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ORIGINAL ARTICLE

Birth weight, rapid weight gain in infancy and markers of overweight and obesity in childhood

MR Sacco[1], NP de Castro[1], VLV Euclydes[1], JM Souza[2] and PHC Rondó[1]

OBJECTIVE: To evaluate the relationship between birth weight and rapid weight gain in infancy and markers of overweight/obesity in childhood, using different cutoff values for rapid weight gain.

SUBJECTS/METHODS: Cross-sectional study involving 98 5-year old pre-school Brazilian children. Rapid weight gain was considered as weight gain in standard deviation score (SDS) above $+0.67$, $+1$ and $+2$ in relation to birth weight, at any time during the first 2 years of life. The nutritional status of the children was determined by anthropometry and electrical bioimpedance. Multiple linear regression analysis was used, considering fat mass percentage, body mass index (BMI), waist and neck circumferences as outcomes.

RESULTS: Birth weight, rapid weight gain (assessed by different cutoff values) and maternal obesity were positively associated with increased fat mass percentage, BMI, waist and neck circumferences. Different cutoff values of rapid weight gain did not change the positive associations between rapid weight gain and fat mass percentage ($> +0.67$ SDS, $P = 0.007$; $> +1$ SDS, $P = 0.007$; $> +2$ SDS, $P = 0.01$), BMI ($> +0.67$ SDS, $P = 0.002$; $> +1$ SDS, $P = 0.007$; $> +2$ SDS, $P < 0.001$), waist circumference ($> +0.67$ SDS, $P = 0.002$; $> +1$ SDS, $P = 0.002$; $> +2$ SDS, $P < 0.001$) and neck circumference ($> +0.67$ SDS, $P = 0.01$; $> +1$ SDS, $P = 0.03$; $> +2$ SDS, $P < 0.001$).

CONCLUSIONS: The use of different cutoff values for the definition of rapid weight gain did not interfere in the associations between birth weight and rapid weight gain with fat mass percentage, BMI, waist and neck circumferences. Children with the highest birth weight, those who undergo rapid weight gain in infancy and whose mothers were obese, seemed to be more at risk for overweight/obesity.

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Keywords: birth weight; rapid weight gain; obesity; fetal development; fat mass

INTRODUCTION

Data published by the World Health Organization[1] have shown a worrisome increase of overweight and obesity during the first years of life. In infancy, hyperplasia and/or hypertrophy of adipose cells results in an exacerbated expansion of adipose tissue, a characteristic of obesity, which tends to persist into adulthood.[2] This mechanism can be explained by the developmental origins of health and disease hypothesis, which suggests that an insult or stimulus during critical periods of development, such as growth in the intrauterine period and infancy, has long-term effects on the physiology, structure and functions of the organism.[3–5]

Birth weight is a proxy of intrauterine growth and appears to be associated with body composition throughout an individual's life.[6,7] In addition to birth weight, rapid weight gain has also been associated with the incidence of obesity later in life.[8,9] The greatest variation in rates of weight gain is seen in the first 1–2 years of life when infants may show significant rapid weight gain or 'catch-up' to compensate for intrauterine restraint.[10]

No standard definition of rapid weight gain exists in the international literature. In most studies, rapid weight gain in infancy is defined as an increase in weight $> +0.67$ standard deviation score (SDS) between birth and 2 years.[11,12] However, other cutoff values for rapid weight gain have also been reported: $> +1$ SDS,[13] $>$90th percentile[14] and $>$9 764 g.[15] In a review comprising studies that used different cutoff values for rapid weight gain in infancy, Ong and Loos[16] found an association between rapid weight gain and subsequent obesity risk.

Body mass index (BMI), a parameter extensively employed in epidemiological studies, is generally used for the diagnosis of overweight and obesity in childhood.[1,17] Neck circumference has been proposed as a potential marker of childhood obesity. This marker shows an important association with BMI, is a simple and rapid measure and particularly useful in population studies.[18] Waist circumference is a proxy of visceral fat and is also an important marker of overweight/obesity and chronic diseases.[19,20] McCarthy *et al.*[21] suggested refinement of the diagnosis of overweight/obesity by the assessment of body composition and published reference curves of fat mass percentage measured by bioelectrical impedance.

