Is Breastfeeding Protective for Blood Pressure in Schoolchildren? A Cohort Study in Northeast Brazil

Rosemary de Jesus Machado Amorim,¹ Aleksandra Ferreira da Costa Coelho,¹
Pedro Israel Cabral de Lira,² and Marilia de Carvalho Lima¹

Abstract

Objective: This study assessed the influence of breastfeeding and nutritional status of full-term infants on blood pressure at school age.

Subjects and Methods: This was a cross-sectional study nested in a cohort of 375 infants recruited at birth between 1993 and 1994 in the state of Pernambuco, Brazil. A sample of 213 8-year-old children had their blood pressure measured. A multivariate linear regression analysis was used to identify the influence of low birth weight and breastfeeding duration on blood pressure, adjusting for socioeconomic conditions, maternal nutritional status, eating habits, growth rate (0–6 months), and the children's anthropometry at 8 years.

Results: Mean values of children's blood pressure were significantly higher with lower duration of breastfeeding. Higher per capita family income, maternal body mass index and height, child's weight and length at birth, and child anthropometric dimensions at 8 years of age were associated with higher levels of blood pressure. The multivariate linear regression analysis showed that children who were breastfed for less than 40 days had higher systolic blood pressures, explaining 2.2% of its variation. Anthropometry at 8 years of age explained the higher variance in systolic blood pressure (12.6%) with emphasis on waist circumference (9.5%), followed by per capita income (3.2%) and maternal height (2.1%). Birth weight and length had no influence on blood pressure levels in this age group.

Conclusions: Children's waist circumference, duration of breastfeeding, socioeconomic conditions, and maternal nutritional status influenced blood pressure levels of schoolchildren born full term, rather than low birth weight.

Introduction

UNDERNUTRITION DURING THE PERIOD of fetal maturation may program the development of diseases in adulthood, such as hypertension, coronary heart disease, type 2 diabetes, cerebrovascular accident, dyslipidemia, chronic kidney disease, and cancer.¹ Intrauterine growth restriction, especially when followed by excessive weight gain in children, is associated with an increased risk of chronic diseases.² This accentuated weight gain may be due to unhealthy feeding habits, especially in relation to the short duration of breastfeeding.³

Despite the numerous benefits of breastfeeding for both mother and child, its exclusive duration during the first 6 months of life is still unsatisfactory in the global context. The negative economic impact associated with incomplete breastfeeding increases costs in public health, and resources should be invested in improving the practice of breastfeeding.³ The early introduction of infant formulas with high

sodium levels may overload an immature renal system and aggravate the biological risk of low birth weight.⁴

The physiopathology of changes in blood pressure attributed to excess body weight in children has not been totally elucidated. An excess of abdominal fat is associated with the development of chronic diseases, especially cardiovascular. Central adiposity and insulin resistance have been indicated as determinants of blood pressure levels in childhood.⁵ Hypertension is an important risk factor for cardiovascular diseases, which represent one of the principal causes of mortality and morbidity worldwide.⁶ Because of the potential for serious complications, hypertension has become a major public health problem.⁷

In northeastern Brazil, a birth cohort that has been monitored since 1993 has provided the opportunity to conduct the present study aiming to assess the influence of breastfeeding on blood pressure at school age of infants born full-term with low and appropriate birth weight.

¹Mother and Child and ²Nutrition Departments, Federal University of Pernambuco, Recife, Pernambuco, Brazil.

Subjects and Methods

Study location and population

The study was conducted in five small towns in the interior of Pernambuco State (Água Preta, Catende, Joaquim Nabuco, Ribeirão, and Palmares), northeast Brazil. The locations are situated approximately 130 km from Recife, the state capital, have a population of approximately 190,653 inhabitants, and share similar health conditions and geographic, socioeconomic, and demographic aspects. The main economic activity of the region is linked to agriculture, especially the production and processing of sugar cane. Owing to its seasonal nature, this form of employment has its peak periods and slack periods, which therefore contribute to the high unemployment rates during the off-season. During the recruitment period of this cohort, regional illiteracy rates among women were approximately 30%, the prevalence of low birth weight was 9%, and the infant mortality rate was 85 per 1,000 live births.⁸

