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ORIGINAL ARTICLE

Association of weight at birth in the development of overweight/obesity in schools aged from 5-9 years in Fortaleza, Ceara, Brazil

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Abstract

Introduction: Changes in the nutritional profile of the population in recent decades have led to an increase in obesity in adults and children. Birth weight may be a determinant of overweight/obesity risk and is considered a health indicator, which may influence the child's growth and development, also affecting health in adulthood. **Objective:** This study aims to check the association between birth weight and overweight/obesity in children aged 5 to 9 years. **Methods:** Observational and descriptive cross-sectional study with primary data on a sample of 500 schoolchildren aged 5 to 9 years, enrolled in public institutions in Fortaleza, CE. Primary data was collected with a structured form, family history and measures of weight and height at the time of the interview. Continuous variables were compared using non-parametric tests and categories of independent variables using chi-square and Fisher's exact test, with a p -value < 0.05 . **Results:** Both low weight (< 2.500 g) and weight over 3.500g were positively correlated with the presence of overweight/obesity, with 40.54% of those born with low weight and 52.9% of those born with weight over 3.500g were overweight/obese at school age ($p=0.001$). A statistically significant association was found with the lowest social class ($OR=3.51$, 95%CI: 1.60-7.69), with the highest per capita income ($OR=1.59$, 95%CI: 1.08-2.33) and with birth weight over 3.500g ($OR=2.55$, 95%CI: 1.67-3.90). **Conclusion:** This study demonstrated a statistically significant correlation between overweight/obesity and birth weight, corroborated by other studies that investigate the same association.

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INTRODUCTION

Changes in the nutritional profile of the population in recent decades have led to an increase in obesity and a reduction in malnutrition among adults and children. Birth weight can be a determinant of risk of overweight/obesity, being related, among other factors, to intrauterine growth and the nutritional status of the newborn¹.

The assessment of nutritional status has become an increasingly important aspect in the establishment of risk situations, in the nutritional diagnosis and in the planning of health promotion and disease prevention actions. Its importance is recognized both in primary care, to monitor the growth and health of children and adolescents, and in the early detection of nutritional disorders, whether malnutrition or obesity².

Among the various factors associated with overweight/obesity in childhood, birth weight appears with great frequency. Furthermore, the body mass index (BMI), also including that of both parents, family income and the type of school the child attends can contribute to childhood overweight/obesity^{3,4}. According to a survey by the Brazilian Institute of Geography and Statistics (IBGE), 1 in 3 children in Brazil is overweight and about 9.5% of those aged between 5 and 10 years are obese⁵.

Birth weight is also related to maternal biological risks, such as gestational weight gain, the mother's BMI prior to pregnancy and the presence of previous diabetes *mellitus*, equating findings from Brazilian studies with those from other countries⁶.

Starting in 1986, in a series of pioneering studies by David Barker and colleagues, an association was observed between low birth weight, characterized by birth weight below 2,500 g, and the presence of overweight/obesity in childhood and adolescence. and in adult life, in addition to a higher risk of other cardiovascular diseases in the future. Children with low birth weight are described as having reduced muscle tissue and a high number of adipocytes. This phenotype persists beyond the prenatal period and may be associated with increased central adiposity in childhood, leading to a greater risk of arterial hypertension and cardiovascular disease in adults. In addition to these factors, a relationship between low birth weight and gestational age, maternal age, per capita income, maternal education and hospitalization during the gestational period was evidenced. High birth weight, however, characterized by birth weight equal to or greater than 4,000 g, has also been associated with the development of excess body weight in childhood and adolescence^{6,7,8,9}.

Results that oppose the evidence of a significant association with high birth weight, however, have also

been described, especially in studies carried out in countries with economic progression. Knowing that low birth weight is more prevalent in impoverished and developing populations, while high birth weight presents increased numbers in some developed countries, the socioeconomic level of the evaluated samples has been pointed out as an important confounding bias in the association. of overweight/obese birth weight. In the city of Diamantina-MG, a study showed that the family socioeconomic pattern influences the BMI by age, while the age group interferes with weight/height indexes by age. For this reason, the association still seems inconsistent in studies carried out with children from rising countries^{6,9,10}.

