Association between rapid weight gain and overweight in children aged 0 to 5 years in Latin America

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Abstract

Objectives: to assess the prevalence of rapid weight gain (RWG) in children born with normal weight and its association with overweight (OW) in four Latin America countries.

Methods: cross-sectional study in children aged 0 to 5 from the Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher *in Brazil and the* Encuesta Nacional de Demografía y Salud *in Bolivia, Colombia and Peru,using a birth weight ≥2,500g. The outcome variable was OW, the exposure was RWG and breastfeeding (BF) was the adjustment variable. Prevalence, odds ratio and 95% confidence intervalwere estimated using multivariate logistic regression model.*

Results: there was a greater prevalence of RWG and BF at less than 6 months in Brazil, and a greater prevalence of OW in Brazil and Bolivia. The chances of OW when RWG was present and adjusted for BF were 6.1 times (CI95% = 3.8-9.7) in Brazil, 4.4 times (CI95% = 3.6-5.3) in Bolivia, 6.7 times (CI95% = 5.5-8.2) in Colombia, and 12.2 times in Peru (CI95% = 9.4-15.7) with a $p < 0.001$ *for all countries.*

Conclusions: RWG in children with normal birth weight was associated with a greater chance of being OW in the four observed Latin America countries.

Key words *Pediatric Obesity, Infant, Preschool, Weight gain, Latin America*

http://dx.doi.org/10.1590/1806-93042022000100006

Introduction

Overweight (OW) in the adult population is considered a global pandemic, observing that in 2016, 39% of adults aged 18 and over were considered overweight and 13% were obese.[1] In studies using child populations, the same trend is present, as the worldwide prevalence of overweight and obesity in children, aged 0 and 5 years, increased from 33.3 million (5.4%) to 38.9 million (5.7%) between 2000 and 2020. It is estimated that in Latin America and the Caribbean, 3.9 million (7.5%) children under 5 years of age were overweight or were experiencing obesity in 2020.[2]

Overweight has a multifactorial etiology, with some of its determining factors being genetic, environmental and psychosocial.[3] In recent decades, the increase in obesity prevalence reported in children in Latin America can be attributed, in part, to the phenomenon of nutritional and epidemiological transitions experienced in populations on a global scale.[3,4] Obesity has a major negative impact on child health, with consequences that can evolve into adulthood. In adults, it can lead to breathing difficulties, increased risk of fractures, hypertension, the presence of early cardiovascular disease biomarkers, insulin resistance, and negative psychological effects.[5]

Harmful exposures to health during the early life cycle, including rapid weight gain (RWG) in early childhood, can contribute to an increased occurrence of chronic non-communicable diseases in adulthood.[6] Child RWG can be defined when the difference in z-score of weight-for-age between two assessment is greater than 0.67.[7] Studies have shown an association between RWG in childhood and an increased risk of overweight and obesity in the short, medium and long term.[3,8,9] A systematic review and meta-analysis study concluded that children with RWG had 3.66 times more chance of being overweight or obese in adulthood.[3] In addition, RWG was also associated with greater values not only for body mass index (BMI), but also for the percentage of body fat, waist circumference and waist-to-height ratio during the pre-adolescence period.[8]

Latin American countries present different stages in the demographic and epidemiological transition processes, which is a reflection of their opposite economic, social and cultural realities.[10] Furthermore, there is a lack of studies that explore the relationship between RWG and OW in childhood, and existing studies present a small sample size and lack published samples without national representation,[6,11] or from developed countries.[3,10]

Studies carried out in Brazil have reported RWG prevalence ranging from 36.8% (from birth and 24 to 34 months of age)[6] and 61.2% (from birth and 5 years of age)[11] and both observed a statistically significant relationship between the RWG and OW in childhood. The inclusion of RWG prevention measures may be one of the potential ways to reduce the prevalence of childhood obesity,[12] however, it should be stressed that this is a subject that has not been adequately explored in studies in terms of causality of childhood obesity.

Thus, the aim of the present study was to analyze the prevalence of RWG in children born with adequate weight and its association with OW in children between zero and five years in four Latin American countries.