The early detection of overweight and obesity during the first years of life permits the application of adequate interventions to avoid obesity-related problems later in life. Therefore, the objective of the present study was to evaluate the association of birth weight and rapid weight gain in infancy with markers of overweight and obesity in childhood using different cutoff values for rapid weight gain.

[1]Department of Nutrition, School of Public Health, University of São Paulo, São Paulo, Brazil and [2]Department of Epidemiology, School of Public Health, University of São Paulo, São Paulo, Brazil. Correspondence: Professor PHC Rondó, Department of Nutrition, School of Public Health, University of São Paulo, Avenue Dr Arnaldo 715, Cerqueira Cesar, CEP-01246-904 São Paulo, Brazil.
E-mail: phcrondo@usp.br
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MATERIALS AND METHODS

This cross-sectional study was conducted at all municipal schools in Capão Bonito city, Brazil, and included 5-year-old children enrolled in the first grade of elementary school. Children born prematurely and children with genetic and chronic diseases were excluded from the study.

Birth weight and gestational age were obtained from the child's hospital discharge record and/or immunization card. Weight gain during the first 2 years of life was transcribed from the child's immunization card or health service records. The flowchart in Figure 1 illustrates the different phases of the study.

The parents/legal guardians answered a general questionnaire containing information about demographic, educational level, and obstetric variables, breastfeeding, family history of obesity (particularly maternal obesity), and physical activity of the children.[22]

The anthropometric measurements were determined in duplicate, by the same pediatrician, according to Lohman *et al.*[23] After 10- to 12-h fast, the children were weighed on a portable electronic scale (model 7500, Soehnle, Murrhardt, Germany) to the nearest 100 g. Height was measured using a Leicester Portable Height measure (Seca, Hamburg, Germany) to the nearest 0.1 cm. Waist and neck circumferences were obtained with a tape measure (model 34103, Stanley, New Britain, CT, USA) to the nearest 0.1 cm. Waist circumference was classified according to the National Health Statistics Report,[24] with values above the 85th percentile (58.8 cm for boys and 60.6 cm for girls) being defined as excess weight. Neck circumference was classified according to Nafiu *et al.*,[18] with values above 28.5 and 27 cm for boys and girls, respectively, being defined as excess weight. The cutoff values for children aged 6 years or more were used as no cutoff values are available for 5-year-old children.

BMI was considered to be a marker of nutritional status using the WHO[25] curve as a reference standard. Children with a BMI-for-age between 1 and 2 *z*-score from the mean were classified as overweight and those with a BMI-for-age >2 *z*-score were classified as obese. In this study, rapid weight gain was defined as weight gain $>+0.67$, $+1$ or $+2$ SDS in relation to birth and a time point within the first 2 years of life, considering that there were at least eight measurements from the children in this period of life. Body composition was evaluated by bioelectrical impedance (MC-180MA, Tanita Corporation, Tokyo, Japan). Body fat percentage was classified based on the values proposed by McCarthy *et al.*[21] using the 85th and 95th percentiles for age and gender as cutoff values for overweight and obesity, respectively.

The Stata 10 for Windows software (Stata Corporation, College Station, TX, USA) was utilized for data analysis. The variables are reported as absolute and relative frequencies and measures of central tendency (means) and dispersion (standard deviation and range). Four multiple linear regression models were used, one for each dependent variable analyzed (fat mass percentage, BMI, waist circumference and neck circumference) and for the different definitions of rapid weight gain (above $+0.67$, $+1$ and $+2$ SDS). Birth weight and rapid weight gain were the independent variables of interest and were controlled for the child's gender, breastfeeding, physical activity and maternal variables (age at birth of the child, obesity and education). Birth weight and rapid weight gain remained in the regression model irrespective of the *P* level. The other variables were kept in the model when $P \leq 0.20$. A level of significant of $P<0.05$ was adopted.

The study was approved by the Ethics Committee of the School of Public Health, University of São Paulo, Brazil. All parents/legal guardians agreed to the participation of their children by signing the free informed consent form.