There are few studies based on the Brazilian pediatric population, carried out in the South, Southeast and Midwest regions. The Northeast region, which has a high number of children with low birth weight and marked socioeconomic differences compared to other regions, does not present relevant studies. Due to the nutritional transition, the Northeast is experiencing an increasing prevalence of overweight and obesity, which may expand the importance of high birth weight in the health of the future population^{11,13,14}.

Obesity has negative impacts in childhood and later in adulthood, leading to hypertension, early markers of cardiovascular disease, insulin resistance, and adverse psychological effects. Based on the above, it is important to consolidate the relationship between low birth weight and high birth weight with overweight/obesity in childhood, with a focus on developing preventive measures in the context of maternal and child health¹⁵.

Thus, the objective of this study was to correlate the birth weight of a group of children in a municipality in Ceará, as well as their socioeconomic conditions, with the occurrence of overweight/obesity, seeking to evaluate this association as a risk factor for overweight/obesity. in the childhood.

METHODOLOGY

This is an observational and descriptive study, of the transversal type, carried out from March /2016 to March /2017. It was conducted in the city of Fortaleza - Ceará, which is divided into six regions, with each region managed by a Regional Executive Secretariat (SER). The study sample consisted of 500 school children, of both sexes, aged between 5 and 9 years, 11 months and 29 days from selected public schools in Regional IV, who parents agreed to include in the study, signing the Term of Free and E clarified Consent.

Regional IV corresponds to the central region of the city, being the only one of the regional ones that borders

all the others in the city, covering 19 neighborhoods. Regional IV public school students are distributed in a federal school, 26 state schools, 28 municipal schools and 103 private schools. Public schools were designed in the city of Fortaleza through the School Registers of the Municipal and State Department of Education. By means of a lottery, public schools linked to SER IV were selected. In these schools, randomly, by drawing lots, the children were invited to the study.

Comprising 11 Basic Health Units (UBS), it has a municipal hospital, which is the second largest emergency in Ceará and the largest Pediatric Reference Hospital in Ceará, the Albert Sabin Children's Hospital (HIAS). The Albert Sabin Children's Hospital was the reference place to which the children were referred after the draw in the schools, to carry out the necessary procedures during the research.

To calculate the sample size, the number of children from public schools in Region IV of Fortaleza and the incidence of dyslipidemias in childhood were considered, based on the I Guideline for the Prevention of Atherosclerosis in Childhood and Adolescence, the V Brazilian Guideline of Dyslipidemias and Prevention of Atherosclerosis. The prevalence of dyslipidemia was estimated at 35%. The segmental proportion by age group was calculated so that it was representative of all ages. The final sample size assumed a maximum margin of error of 3% and a confidence level of 95%. All children who had underlying chronic diseases, who were using any medication that interfered with the variables analyzed and who were on the Tanner sexual maturation scale at stage 2 or above were excluded.

With the approval of the Municipal Education Department of Fortaleza, the selected schools were visited to receive information about the research. Primary data were obtained by a previously trained interviewer, collected through an applied form, through family history reports by those responsible and through weight and height measurements taken at the time of the interview. The structured form applied gathered the following variables: identification (name, gender, school, year of education, date of birth, age, in complete years and months, number of inhabitants in the household, how many siblings he/she has and skin color; evaluation of the economic level according to the Brazilian Economic Classification Criteria; parents' education, with classification categorically in elementary, high school, higher education, complete or incomplete); delivery and birth conditions (birth weight, capurro/gestational age, head circumference, length); personal and family history (family history of risk of atherosclerosis, hypertension, dyslipidemia, diabetes and obesity; dietary assessment (quantitative and qualitative analysis of the diet through a food survey and assessment

of eating habits) and physical assessment (assessment of the level of physical activity of children by measuring the time of recreational inactivity with the measurement of the number of hours of leisure spent with television, electronic games and/or computer, per day, and the Leisure Physical Activity Questionnaire).