Birth cohort

The original cohort consisted of 375 full-term infants (163 with low birth weight and 212 with appropriate birth weight), which aimed to monitor the growth and development during the first 2 years of life. The cohort was made up of newborn infants recruited during the first 24 hours of life in six maternity units located in the geographical region of the study between 1993 and 1994.⁸

The low-birth-weight group consisted of infants weighing from 1,800 to 2,499 g, and the appropriate-birth-weight group ranged from 3,000 to 3,499 g. The low-birth-weight infant was matched for sex with the next two eligible appropriate-birth-weight infants. The study included infants from families with a monthly income of up to three regional minimum salaries, which at the time was equivalent to around US\$70, who had expressed their intention to remain living in the area of the study. Exclusion criteria were multiple births, prematurity, newborn infants with clinical features of congenital infections, genetic syndromes, and congenital malformations, and the need for intensive treatment during the immediate neonatal period.⁸

At recruitment mothers were interviewed by a research assistant using a structured questionnaire to collect information on socioeconomic, environmental, demographic, and maternal reproductive conditions. Weight and length were measured during the first 24 hours of life, and the nutritional status was classified using the Rohrer ponderal index. Weight and length were reassessed at 6 months of life.

Follow-up data collection

In the year 2001, an active search using the residential address and date of birth was undertaken by two research assistants for the infants who had originally taken part in the cohort. When families were not encountered, the search continued with information provided by relatives, neighbors, or schools, or calls were made on local radio stations.

The sample consisted of 213 children: 86 (40.4%) with low birth weight and 127 (59.6%) with appropriate birth weight. Of the total, 88 (41%) were male, and 125 (59%) were female. The percentage of losses in the cohort at this stage was 43.2%, with 15.4% due to death (17 in the group with low birth weight and eight in the group with appropriate birth weight), 26% because of migration, and 58.6% were not located.

The frequency of total breastfeeding (breastfeeding, even if consuming other types of food, milk, water, or tea) was collected weekly from birth until 6 months of life.⁸

Maternal socioeconomic and environmental variables

The socioeconomic variables considered were per capita family income, maternal years of schooling, family size, smoking during gestation, and household possessions and facilities such as refrigerator ownership, water supply, and type of toilet and waste collection.

Growth rate

The SD score (SDS) values for infants' weight and length at birth and at 6 months were calculated using the median values of the World Health Organization standard reference growth curve (Anthro software, 2007). An SDS of the difference between weight and length at 6 months and at birth greater than 0.67 (SDS) was taken to indicate catch-up growth.⁹

Child and mother blood pressure

At 8 years of age children's blood pressure was measured on the right arm, using a standard mercury column sphygmomanometer and an inflatable cuff (18×9 cm or 25×12 cm as appropriate). The measurements were taken in duplicate, and mean values were considered after a resting period of 5 minutes conducted by the same trained researcher. The tables recommended by the National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents were used according to the sex, age, and height percentile of each child.¹⁰

Maternal hypertension was defined as a systolic blood pressure of ≥140 mm Hg and/or a diastolic blood pressure of ≥90 mm Hg according to the guidelines of the Seventh Report of the Joint National Committee.⁶

Child and mother anthropometry

The anthropometric measurements of the children, at 8 years of age, and mothers were conducted by one previously trained researcher. Mother and child's weights were measured on digital scales (model E-150/3P; Filizola, São Paulo, Brazil), previously calibrated and with a capacity of 150 kg, recording weight with a precision of within 0.1 kg. Height was measured with the aid of a sliding-scale stadiometer (Leicester height measure; Child Growth Foundation, London, United Kingdom), with a precision of 0.1 cm, according to World Health Organization recommendations. The mother's and child's height measurements were taken in triplicate, and the average of the three values was used for the final result. Children's SDS values for weight-for-age and height-for-age and body mass index (BMI)-for-age were calculated using AnthroPlus software (2007). The BMI of the mother was calculated with the following expression: weight (in kg)/height² (in m).¹¹