Methods

This was a cross-sectional epidemiological study, which used data from four population surveys conducted in four Latin American countries: *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher* (PNDS), carried out in Brazil between 2006 and 2007,[13] *Encuesta Nacional de Demografía y Salud*, conducted in Bolivia (ENDSA), in 2008,[14] *Encuesta Nacional de Demografía y Salud* (ENDS), conducted in Colombia between 2009 and 2010,[15] and in Peru, *Encuesta Demográfica y de Salud Familiar* (ENDES), conducted in 2012.[16] The four country sample data are part of the DHS Measure (Demographic and Health Survey) project, which are conducted on a global scale with the support of the United States Agency for International Development (USAID) in partnership with other international institutions.[17]

The DHS are national representative household surveys, carried out using complex probability sampling models.[17] The sampling units are selected in at least two stages: in the initial stage, the Primary Sampling Units (PSU) are selected, composed of conglomerates such as a sector census, provinces, municipalities and a set of households according to the definition of each country. Subsequently, the secondary units, formed by household units, are selected.[17]

For the Brazilian data analysis, which relies on the PNDS, the databases referring to households, women, pregnancies and children were grouped as previously described.[18] For the data analysis of Bolivia, Colombia and Peru, the referred databases were used according to the women population, aged 15 to 49 years, which also contains data on children under five years of age. Some variables available in the database for households were included, each one properly coded.

Brazilian population was sampled during November 2006 and May 2007. From a total of 14,617 selected households, 15,575 women were interviewed.[13] Data from Bolivia were taken from February to June 2008, with 20,003 selected households and 16,939 women included in the study.[14] Data from Colombia were collected from November 2009 to November 2010, in a total of 51,447

selected households, with a total of 49,818 women interviewed.[15] Finally, data from Peru were collected from March to December 2012, with 27,488 selected households and 23,888 women interviewed.[16] Figure 1 presents the sample flowchart.

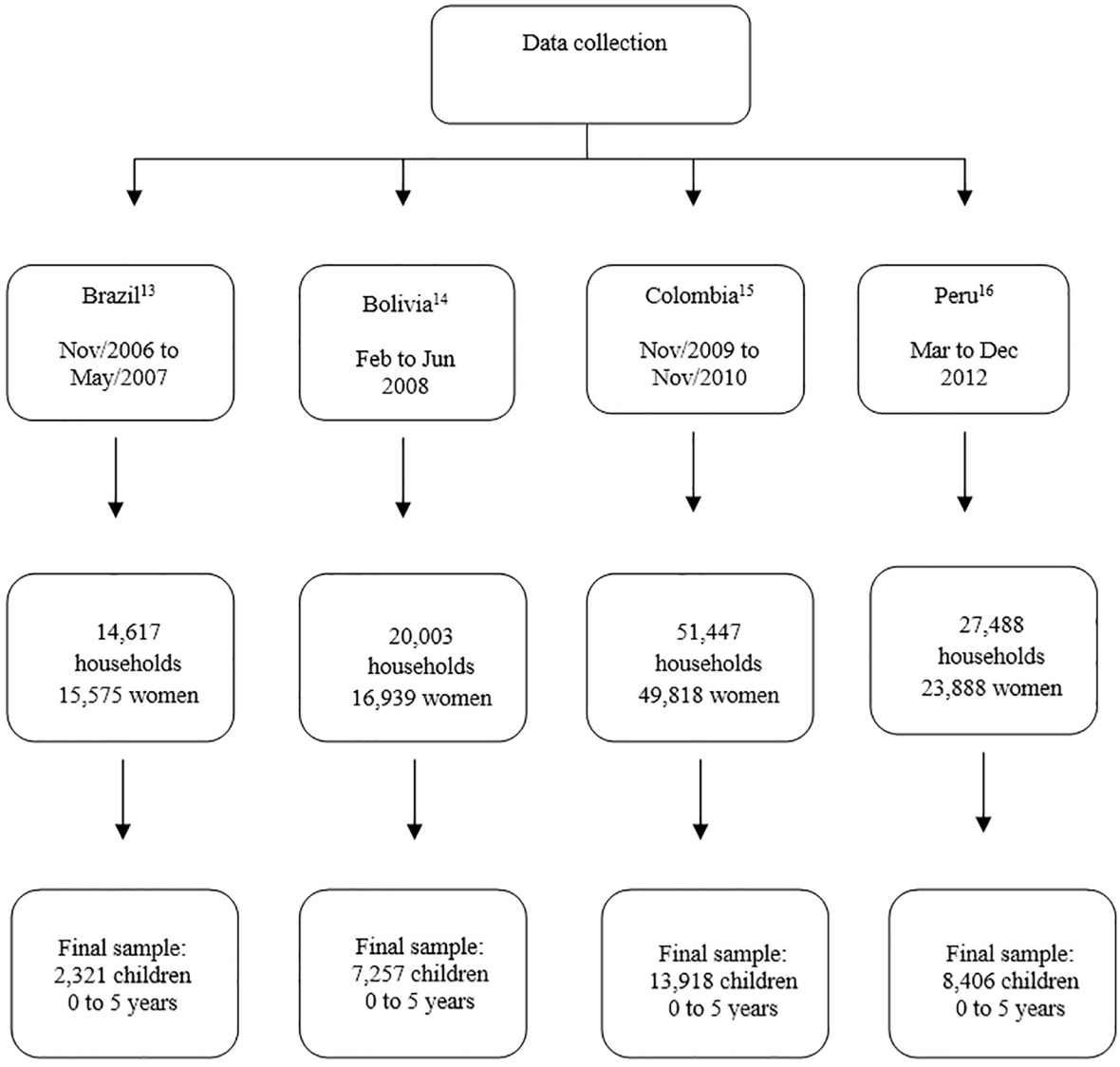
The inclusion criterion for the present study included children aged 0-5 years old with normal birth weight (equal to or greater than 2,500 grams). Children with low birth weight were excluded in the analyses. In Brazil, the final sample consisted of 2,321 children; in Bolivia, 7,257; in Colombia, 13,918; and in Peru, 8,406 children. Children who had questionable values for their weight-for-age index, assessed by the WHO Anthroprogram[19] (z scores < -6 and >5) and who had incomplete data for target variables, were excluded from the analysis.