Regarding the anthropometric variables, the following procedures were performed: child weighing (weight measured in kg, measured on a Filizola digital anthropometric scale, adult type, standing, with 100g precision. The child was weighed in light clothes, without shoes and feet). juxtaposed, according to the standards recommended by the WHO 2007¹² and height verification (verified the child's height in centimeters, measured in a stadiometer, according to the standards recommended by the WHO 2007)¹². To calculate the BMI, the weight in kg over weight squared (kg/m^2) was calculated and, based on the measurements obtained, classified by the z-score tables of the WHO 2007¹² 116, with the following criteria by age and sex: Z-score < 2 = Thinness; Z score ≥ -2 and $< +1$ = Eutrophy; Z Score $\geq +1$ and $< +2$ = Overweight and Z Score $\geq +2$ = Obesity.

To characterize the study population, a bivariate analysis was performed with parametric and non-parametric tests depending on the specificities of the distributions and measurement units of the variables. The distributions of continuous variables were described using the mean and standard deviation. And the categorical variables by the relative frequency of the categories. Univariate analyzes were performed by comparing proportions using the Chi-square test, when the lowest expected value of the cells in the contingency table was greater than five. In other situations, Fisher's Exact Test was applied. There was a selection of independent variables, composing the multiple logistic regression models.

For data processing and analysis, STATA 13.0 software was used. The forms were reviewed, then typed, validation and consistency reports were performed for error detection and correction. The research protocol was submitted for approval by the Ethics Committee for the Analysis of Research Projects – CAPPesq – of the Clinical Board of Hospital das Clínicas and of the Faculty of Medicine of the University of São Paulo, being approved in a session of 08/08/08. 2012 under research protocol with registration No. 194/12.

RESULTS

500 children aged 5 to 9 years, 11 months and 29 days participated in the study, who were categorized by age groups of 5, 6, 7, 8 and 9 years, being, respectively, 117 children aged 5 years (23.4%); 66 children aged 6 years (13.2%); 129 children

aged 7 years (25.8%); 100 children aged 8 years (20%); and 88 children aged 9 years (17.6%). 260 children were female (52%) and 240 children were male (48%) (Table 1).

Regarding race, it was observed that the vast majority was brown (72.8%), followed by white (19.6%), and a black (6.6%) and indigenous (1.0%) minority.

The children's schooling is shown in Table 1. Regarding the assessment of the mother's level of education, 38.4% had incomplete elementary school, 30.2% had completed elementary or incomplete high school, and 26.8% had even incomplete higher education.

According to the Brazil Criterion of division by social classes, it was observed that the vast majority of participants were in classes C1 and C2 (middle and lower middle classes), around 74.8% of the sample¹⁴.

Regarding the type of housing, 63.8% had their own house. The mean number of siblings was 1.9 (± 1.4) sibling per child. The average number of people living in the same household as the child who participated in the study was 4.4 (± 1.3) people/household. During the interview, 15 participants did not want to inform their income for various reasons, and this information was absent for them. The average monthly income was BRL 1,136.30 (± 617.63), ranging from a minimum of BRL 100.00 to BRL 4990.00. The average per capita income was R\$ 267.69 (± 146.64). In the division of per capita income by quartile, it was observed that 50.52% had per capita income in the 1st and 2nd quartile, and 49.48% had per capita income in the 3rd and 4th quartile.

Regarding birth data, the mean gestational age was 38.5 (± 1.6) weeks, with 25 children (5.0%) born at less than 37 weeks, 466 children (91.36%) were born between 37 and 41 weeks and 9 children (1.8%) were born at 42 weeks or more. Regarding birth weight, the mean was 3,240.7g ($\pm 0,526$); and the weight ranges had the following distribution: 37 children (7.4%) had a birth weight of less than 2500g, 325 children (65%) were born weighing between 2500g and 3500g and 138 (27.6%) were born with weight greater than 3500g (Table 2).

It was observed in the study that 295 (59%) children were eutrophic, 134 (26.8%) were overweight, 60 (12%) were obese and 5 (1%) children were severely obese, according to the BMI classification by the Z score. Overweight, obesity and severe obesity added up to 199 children (39.8% of participants) (Table 3).