Waist circumference was obtained using a nonstretchable tape measure (Lasso; Child Growth Foundation), with children in their underwear, standing upright with a relaxed abdomen, arms by their sides, feet together, and with the weight evenly distributed on both feet. Following this, the examiner would mark the midpoint between the bottom edge of the last rib and the ipsilateral iliac crest. A nonstretchable tape measure was then circled around the abdomen between

these two points, approximately at the level of the umbilicus.¹² These measurements were taken in triplicate for all individuals in the sample, using the average of the three recorded values for analysis of the data. The cutoff point used was the 90th percentile for age and sex.¹³

Data analysis and processing

Data were collected using questionnaires with closed and precoded questions and checked daily. The obtained information was stored in a database in Epi Info™ (version 6.04; Centers for Disease Control and Prevention, Atlanta, GA). The statistical analysis was conducted with Statistical Package for the Social Sciences software (version 12.0 for Windows; SPSS Inc., Chicago, IL). The dependent variable, child blood pressure, was treated as a continuous variable. Student's *t* test and the analysis of variance test were used to compare the differences of mean values in the bivariate analyses, and the χ^2 test was used to verify the association between categorical variables. The statistical significance considered was a *p* value of ≤ 0.05 . The multiple linear regression analysis was performed using a hierarchical model of input variables, with the aim of assessing the impact of explanatory variables on the levels of child systolic and diastolic blood pressure. Among the ex-

planatory variables, maternal height was treated as a continuous variable, and the other variables were dichotomous. The correlation matrix indicated that there was no multicollinearity between the variables because the Pearson correlation coefficients were < 0.48 . In relation to child nutritional status at birth, body proportionality was not selected for diastolic blood pressure analysis as it presented multicollinearity with weight. All variables with $p < 0.20$ in the bivariate analysis were selected for inclusion in the regression models, except for per capita family income in the diastolic blood pressure analysis, as it is a variable of interest for the study.

A block modeling process was adopted, and the variables that presented $p < 0.20$ in each model were retained, even if they lost their significance with the introduction of other variables in the next models. The modeling process used the enter method for all variables. The initial block was made up of per capita family income. In the second model maternal variables related to nutritional status (BMI and height) were offered. The variable related to nutritional status at birth was introduced into the third block. The fourth block contained breastfeeding, and the fifth block introduced variables related to nutritional status at the age of 8 years. The residuals of the models for the levels of systolic and diastolic blood pressure were analyzed and presented no abnormalities.

TABLE 1. CHARACTERISTICS OF THE SAMPLE ($N=213$) AT 8 YEARS OF AGE IN RELATION TO SOCIOECONOMIC, MATERNAL, AND CHILDREN'S VARIABLES, ACCORDING TO BIRTH WEIGHT

Variable	n	%	Low birth weight [n=86 (%)]	Appropriate birth weight [n=127 (%)]	p
Per capita family income (MW)					0.07
<0.50	145	68.0	65 (75.6)	80 (63.0)	
≥ 0.50	68	32.0	21 (24.4)	47 (37.0)	
Maternal schooling (years)					0.54
0–4	96	45.1	42 (48.8)	54 (42.5)	
5–8	70	32.8	28 (32.6)	42 (33.1)	
≥ 9	47	22.1	16 (18.6)	31 (24.4)	
Kind of floor					0.24
Cement or earth	158	74.2	68 (79.1)	90 (70.9)	
Ceramic	55	25.8	18 (20.9)	37 (29.1)	
Water supply					0.93
Not piped	19	8.9	8 (9.3)	11 (8.7)	
Piped	194	91.1	78 (90.7)	116 (91.3)	
Toilet					0.38
Latrine	68	31.9	24 (27.9)	44 (34.6)	
Flush	145	68.1	62 (72.1)	83 (65.4)	
Garbage collection					0.70
No	31	14.6	14 (16.3)	17 (13.4)	
Yes	182	85.4	72 (83.7)	110 (86.6)	
Refrigerator					0.20
No	51	23.9	25 (29.1)	26 (20.5)	
Yes	162	76.1	61 (70.9)	101 (79.5)	
Smoked during gestation					0.79
Yes	39	18.3	17 (19.8)	22 (17.3)	
No	174	81.7	69 (80.2)	105 (82.7)	
Maternal height (cm)					0.11
<150	49	23.0	25 (29.1)	24 (18.9)	
≥ 150	164	77.0	61 (70.9)	103 (81.1)	
Maternal BMI (kg/m^2) ^a					<0.001
<25	90	49.7	47 (67.1)	43 (38.7)	
≥ 25	91	50.3	23 (32.9)	68 (61.3)	