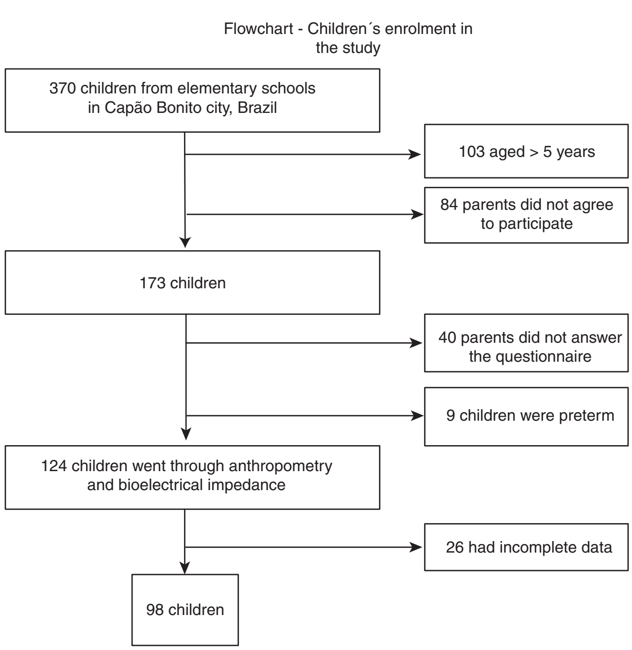

Figure 1. Flowchart of children's enrollment.

RESULTS

All 370 children, aged 5 years, attending the elementary schools in Capão Bonito city, Brazil, were selected for the study. However, 187 were excluded because 103 aged over 5 years at the time of data collection and 84 parents did not agree to participate. From the 173 remaining children, 40 parents did not answer the questionnaire and 6 children were born preterm. From the 124 remaining children, 26 had incomplete data on anthropometry and/or bioelectrical impedance (Flowchart). Therefore, the final sample consisted of 98 children.

There was no difference in mean birth weight (3.4 ± 0.5 and 3.3 ± 0.5 kg, respectively), maternal age at birth of the child (25.9 ± 6.6 and 26 ± 6.4 years) or maternal education (7.4 ± 3.9 and 6.9 ± 4.1 years) between the 124 and 98 children.

Table 1 shows the characteristics of the 98 children and their mothers; more of the children being girls (56.1%). Only three (3.1%) children had low birth weight (<2.5 kg) and almost half of them (49%) weighed from 3.0 to 3.5 kg at birth. Rapid weight gain was observed in 61.2%, 51% and 21.4% of the children, according to the following cutoff values $>+0.67$, $>+1$ and $>+2$ SDS, respectively. Body fat percentage was above the 85th percentile at 5 years of age in approximately 43% of the children, characterizing overfat (30.6%) or obesity (12.2%).[21] According to the WHO[25] BMI-for-age *z*-score, 14.3% of the children presented overweight and 9.1% obesity (9.1%). In relation to the waist circumference curve classification,[24] 17.3% of the children were above or equal the 85th percentile. Using neck circumference as an indicator, 19.4% of the population was overweight/obese.[18] The mean duration of breastfeeding was 13.5 (± 14.1) months, with mothers reporting exclusive breastfeeding for 4.1 (± 2.6) months. Using the questionnaire adapted from Bracco *et al.*,[22] approximately 85% of the children were active. Among the mothers of children participating in the study, 11.2% were adolescents (<19 years) and 63.3% were between 20 and 30 years of age. Approximately 17% of the mothers reported to be obese, a finding confirmed by the main researcher, and 64.3% had 8 years or less of formal education.

Tables 2–4 show multiple linear regression models including fat mass percentage, BMI, waist circumference and neck circumferences as outcomes, and using three cutoff values for rapid weight gain (above $+0.67$, $+1$ and $+2$ SDS). For all models, fat mass percentage, BMI and waist circumference were associated with birth weight, rapid weight gain in infancy and maternal obesity. Associations with birth weight, rapid weight gain and gender were observed for the model including neck circumference as outcome.