It was evidenced that both low weight (<2,500g) and high weight (>3,500g) positively correlated with the presence of overweight/obesity in the children of the study, with 40.54% of those who were born with low weight and 52.9% of those who were born with high weight were overweight/obese at school age ($p = 0.001$), as seen in Table 3.

In a multivariate analysis for overweight/obesity, in Table 4, it is observed that there was a statistically significant association with the lowest social class (OR = 3.51; 95%CI: 1.60 – 7.69), with *per capita income* higher (OR = 1.59; 95%CI: 1.08 – 2.33) and with high birth weight (>3,500g) (OR = 2.55; 95%CI: 1.67 – 3.90).

Table 1. Sociodemographic characterization in a sample of 500 school children aged 5 to 9 years in Fortaleza, CE, Brazil.

N=500 (%)	
Age	
5 years	117 (23.4%)
6 years	66 (13.2%)
7 years	129 (25.8%)
8 years	100 (20%)
9 anos	88 (17.6%)
Sex	
Feminine	260 (52%)
Male	240 (48%)
Breed	
White	98 (19.6%)
brown	364 (72.8%)
black	33 (6.6%)
Indian	5 (1%)
Child's education	
Infant V	120 (24%)
1 st year _	84 (16.8%)
2 nd year _	134 (26.8%)
3 rd year _	94 (18.8%)
4 th year	68 (13.6%)
Social class	
B1	6 (1.2%)
B2	51 (10.2%)
C1	184 (36.8%)
C2	190 (38%)
D	67 (13.4%)
E	2 (0.4%)
AND Housing Type	
Leased	181 (36.2%)
own	319 (63.8%)
Average income per capita¹	
Q1/Q2 - BRL 24.00 - BRL 230.00	245 (50.52)
Q3/Q4 - BRL 231.00 - BRL 1000.00	240 (49.48)
Maternal Instruction	
Illiterate/Infant. incomp	19 (3.8%)
Children Compl/Fund. incomplete	192 (38.4%)
Fund Complete/Average Incomplete	151 (30.2%)
Medium Comp/Super. incomplete	134 (26.8%)
Graduated	4 (0.8%)

¹ Per capita income by value quartile - N = 485

DISCUSSION

This study was the first in the State of Ceará carried out with schoolchildren aged between 5 and 9 years old

Table 2. Data on birth, gestational age and birth weight in a sample of 500 school children aged 5 to 9 years in Fortaleza, CE, Brazil.

N=500 (%)	
Gestational Age¹	
< 37 weeks	25 (5%)
37 weeks to 41 weeks	466 (91.36%)
> 41 weeks	9 (1.8%)
birth weight²	
<2.500g	37 (7.4%)
2.500g a 3.500g	325 (65%)
>3.500g	138 (27.6%)

¹Gestational Age categorized as < 37 weeks (preterm); between 37 weeks to 41 weeks (term) and > 41 weeks (post-term); ²Birth weight categorized as < 2500g (low weight); 2500g to 3500g (reference weight) and >3500g (high weight).

from public institutions in Regional IV of the city of Fortaleza, totaling 500 participants, representing 0.57% of the total age group at the study site. according to IBGE. The distribution by sex, age group and race was equivalent to the IBGE data, demonstrating sample balance¹⁷.

Regarding the children's schooling, there was an adequacy to the expected school level for each age group, without considerable delays. The maternal education level showed that the majority had some level of education, with 30.2% having not yet completed high school and 27.2% having completed high school or higher. Only 3.8% of the children's mothers were illiterate.

It was shown that the majority of participants fell into the social levels C1 and C2 according to the Brazil Criterion, corresponding to the middle and lower middle classes. According to ABEP, in 2016, Fortaleza had 15% of the population in class C1 and 26.1% in class C2, corresponding to 41.1% of the population classified as medium and low-middle, as observed in study¹⁶.

The average monthly income was R\$1,136.30 (±617.63), approaching the data published by the Brazil Criteria for the socioeconomic stratum C2, estimated at R\$1,625.00 monthly¹⁶.