^an = 181 (32 mothers failed to come to the interview).

BMI, body mass index; MW, minimum wage (equivalent to US\$70).

Ethical aspects

Free, informed consent was obtained from parents or those legally responsible for the children. Sick children were referred to the local health center. The study was approved by the Research Ethics Committees at the Centro de Ciências da Saúde at the Universidade Federal de Pernambuco (registration number 016/2001-CEP/CCS) and at the London School of Hygiene and Tropical Medicine.

Results

The frequency of high systolic blood pressure in children was 8% of the sample (17 of 213), whereas higher levels of diastolic blood pressure were observed in 4.2% (nine of 213); there was no simultaneous increase in systolic and diastolic blood pressure.

The characteristics of the sample at 8 years of age are shown in Table 1. It was observed that approximately two-

thirds of the sample received less than 0.5 of a minimum salary per capita and that around 45% of all mothers had attended school for less than 5 years. In relation to basic sanitation, around 9% of the sample consumed untreated water, and almost one-third did not have toilet facilities connected to the sewage system. Smoking was found in 18% during gestation. About one-fourth of the mothers were shorter than 150 cm, and 50% were overweight. There were no statistically significant differences for most of the variables between the two groups of children, except in relation to the BMI of the mother.

Table 2 shows significantly higher mean systolic blood pressure for children living in families with a per capita family income of ≥ 0.50 minimum salary and whose mothers had height of ≥ 150 cm and BMI of ≥ 25 kg/m². In relation to diastolic blood pressure only a statistically higher mean value was observed for children whose mothers had a BMI of ≥ 25 kg/m².

TABLE 2. MEAN VALUES OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE AT THE AGE OF 8 YEARS (N=213), ACCORDING TO SOCIOECONOMIC CONDITIONS AND MATERNAL CHARACTERISTICS

Variable	n	%	SBP (mm Hg)	p	DBP (mm Hg)	p
Socioeconomic						
Per capita family income (MW)				0.02		0.27
<0.50	145	68.0	94.8		48.3	
≥ 0.50	68	32.0	98.1		44.8	
Maternal schooling (years)				0.42		0.92
0–4	96	45.1	95.2		42.3	
5–8	70	32.8	95.6		44.6	
≥ 9	47	22.1	97.5		41.0	
Kind of floor				0.007		0.06
Cement or earth	158	74.2	98.9		46.5	
Ceramic	55	25.8	94.8		41.9	
Water supply				0.38		0.64
Not piped	19	8.9	95.7		42.9	
Piped	194	91.1	97.7		44.7	
Toilet				0.88		0.39
Latrine	68	31.9	96.0		42.4	
Flush	145	68.1	95.7		44.4	
Garbage collection				0.50		0.65
No	31	14.6	95.7		43.3	
Yes	182	85.4	97.0		41.9	
Refrigerator				0.12		0.91
No	51	23.9	96.4		43.1	
Yes	162	76.1	94.0		42.9	
Maternal						
Smoking during gestation				0.24		0.30
Yes	39	18.3	94.2		40.8	
No	174	81.7	96.2		43.6	
Height (cm)				0.005		0.20
<150	49	23.0	92.4		40.6	
≥ 150	164	77.0	96.9		43.8	
BMI (kg/m ²) ^a				0.05		0.01
<25	90	49.7	94.8		40.9	
≥ 25	91	50.3	97.6		46.9	
SBP (mm Hg) ^a				0.73		0.83
<140	157	86.7	96.0		44.0	
≥ 140	24	13.2	96.8		43.3	
DBP (mm Hg) ^a				0.34		0.24
<90	144	79.5	95.8		43.2	
≥ 90	37	20.4	97.5		46.6	

^an=181 (32 mothers failed to come to the interview)

BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure; MW, minimum wage (equivalent to US\$70).