The interviews were carried out by trained members of the research team according to standardized protocols[17]. The anthropometric measurements from the subjects were obtained according to internationally standardized procedures,[20] in accordance to the DHS protocols used in the four countries.[17]

Birth weight was obtained from each child's birth certificate, and when such information was not available, the mother or responsible guardian was asked to provide the weight at birth. An infantometer was used to assess the length of children under two years of age, and a stadiometer was used to measure the height of children aged two years or over. Both devices were calibrated to a precision of one millimeter. Weight was obtained on an electronic scale calibrated with a precision of 100g.

Figure 1

Sample size flowchart.



Source: Data from *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher* (PNDS) in Brazil from November 2006 to May 2007;[13] *Encuesta Nacional de Demografía y Saludof Bolivia* (ENDSA), from February to June 2008;[14] Colombia (ENDS), to November 2009 to November 2010;[15] and Peru (ENDES), from March to December 2012.[16]

Weight and length/height were measured at the time of the interview.

In order to guarantee the comparability of the results of the present study, the target variables taken from the four countries were used in the data analysis.

The main exposure variable, RWG, was defined when the difference between the weight-for-age (WAZ) z-score value at the time of the interview and the WAZ z-score value at birth was greater than 0.67.[7] Obesity was the outcome variable, which was defined as a z-score of BMI for age (BMIz) ≥ 2.[21]

The adjustment variable was the duration of breastfeeding, considering the guidelines by the World Health Organization on the minimum ideal time of exclusive breastfeeding during 6 months.[22] Because the data base did not distinguish between exclusive or non-exclusive breastfeeding, the variable was therefore classified as "breastfeeding duration greater than or equal to 6 months" and "breastfeeding duration less than 6 months", regardless of being exclusive or non-exclusive. The variable "age" was categorized into five age groups to describe the sample population and defined as 0 to 12 months, 13 to 24 months, 25 to 36 months, 37 to 48 months, and 49 to 60 months.

For descriptive analysis, the prevalence and 95% confidence intervals of RWG, OW and duration of breastfeeding were estimated. In addition, Pearson's chi-square test was performed to test the differences between the proportions of these variables. Multivariate logistic regression was performed to estimate the odds ratio (OR) and 95% confidence interval (CI95%) of the association between RWG and OW. All models were adjusted for duration of breastfeeding as a potential confounding variable.

Data were analyzed using the STATA program, version 13.1[23] by means of an unconditional analysis of subpopulations. In other words, all participants were included in the analysis, even those who met the exclusion criteria.[24] Because this was a complex sampling plan, the unconditional analysis included models of the group of excluded subjects and this guaranteed the maintenance of the complex structure of the final sample.[24]

The surveys were approved by the Human Research Ethics Committees of the respective countries and participants were informed about the research objectives. Those wishing to participate gave their Informed Consent. The databases are part of the public domain and can be freely accessed through the respective websites: http://bvsms.saude.gov.br/bvs/pnds/index.php and https://dhsprogram.com/data/availabledatasets.cfm.