The association between socioeconomic conditions and their consequences for weight in children is controversial. Income and education are associated with food choice and availability. Economically disadvantaged families are more susceptible to the lack of certain inputs, which leads to compensatory practices, such as the increased consumption of low-cost products, generally high in calories and with low nutrient content. Although several studies associate such susceptibility with excess weight^{18,19}, other studies have not demonstrated such an association^{20,21,22}.

A cross-sectional study published in 2016, which demonstrated the factors associated with body mass index (BMI) in Brazilian children based on data from the Demographic and Health Survey of Children and Women (PNDS) between 2006 and 2007, showed that the conditions socioeconomic factors positively influenced the increase in BMI in children in 82.9% of the studied sample. It was also observed that 14.6% was mediated by the intake of obesogenic foods, indicating that, as the socioeconomic level increases, food choices can lead to an increase in the intake of unhealthy products, predictors of an increase in childhood BMI^{22,23}.

The evaluation of the birth data of the study participants showed that the mean gestational age was 38.5 (±1.6) weeks and that most children were born with an adequate gestational age (91.36%), with a frequency of deliveries born with less than 37 weeks of only 5%. Birth weight had a mean of 3,240.7g (±0,526); with a frequency of low birth weight of 7.4% and of weight above 3,500 of 27.6%. In Brazil, population studies show that the average birth weight is 3,168g and low weight was found in 8.5% of births in the country, with regional variations, with 9.2% in the Southeast and 7.6% in the North. %²⁴.

Table 3. Anthropometric profile of BMI Z score and association of overweight/obesity with birth weight in a sample of 500 school children aged 5 to 9 years in Fortaleza, CE, Brazil.

N=500 (%)				
Z score BMI¹				
thinness				6 (1.2%)
eutrophy				295 (59%)
overweight				134 (26.8%)
Obesity				60 (12%)
severe obesity				5 (1%)
Birth Weight²				
	<2,500	2,500-3500	>3,500	p-value
	n=37 (%)	n=325 (%)	n=138 (%)	
Overweight/Obesity				
-Absence	22 (59.46)	214 (65.85)	65 (47.1)	
-Presence	15 (40.54)	111 (34.15)	73 (52.9)	0.001

¹Birth weight: categorized into underweight (<2500g), normal birth weight (2500g to 3500g) and over weight (>3500g); ²BMI: body mass index calculated by weight (kg) over height (m) squared (kg/m²) and later classified by z score by age group and sex according to the WHO.

Table 4. Multiple logistic regression of overweight/obesity, in a sample of 500 school children aged 5 to 9 years in Fortaleza, CE, Brazil.

Independent variables	Odds Ratio	Standard Error	p-value	95% CI of OR
Social Class¹				
C ²	1.65	0.53	0.122	0.87 - 3.12
D	3.51	1.40	0.002	1.60 - 7.69
income²				
BRL 230-1000	1.59	0.31	0.017	1.08 - 2.33
Birth weight³				
<2500g ⁴	1.16	0.42	0.683	0.56 - 2.37
>3500g	2.55	0.55	0.000	1.67 - 3.90

¹Reference Category: Social Class B; ²Reference Category: BRL 24.00 - 230.00;

³Reference Category: 2,500g - 3,500g; ⁴This variable was kept in the multiple regression model to ensure a better fit of the overweight/obesity variable.

It was shown that birth weight was positively correlated with the presence of overweight/obesity in the child. Among those born with low weight, 40.54% were overweight/obese at the current age; and, among children born weighing more than 3,500g, 52.9% were overweight at current school age ($p = 0.001$). In Table 5, in the multivariate analysis to assess the magnitude of the association between overweight/obesity and independent variables, a strong association between overweight/obesity and weight above 3500g ($p=0.000$) was evidenced, with a 2.55 greater chance of being overweight (95%CI: 1.67 – 3.90).

This finding was also evidenced in a meta-analysis involving studies from developing countries in North and South America, Europe, Asia and Australia, demonstrating with high consistency that an increase in birth weight (>4,000 g) can lead to a doubling risk of being overweight in the long term, regardless of geographic/ethnic status, origin, sex, socioeconomic status, parental weight status, etc.²⁵.

