combination of a low-quality diet and sedentary lifestyle is widely recognized as synergistic in increasing the risk of obesity and, consequently, the development of chronic NCDs[41]. Singhal and Lucas[42] have proposed the "growth acceleration hypothesis," which postulates that an accelerated rate of weight, height, and adiposity gain during critical periods, such as infancy, may establish adverse metabolic features and cardiovascular disease risk. In our study, children at cardiometabolic risk, with unhealthy diet, sedentary lifestyle, and fed only with formula, had high odds of obesity. Finally, in the fully adjusted model (Table 4), we observed that BF remained a protective factor for obesity, which is consistent with other studies[43,44].

This study evidences the protective power of BF in periods of duration that had not been analyzed (from one week to more than one year of age), with respect to the risk of obesity in children and adolescents. The results are useful for implementing policies for the promotion of public health and the prevention of obesity and chronic NCDs.

Costa Rica and the countries worldwide should support the initiation of BF from birth and its long-term duration, in line with the Baby-Friendly Hospital Initiative, the availability of BF-friendly spaces, and educational campaigns that support women in their decision to breastfeed[24,45,46]. Human Milk Banks, Breastfeeding and Development Clinics, and maternal and child support networks, as part of a positive BF culture, should also be strengthened[24,47].

Finally, among the limitations of this study is the use of bioimpedance, as it is not a method considered the gold standard for measuring body composition and possible recall bias of parents since data on participants' BF and mixed feeding may not be accurate, as they go back 7 to 15 years at the time of the interview. This is a cross-sectional study not designed to assess associations between BF and health risk behaviors or overweight/obesity, and information on participants' early eating and physical activity habits during early childhood was not available, which would be beneficial in explaining the role of parenting and family lifestyles in the development of obesity.

These results should encourage health professionals to provide support and advice to mothers and caregivers of children and adolescents on the importance of complementary feeding, healthy eating patterns, and physical activity during the early stages of life to curb the increase in obesity[41].

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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