There were significant higher mean values of systolic blood pressure for children who were breastfed for <40 days, had a birth length of ≥ 46.5 cm, and higher measurements of waist circumference and height- and BMI-for-age at 8 years (Table 3). For diastolic blood pressure higher mean values were found for those born with weight from 3,000 to 3,499 g and with higher waist circumference and height-for-age at 8 years.

The results of the multivariable linear regression analysis are presented in Tables 4 and 5. Table 4 shows that waist circumference at 8 years was the variable that best explained the variation of systolic blood pressure (9.5%), followed by per capita family income (3.2%), breastfeeding (2.2%), and maternal height (2.1%). Maternal BMI was the only variable that significantly explained (3.8% of) the variation in children's diastolic blood pressure (Table 5).

Discussion

This study has several strengths. It is a cohort study that has a database on socioeconomic and family environmental conditions, maternal reproductive history, gestational age, and birth weight and length and that also adopted a rigorous

methodology for data collection. The main limitation of this study is related to the population losses at 8 years after recruitment. This problem is often observed in cohort studies, especially in developing countries. The present study was developed in a poor region in northeast Brazil, where unemployment rates are high, and the population often migrates to the south and southeast of the country in search of better living conditions. The presence of a possible selection bias may have occurred in the sense of underestimating the negative effects of individuals living in the very worst socioeconomic conditions. In this cohort it was observed that regardless of birth weight, a higher percentage of losses occurred among children who presented the worst socioeconomic conditions, and these differences were not statistically significant.¹⁴

In the present study, infants who were breastfed for <40 days showed a mean increase of around 4.0 mm Hg in blood pressure levels. Although such an increase does not seem relevant when analyzed on an individual level, it represents a great difference in the population as a whole.

A cohort study conducted in the United Kingdom observed a significant reduction in systolic blood pressure for children

TABLE 3. MEAN VALUES OF SYSTOLIC AND DIASTOLIC BLOOD PRESSURE AT THE AGE OF 8 YEARS ($N=213$), ACCORDING TO CHARACTERISTICS AT BIRTH, FROM BIRTH TO 6 MONTHS, AND AT 8 YEARS OF AGE

Variable	n	%	Mean SBP (mm Hg)	p	Mean DBP (mm Hg)	p
At birth						
Weight (g)				0.24		0.04
<2,500	86	40.4	94.9		40.4	
3,000–3,499	127	59.6	96.1		44.9	
Length (cm)				0.04		0.19
<46.5	51	23.9	93.5		40.6	
≥ 46.5	162	76.1	96.6		43.9	
Body proportion ^a				0.29		0.08
LBW stunted	30	14.4	93.2		39.4	
LBW wasted	51	24.5	95.4		40.0	
ABW	127	61.1	96.5		44.9	
Birth to 6 months						
Total breastfeeding (days) ^b				0.007		0.06
<40	51	27.5	99.3		46.6	
≥ 40	136	72.5	94.8		41.5	
Weight gain (z-score) ^c				0.47		0.55
≤ 0.67	97	58.1	95.2		44.1	
>0.67	70	41.9	97.0		41.5	
Length gain (z-score) ^c				0.89		0.34
≤ 0.67	125	74.8	95.9		44.0	
>0.67	42	25.2	96.4		39.9	
At 8 years						
Waist circumference (cm)				<0.001		0.002
>75	7	3.3	113.0		57.1	
≤ 75	206	96.7	95.3		42.6	
Height-for-age (z-score)				0.04		0.07
<-2	11	5.2	90.1		34.7	
≥ -2	202	94.8	96.2		43.6	
BMI-for-age (z-score)				<0.001		0.11
<1	186	86.3	94.5		42.4	
≥ 1	27	12.7	105.0		47.6	

^a $n=208$ (five children were neither wasted nor stunted).