Results

The children's characteristics, estimates of breastfeeding prevalence, RWG and OW and the respective 95% confidence intervals for the four studied populations are presented in Table 1. The greatest prevalence of RWG and breastfeeding for less than 6 months was observed in Brazil (35.59% and 41.73%, respectively). The greatest prevalence of OW was reported in Brazil and Bolivia (11.09% and 11.58%, respectively).

Table 2 presents the prevalence distribution of children with RWG, by age group, according to country. In Brazil there was no observed statistically significant difference between age groups ($p = 0.274$). However, other countries have a greater proportion of children with RWG from zero and twelve months of age: 21.5% in Bolivia ($p < 0.001$), 30.2% in Colombia ($p < 0.001$) and 27.05% in Peru ($p < 0.001$).

Figure 2 presents the OR and CI95% values obtained from the logistic regression model for estimating the strength of association between RWG in children born with adequate weight and OW children in each analyzed country.

We observed that the chance of children being overweight when experienced RWG, compared to those who did not have RWG, was 6.1 times (CI95% = 3.8-9.7) in Brazil, 4.4 times (CI95% = 3.6-5.3) in Bolivia, 6.7 times (CI95% = 5.5-8.2) in Colombia, and 12.2 times in Peru (CI95% = 9.4-15.7), which was considered the greatest chance. It is noteworthy that the association between RWG and OW was statistically significant ($p < 0.001$) in the four countries, and all models were adjusted for the variable duration of breastfeeding (Figure 2).

The OR and CI95% values to estimate the strength of association between the RWG in children born with normal weight and OW in children from the respective countries were also evaluated and stratified by age group, in addition to being adjusted for the duration of breastfeeding variable (Figure 3). Peru and Brazil presented the greatest OR during the first 12 months of age (15.2 and 12.7, respectively); Peru and Colombia, between 1 and 2 years of age (16.0 and 9.0, respectively), between 2 and 3 years of age (8.4 and 6.1, respectively), and between 3 and 4 years of age (8.8 and 11.4 respectively); and, finally, Peru and Brazil between 4 and 5 years of age (13.9 and 9.0, respectively).

Discussion

The results of this study confirm the cross-sectional relationship between the presence of RWG and a high chance of a child becoming OW in Brazil, Bolivia, Colombia and Peru. In addition, a prevalence of RWG

above 15.0% and a prevalence of OW above 5.6% were estimated in the four evaluated countries.

In general, Latin American nations are classified as low and middle income countries having a predominately agriculture-based economy. However, some nations are industrially and technologically more advanced, such as Brazil.[25] There exists a correlation between robust healthy economies and a reduced period of breastfeeding duration, with some high income countries reporting a less than 20.0% breastfeeding prevalence.[26]

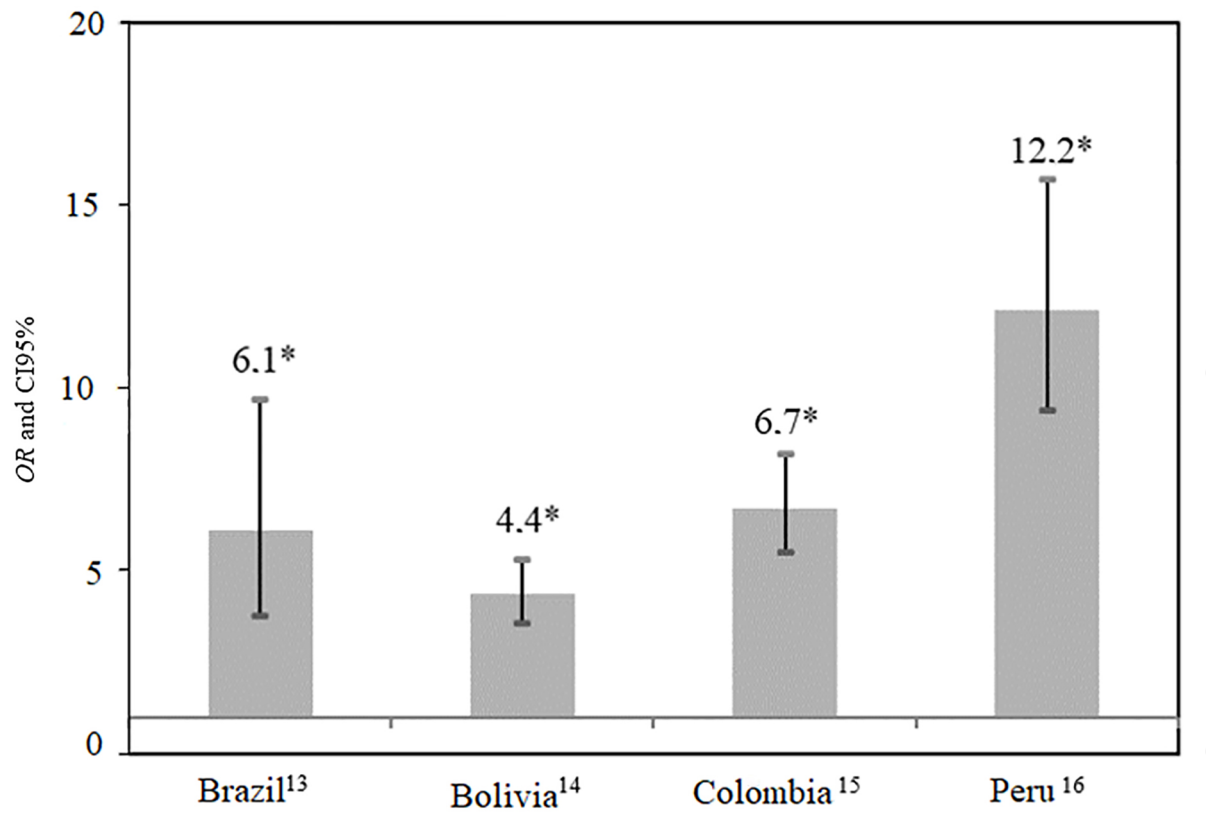
When evaluating the Gross Domestic Product (GDP) per capita, considering the year in which the DHS were developed,[27] we failed to observe a relationship between greater economic status and a shorter breastfeeding period for each of the countries under study. Other indicators must be evaluated related to social inequality, such as health service coverage, education, sanitation and drinking water supply, as well as policies to encourage breastfeeding, and not just those related to income.