Similar data were demonstrated by Yu *et al.* in a meta-analysis of 15 studies mainly from China, with similar results, identifying high birth weight associated with increased risk of obesity, in addition to low birth weight associated with reduced risk²⁶.

According to Parsons *et al.*, in a meta-analysis that included predominantly longitudinal studies, evidence was found of a positive association between birth weight and obesity in children under seven years of age, but few articles addressed potential confounding variables such as gestational age, parental obesity and socioeconomic status. One of the studies reviewed by the author showed a non-linear effect of birth weight on obesity.

In developed countries, high birth weight is the main risk factor associated with obesity among children and adolescents whose mothers had gestational *diabetes mellitus*. The same study concluded that research on the subject should be carried out with methodological rigor, seeking to identify factors that may reduce the effect of birth weight on overweight/obesity among children and adolescents^{1,3}.

Although a large number of publications show a predominantly positive association between birth weight and overweight in childhood, in a systematic review by Martins and Carvalho, it was not possible to estimate, in a single measure, how much birth weight contributes for the emergence of overweight and/or obesity, either by the various definitions attributed to overweight by the different designs used or by limitations related to the methods of analysis used. In addition, other factors, such as parental obesity, especially maternal obesity, would be an important predictor of childhood obesity, regardless of birth weight, gestational age and socioeconomic status²⁸.

Another aspect to be emphasized and that is the object of study of literature reviews is the role of weight gain velocity in the development of overweight/obesity. A systematic review²⁹ cites the influence of rapid growth during the first four months of life on the development of obesity at seven years of age, regardless of birth weight, gestational age, weight at one year of age, BMI and level. maternal education. The definition of rapid growth adopted was a variation equal to or greater than +1 weight-for-age Z-score. The final analysis showed an independent association between the rate of weight gain in the first four months of life and overweight at seven years, adjusting for “birth weight” and several variables. Although the study prioritized verifying the influence of genetic factors, it was not possible to confirm this hypothesis³⁰.

Other studies have verified the effect of rapid growth resulting from intrauterine growth restriction on the risk of obesity (catch-up). According to Eriksson *et al.*³¹, the risk of obesity in adults was higher when, in children, they had an increase in BMI, even if they were born with low birth weight^{28,31}.

Also according to Parsons' review, children who were born with low weight also had a higher risk of acquiring obesity in childhood, although this risk was greater for children who were born with high weight 25. This fact can be explained by a theoretical current that emphasizes predominantly biological aspects, related to the fetal programming hypothesis, in which low birth weight, resulting from adverse intrauterine conditions, would promote compensatory reprogramming during childhood, leading to a greater risk of chronic diseases in adults^{9,32}.

In contrast, according to a review by Martorell *et al.*, who investigated the influence of nutritional factors during pregnancy and in the first three years of life on the development of obesity in adults and adolescents, evidence of risk for low birth weight and for intrauterine growth restriction in the development of obesity in adolescents or adults were inconsistent²⁸.

Recently, The theory on the developmental origins of health and disease (DOHaD) about early causes of future disease has become one of the most promising in medicine. DOHaD aggregates information from various areas of knowledge, proposing new research methodologies in order to clarify the influence of adverse events occurring in early stages of human development on the pattern of health and disease throughout life. This new

field of science proposes new models of causality and mechanisms involved in the emergence and development of chronic diseases. The results of these investigations may have a significant impact on the prevention of chronic diseases, as well as on health promotion at different stages of life.

Birth weight, especially, has been suggested and used as a basic indicator to establish this influence, since it is decisively determined by prenatal development conditions²⁵.

CONCLUSION

Excess weight is among the main health-challenging factors today. It has been shown that birth weight, being a critical indicator of prenatal developmental conditions, is related to the risk of overweight in the long term. The present study demonstrated a statistically significant association between overweight and obesity at birth, corroborated by other studies that aim to investigate the same association. The study has the weakness of not analyzing statistically all the factors that can lead to obesity, in a way that completely proves the mentioned association. More studies, however, are needed to consolidate this relationship, aiming at the medium and long term development of preventive measures in the scope of maternal and child health.

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