^b $n=187$ (data on breastfeeding unavailable for 26 children).

^c $n=167$ (children examined at birth, at 6 months, and at 8 years of age).

ABW, appropriate birth weight; BMI, body mass index; DBP, diastolic blood pressure; LBW, low birth weight; SBP, systolic blood pressure.

TABLE 4. LINEAR REGRESSION MODEL OF FACTORS ASSOCIATED WITH LEVELS OF SYSTOLIC BLOOD PRESSURE IN CHILDREN AT 8 YEARS OF AGE

Variable ^a	β not adjusted ^b	95% CI (mm Hg)	β adjusted	95% CI (mm Hg)	R ² (%) ^c
Model 1					
Per capita family income (MW) ≥ 0.50	3.88*	0.76, 7.00	3.88*	0.76, 7.00	3.2 (3.2)
Model 2					
Maternal height (10 cm)	2.8*	0.04, 0.52	2.5*	0.09, 0.49	2.1 (5.3)
Model 3					
Birth length (cm) ≥ 46.5	3.48*	0.21, 6.76	2.56	-0.71, 5.86	1.2 (6.5)
Model 4					
Total breastfeeding (days) < 40	4.49 [†]	1.26, 7.72	3.46*	0.21, 6.71	2.2 (8.7)
Model 5					
Waist circumference (cm) > 75	17.65 [‡]	10.36, 24.94	8.56*	0.46, 16.7	9.5 (18.2)
Height-for-age (z-score) ≥ -2	5.96	-0.83, 12.76	4.99	-1.31, 11.3	1.2 (19.4)
BMI-for-age (z-score) ≥ 1	11.49 [‡]	7.51, 15.46	7.59 [†]	2.93, 12.3	1.9 (21.3)

^aReference categories for the categorized variables were as follows: per capita family income, < 0.50 minimum wage (MW) (equivalent to US\$70); birth length, < 46.5 cm; total breastfeeding, ≥ 40 days; waist circumference, ≤ 75 cm; height-for-age (z-scores), < -2 ; and body mass index (BMI)-for-age (z-scores), < 1 .

^bNonstandardized regression coefficient.

^cCoefficient of determination.

Levels of significance: * $p \leq 0.05$, [†] $p \leq 0.01$, [‡] $p \leq 0.001$.

CI, confidence interval.

with any breastfeeding for at least 6 months when assessed at the age of 7 years.¹⁵ Similar results were observed when assessing preschool children who had been breastfed until at least 6 months. These children had lower systolic blood pressure than those who were never breastfed or were breastfed for a shorter duration.¹⁶

The beneficial effects of maternal milk on the levels of blood pressure may be explained by a high concentration of long-chain polyunsaturated fatty acids, which are important structural components of the cell membranes, including the vascular endothelium, which is responsible for a continuous synthesis of nitric oxide.¹⁷ This gas acts on vascular homeostasis, as a potent endogenous vasodilator, and protects the

vessel from injurious consequences of platelets and cells circulating in blood.^{18,19} A change in the endothelial function is an important factor for the development of cardiovascular diseases, particularly the decrease in circulating levels of nitric oxide leading to vasoconstriction and platelet aggregation.¹⁹⁻²¹

Intrauterine growth restriction may lead to changes in renal morphology and physiopathology. Studies have demonstrated that children with a low nephron number tend to suffer changes in postnatal renal function, and consequently a fall in the glomerular filtration rate, and an accumulation of fluid and hypertension in adulthood. In addition, vascular compliance in children who suffer from fetal malnutrition also

TABLE 5. LINEAR REGRESSION MODEL OF FACTORS ASSOCIATED WITH LEVELS OF DIASTOLIC BLOOD PRESSURE IN CHILDREN AT 8 YEARS OF AGE