The association between events that occur in early life, such as poor prenatal and postnatal growth, short- and long-term excessive adiposity, and overweight in children, have been described in the literature.[3,7] In children who were born with low birth weight, RWG may be protective to regain adequate weight. However, RWG does not occur only in children who were born with a low birth weight or prematurity. RWG occurred in children who were born with normal weight,[3] as demonstrated in the present study. In this sense, the occurrence of infant RWG can also be explained by other risk factors, which include the prenatal period, such as excessive gestational weight gain, as well as factors that include the postnatal period and the use of infant formula.[28]

In the present study, which examined children born with normal body weight, RWG indicates potential non-beneficial effects for the accumulation of body fat in childhood. The plausibility of the association between RWG and overweight remains unclear, despite the existence of several studies on the subject.[3] The potential heterogeneity of the strength of association of values between RWG and OW observed in children from these countries requires further investigation using more sophisticated methodological strategies to rule out alternative explanations. Furthermore, factors such as nutritional transition stages, cultural practices of infant

Figure 2

Odds Ratio and 95% Confidence Interval for obesity in children aged 0-5 years, according to rapid weight gain, adjusted for duration of breastfeeding in Brazil, Bolivia, Colombia and Peru.



Wald test; * $p < 0.001$. Source: Data from *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher* (PNDS) in Brazil from November 2006 to May 2007;[13] *Encuesta Nacional de Demografía y Saludof Bolivia* (ENDSA), from February to June 2008;[14] Colombia (ENDS), to November 2009 to November 2010;[15] and Peru (ENDES), from March to December 2012.[16]

Table 1

Prevalence of breastfeeding duration, rapid weight gain and overweight for age in Brazil, Bolivia, Colombia and Peru.

Characteristics of children	Brazil[13]			Bolivia[14]			Colombia[15]			Peru[16]		
	n	%	CI95%	n	%	CI95%	n	%	CI95%	n	%	CI95%
Breastfeeding duration (less than 6 months)	969	41.73	(38.56 - 44.97)	1,065	14.67	(13.60 - 15.81)	3,436	24.69	(23.69 – 25.71)	1,084	12.90	(11.95 - 13.92)
Rapid weight gain (> 0.67)	826	35.59	(31.57- 39.82)	1,091	15.03	(16.55 - 19.52)	2,873	20.64	(21.05 – 23.15)	1,776	21.13	(23.03 – 25.01)
Excess weight-for-age (BMIz ≥ 2)	257	11.09	(9.02 - 13.57)	840	11.58	(10.61 - 12.62)	789	5.67	(5.17 - 6.23)	720	8.56	(7.64 - 9.58)
Population sample size*	2,321			7,257			13,918			8,406		