There were inverse correlations between birth weight and rapid weight gain in infancy, varying from -0.35 to -0.32 ($P<0.001$), for the three different cutoff points used for rapid weight gain.

DISCUSSION

In this study, we investigated the association of birth weight and rapid weight gain in infancy with markers of overweight and

Table 1. Characteristics of the children and respective mothers ($n = 98$)

	n (%)	Mean (s.d.)
Children		
Gender		
Male	43 (43.9)	
Female	55 (56.1)	
Birth weight (kg)		3.3 (0.52)
<3 kg	22 (22.4)	
⩾3 kg	76 (77.6)	
Rapid weight gain (> +0.67 SDS)		
Yes	60 (61.2)	
No	38 (38.8)	
Rapid weight gain (> +1 SDS)		
Yes	50 (51.0)	
No	48 (49.0)	
Rapid weight gain (> +2 SDS)		
Yes	21 (21.4)	
No	77 (78.6)	
Body fat (percentile)[21]		
<2	3 (3.1)	
2–25	3 (3.1)	
25–50	13 (13.3)	
50–75	23 (23.5)	
75–85	14 (14.3)	
⩾85	42 (42.8)	
Fat mass %		20.2 (4.9)
BMI (z-score)[25]		
< −2 SDS	1 (1.0)	
−2 to −1 SDS	10 (10.2)	
−1 to 0 SDS	24 (24.5)	
0 to 1 SDS	40 (40.8)	
1 to 2 SDS	14 (14.3)	
>2 SDS	9 (9.1)	
BMI (kg/m^2)		16.2 (2.5)
Waist circumference (percentile)[24]		
>10	4 (4.1)	
10–25	10 (10.2)	
25–50	24 (24.5)	
50–75	33 (33.7)	
75–85	10 (10.2)	
⩾85	17 (17.3)	
Waist circumference		56.4 (7.1)
Neck circumference[18]		
Normal	79 (80.6)	
Overweight/obesity	19 (19.4)	
Neck circumference		26.1 (1.9)
Breastfeeding (months)[a]		13.5 (14.1)
0	12	
0–3	12	
3–6	11	
6–12	28	
12–24	9	
⩾24	24	
Physical activity		
Yes	83 (84.7)	
No	15 (15.3)	
Mothers		
Age at birth of the child (years)[b]		26.1 (6.4)
⩽19	11 (11.2)	
20–30	62 (63.3)	
30–40	20 (20.4)	
40–45	4 (4.1)	
Obesity		
Yes	17 (17.3)	
No	81(82.7)	
Education (years)		6.9 (4.1)
<4	18 (18.4)	
4–8	45 (45.9)	
8–11	28 (28.6)	
11–17	7 (7.1)	

Abbreviations: BMI, body mass index; SDS, standard deviation score. [a]$n = 96$. [b]$n = 97$.

obesity (fat mass percentage, BMI, waist circumference and neck circumference) in childhood, using different cutoff values for rapid weight gain (above +0.67, +1 and +2 SDS). Fat mass percentage, BMI, waist circumference and neck circumference evaluated at 5 years of age were positively associated with birth weight and rapid weight gain in infancy, irrespective of the cutoff value used.

The literature regarding the association between birth weight and obesity later in life is controversial. There are reports involving very large samples showing that the association follows a U-shaped[26] or J-shaped curve.[27] Recently, studies suggested that elevated weight at birth, and not low birth weight, is a risk factor for obesity later in life.[28,29] In the present study, birth weight was positively associated with overweight/obesity at 5 years of age, in agreement with the latest findings. The relationship between higher birth weight and later obesity might be explained by the developmental origins of health and disease hypothesis, which suggests that disturbances during critical windows of development (such as growth in the intrauterine period and infancy) cause permanent metabolic, physiological and structural adaptations.[30] Studies have explored the mechanisms underlying these associations and possible explanations include an increase in the number and/or size of adipose cells or functional alterations in adipose tissue.[31,32] Long *et al.*[32] provided evidence that the higher birth weight of fetuses of overfed ewes is due to an increase of adipose tissue caused by higher lipogenesis and increased transport of fatty acids to fetal adipocytes. The authors observed that average adipocyte diameter in renal fat was greater in fetuses of overfed mothers when compared with those of mothers not overfed. These physiological alterations in adipose tissue seem to be permanent, demonstrating the influence of the perinatal period and higher birth weight on subsequent obesity.