Variable ^a	β not adjusted ^b	95% CI (mm Hg)	β adjusted	95% CI (mm Hg)	R ² (%) ^c
Model 1					
Per capita family income (MW) > 0.50	1.41	-4.19, 7.00	1.41	-4.19, 7.00	0.2 (0.20)
Model 2					
Maternal BMI (kg/m ²) ≥ 25	6.45 [†]	1.42, 11.48	6.41*	1.37, 11.46	3.8 (4.0)
Model 3					
Birth weight (g) 3,000-3,499	4.61	-0.52, 9.75	3.00	-2.32, 8.32	0.8 (4.8)
Model 4					
Total breastfeeding (days) < 40	4.46	-1.20, 10.12	3.84	-1.82, 9.50	1.1 (5.9)
Model 5					
Waist circumference (cm) > 75	13.77*	1.42, 26.12	10.38 [§]	-2.21, 22.97	1.9 (7.8)
Height-for-age (z-score) ≥ -2	11.51*	0.53, 22.49	9.93 [§]	-1.01, 20.88	1.6 (9.4)

^aReference categories for the categorized variables were as follows: per capita family income, < 0.50 minimum wage (MW) (equivalent to US\$70); maternal body mass index (BMI) (kg/m²), < 25 ; birth weight, $< 2,500$ g; total breastfeeding, ≥ 40 days; waist circumference, ≤ 75 cm; and height-for-age (z-scores), < -2 .

^bNonstandardized regression coefficient.

^cCoefficient of determination.

Levels of significance: [§] $p \leq 0.10$, * $p \leq 0.05$, [†] $p \leq 0.01$.

CI, confidence interval.

appears to be lower, leading to a decreased capacity of vasodilatation as a compensating mechanism, which seems to remain until adulthood.²²

The introduction of formula in the neonatal period for infants with intrauterine growth restriction, as a total or partial replacement for breastfeeding, provides a sodium content three times greater than those receiving exclusive breastfeeding.^{23,24} In addition, it may also be observed that low-birth-weight infants present vascular endothelial dysfunction, and this situation can be aggravated by a short duration of breastfeeding, possibly increasing the biological risks associated with low birth weight.

In the studied sample, an association between low birth weight and blood pressure levels at the age of 8 years, as well as with growth rates from birth to 6 months, was not observed. One hypothesis for this is that school age is probably not the ideal interval to observe this association.

The occurrence of rapid weight gain during the first 2 years of life in low-birth-weight infants has short-term benefits, with lower rates of hospitalization and mortality; however, there is an increased risk of developing obesity and chronic diseases in adulthood, including hypertension, coronary heart disease, and diabetes.²⁵ In our study, waist circumference as a proxy of visceral fat was a factor that contributed the most in explaining the variations of systolic blood pressure levels. Similar findings were observed in a study conducted with 939 preschool children (3–6 years of age), which found an association of waist circumference with elevated blood pressure.²⁶

One curious fact observed in the present study is the lack of association between blood pressure levels at school age and maternal blood pressure, which could be explained by the natural history of hypertension; because most of the mothers in the study were young, there was not sufficient time for the onset of disease. However, a higher mean blood pressure was observed in children whose mothers were overweight/obese, probably because children and mothers share genetic factors, socioeconomic conditions, life styles, and inadequate eating habits. Therefore, maternal BMI may be considered a predictor for hypertension for these children in the future. The negative consequences of infant malnutrition have been highlighted on health and human capital in adulthood, focusing on the prevention of maternal and infant nutritional disorders as a long-term investment that would benefit future generations.⁷

In conclusion, a short duration of breastfeeding, visceral obesity, and maternal overweight showed a greater influence on blood pressure of schoolchildren born at term, rather than low birth weight and growth rate velocity. These findings are essential for the development of intervention strategies, by health policy makers and professionals responsible for attending and monitoring children and adolescents, in order to encourage a longer duration of breastfeeding, which can cause an important impact on the health and economy of the region.

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Address correspondence to:
Rosemary de Jesus Machado Amorim, PhD
Rua Xavier Marques, 209 Apt° 1101
Graças, Recife, PE, Brazil CEP 52050-230

E-mail: roseamorim@gmail.com