Although birth weight is associated with obesity in later life, rapid weight gain in infancy has been suggested to be a more important factor for the development of obesity. In fact, in a recent meta-analysis,[33] the inclusion of infant weight gain from 0 to 1 year improved the prediction of childhood obesity when compared with a model that contained only maternal BMI, birth weight and gender. The authors observed that the influence of weight gain in infancy on later obesity was significant over a wide range of birth weights. In a model adjusted for birth weight, gender and age, the risk of childhood obesity doubled for each weight increase of 1 SDS between 0 and 1 year (odds ratio = 1.97). This increase in the risk of childhood obesity was even higher for each increase of 1 SDS between 0 and 2 years. These findings suggest that, like birth weight, rapid weight gain also alters the physiology of adipose tissue and fat-free tissue.

In this study, rapid weight gain (independently of the cutoff values used) showed an inverse association with birth weight. This suggests that it could be 'catch-up',[10] even in those infants born within the normal birth weight range.

In agreement with the conclusion of Ong and Loos,[16] different cutoff values did not seem to interfere with the presence of overweight and obesity later in life. The overall prevalence of rapid weight gain or 'catch-up' observed in our study (61.7%) at the cutoff > +0.67 SDS was higher than that reported by Ong *et al.*[10] (30.7%), in a study involving 260 British infants. In a retrospective cohort study of adolescents, Monteiro *et al.*[34] observed a prevalence of rapid weight gain in infancy, defined as > +1 SDS and > +2 SDS, of 11% and 4.2%, respectively. The possible explanations for the differences between these three studies are: (1) socioeconomic status and (2) differences in the definition of rapid weight gain. The present study was conducted in one of the most underprivileged regions of the State of São Paulo (Human Development Index 0.663)[35] different from the studies of Monteiro *et al.*[34] in Pelotas city, State of Rio Grande do Sul (Human Development Index: 0.768)[35] and the ALSPAC study,[10] which involved a population in Bristol city, UK. Furthermore, Ong *et al.*[10] and Monteiro *et al.*[34] defined rapid weight gain as the difference between weight (SDS) at 2 years of age and birth weight (SDS) above +0.67. In the present study, rapid weight gain was defined as the difference between weight (SDS) > +0.67, > +1 and > +2 at any time during the first 2 years of life and birth weight (SDS), considering that the anthropometric data were determined at least eight times during infancy.

Table 2. Linear regression models considering fat mass percentage, BMI, waist circumference and neck circumference as outcomes (rapid weight gain > +0.67 SDS)

Outcomes	*Coefficient*	*s.e.*	T	*95%*	*CI*	P
Fat mass %						
Birth weight	2.61	0.98	2.66	0.66	4.56	0.009
Rapid weight gain	3.27	1.05	3.13	1.19	5.35	0.002
Gender	− 1.48	0.96	− 1.53	− 3.39	0.44	0.13
Maternal obesity	3.76	1.25	3.0	1.27	6.24	0.003
$R^2=0.17$; Adj. $R^2=0.13$						
BMI						
Birth weight	1.81	0.47	3.82	0.87	2.75	<0.001
Rapid weight gain	1.95	0.51	3.85	0.94	2.95	<0.001
Gender	− 0.81	0.47	− 0.17	− 1.0	0.85	0.86
Maternal obesity	2.28	0.61	3.78	1.1	3.49	<0.001
$R^2=0.26$; Adj. $R^2=0.23$						
Waist circumference						
Birthweight	5.42	1.34	4.05	2.76	8.08	<0.001
Rapid weight gain	5.27	1.43	3.70	2.44	8.11	<0.001
Gender	− 0.36	1.32	− 0.28	− 2.98	2.25	0.78
Maternal obesity	6.45	1.71	3.28	3.06	9.85	<0.001
$R^2=0.27$; Adj. $R^2=0.24$						
Neck circumference						
Birth weight	1.30	0.35	3.71	0.61	2.00	<0.001
Rapid weight gain	1.56	0.37	4.17	0.82	2.30	<0.001
Gender	0.78	0.34	2.26	0.09	1.46	0.026
Maternal obesity	1.06	0.45	2.37	0.17	1.95	0.020
$R^2=0.29$; Adj. $R^2=0.26$						

Abbreviations: Adj., adjusted; BMI, body mass index; CI, confidence.

Table 3. Linear regression models considering fat mass percentage, BMI, waist circumference and neck circumference as outcomes (rapid weight gain > +1 SDS)

Outcomes	*Coefficient*	*s.e.*	T	*95%*	*CI*	P
Fat mass %						
Birth weight	2.42	0.97	2.48	0.48	4.36	0.015
Rapid weight gain	2.89	1.00	2.89	0.90	4.89	0.005
Gender	− 1.08	0.97	− 1.12	− 3.0	0.84	0.27
Maternal obesity	3.41	1.24	2.75	0.95	5.87	0.007
$R^2=0.16$; Adj. $R^2=0.12$						
BMI						
Birth weight	1.65	0.48	3.45	0.70	2.6	0.001
Rapid weight gain	1.56	0.59	3.17	0.58	2.54	0.002
Gender	0.51	0.47	0.32	− 0.79	1.09	0.75
Maternal obesity	2.04	0.61	3.36	0.83	3.25	0.001
$R^2=0.23$; Adj. $R^2=0.20$						
Waist circumference						
Birth weight	5.11	1.33	3.84	2.47	7.76	<0.001
Rapid weight gain	4.66	1.37	3.39	1.93	7.38	0.001
Gender	0.27	1.69	0.21	− 2.35	2.90	0.83
Maternal obesity	5.89	1.70	3.48	2.53	9.26	0.001
$R^2=0.25$; Adj. $R^2=0.22$						
Neck circumference						
Birth weight	1.15	0.36	3.21	0.44	1.86	0.002
Rapid weight gain	1.17	0.37	3.17	0.43	1.89	0.002
Gender	0.96	0.35	2.71	0.26	1.67	0.008
Maternal obesity	0.85	0.46	1.86	0.06	1.75	0.066
$R^2=0.24$; Adj. $R^2=0.21$						

Abbreviations: Adj., adjusted; BMI, body mass index; CI, confidence.

Both birth weight and catch-up growth had an impact on markers of overweight/obesity (fat mass percentage, BMI, waist circumference and neck circumference). The prevalence of overweight/obesity varied according to the marker used. Using BMI, 23.4% of the children were diagnosed as overweight/obese at 5 years of age, whereas almost the double (42.8%) was diagnosed

Table 4. Linear regression models considering fat mass percentage, BMI, waist circumference and neck circumference as outcomes (rapid weight gain > +2 SDS)

Outcomes	*Coefficient*	*s.e.*	T	*95%*	*CI*	P
Fat mass %						
Birth weight	2.50	0.98	2.57	0.57	4.44	0.01
Rapid weight gain	3.59	1.19	3.03	1.24	5.96	0.003
Gender	−1.32	0.96	−1.36	−3.23	0.59	0.18
Maternal obesity	2.59	1.21	2.13	0.17	4.99	0.04
$R^2=0.16$; Adj. $R^2=0.13$						
BMI						
Birth weight	1.71	0.48	3.59	0.77	2.66	0.001
Rapid weight gain	2.0	0.58	3.45	0.85	3.16	0.001
Gender	0.21	0.47	0.05	−0.91	0.96	0.96
Maternal obesity	1.59	0.59	2.69	0.42	2.77	0.009
$R^2=0.24$; Adj. $R^2=0.21$						
Waist circumference						
Birth weight	5.31	1.33	4.01	2.68	7.94	<0.001
Rapid weight gain	6.01	1.61	3.72	2.81	9.22	<0.001
Gender	−0.11	1.31	−0.09	−2.72	2.49	0.93
Maternal obesity	4.55	1.65	2.76	1.28	7.84	0.007
$R^2=0.27$; Adj. $R^2=0.24$						
Neck circumference						
Birth weight	1.18	0.36	3.30	0.47	1.89	0.001
Rapid weight gain	1.45	0.44	3.32	0.58	2.31	0.001
Gender	0.87	0.35	2.46	0.17	1.57	0.016
Maternal obesity	0.51	0.45	1.15	−0.37	1.39	0.252
$R^2=0.25$; Adj. $R^2=0.22$						

Abbreviations: Adj., adjusted; BMI, body mass index; CI, confidence.

as overfat/obese according to fat mass percentage. BMI has been used over many years as a parameter for the diagnosis of overweight and obesity. However, this parameter does not provide information about the body composition of a subject and is therefore considered to be a poor marker of obesity,[13,36] although it is still used in epidemiological studies.[37,38] Some investigators prefer the use of fat mass percentage as a marker of overweight/obesity[13] and we found this marker to be more sensitive for this diagnosis.

Fat mass percentage or BMI does not indicate the distribution of excess body adiposity. On the other hand, waist circumference is a valuable measure as it reflects central adiposity. The latter has been suggested to be associated with metabolic diseases[19,39] and, when evaluated in childhood, is an indicator of metabolic risks.[20,40] In the present study, waist circumference was positively associated with birth weight and rapid weight gain, in agreement with other studies demonstrating that children undergoing rapid weight gain tend to accumulate excess adipose tissue in the central region.[10]

Neck circumference showed a positive association with fat mass percentage, BMI and waist circumference. As it is a practical and inexpensive measure, neck circumference can be used for the diagnosis of overweight and obesity when BMI data are not available.[18,41,42] The prevalence of overweight/obesity (19.4%) based on neck circumference measurement might be underestimated, as the reference values available refer to American children aged 6 years or older.[18]

Maternal obesity was another factor that showed a significant association with childhood overweight/obesity. Moaraeus *et al.*[43] and Lazzeri *et al.*[44] observed a strong association between parental obesity and obesity in children aged 7–9 years and 8–9 years, respectively. Apparently to be able to target children with the highest risk of overweight and obesity, it is important to monitor family weight status whenever possible.

Duration of breastfeeding, physical activity and educational level were not associated with the outcomes at 5 years of age. Breastfeeding has been reported to be a protective factor against overweight and obesity.[45,46] The lack of an association between breastfeeding and obesity might be due to memory bias, as we conducted a retrospective study in which exposure occurred 3–5 years before the interview. However, similar to our results, other investigators did not find an association between duration of breastfeeding and obesity.[47,48] Physical activity was probably not associated with overweight/obesity because of the difficulty in measuring this variable in a cross-sectional study involving children.[10,49] Parental education has been reported to be an important factor associated with childhood obesity. Gonzalez *et al.*[50] observed that parental education was associated with lower BMI in early adulthood. Keane *et al.*,[51] however, referred a positive relationship between higher maternal educational level and BMI at age 9 years. The lack of association between maternal education and obesity observed in the present study might be due to the homogeneity of our population. The children were selected from public schools in Capão Bonito city, an underprivileged region in the State of São Paulo, with low level of education.

CONCLUSION

The results of this study demonstrate that infancy is a critical period for the development of overweight and obesity in later life, as confirmed by the associations of birth weight and rapid weight gain with fat mass percentage, BMI, waist circumference and neck circumference at 5 years of age. The use of different cutoff values for the definition of rapid weight gain did not modify the associations observed between the variables and outcomes investigated. Children with the highest birth weight, those who undergo rapid weight gain in infancy and whose mothers were obese, seemed to be more at risk for overweight/obesity.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

MRS designed the study protocol, collected data, participated in the statistical analysis, interpretation of data and writing of the paper. NPdeC and VLVE participated in the statistical analysis and interpretation of data, and writing of the paper. JMS participated in the statistical analysis, interpretation of data and writing of the paper. PHCR secured funding, designed the study protocol, participated in the statistical analysis, interpretation of data and writing of the paper. All authors approved the final version of the paper.

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