*Complex sampling plan. The results correspond to the total number of mother-child binomials considered for analysis in this survey, with the exception of post-stratification weights. Source: Data from *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher* (PNDS) in Brazil from November 2006 to May 2007;[13] *Encuesta Nacional de Demografía y Saludof Bolivia* (ENDSA), from February to June 2008;[14] Colombia (ENDS), to November 2009 to November 2010;[15] and Peru (ENDES), from March to December 2012.[16]

Table 2

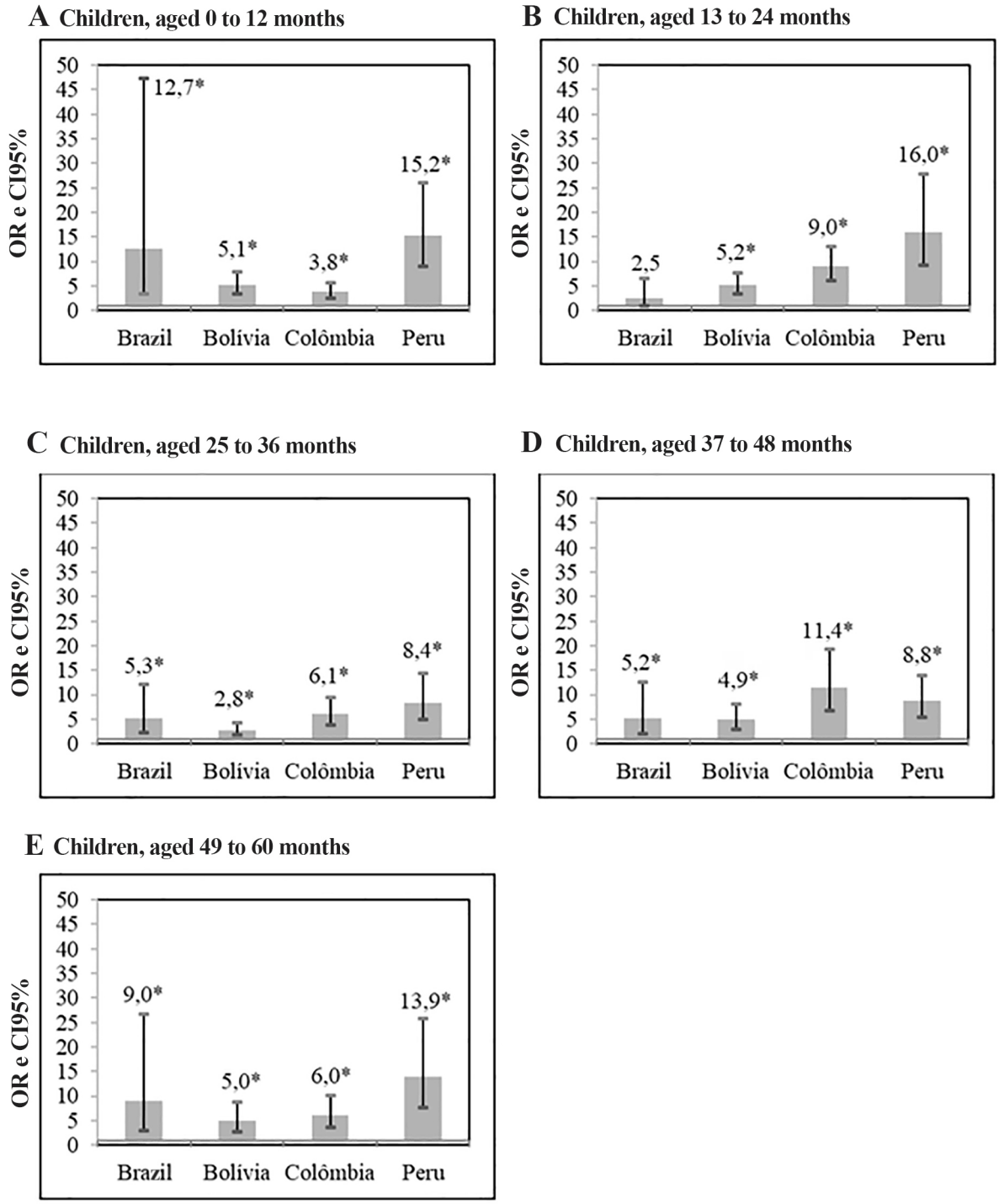
Proportion of children with rapid weight gain according to each age group in Brazil, Bolivia, Colombia and Peru.

Age group (months)	% of children with rapid weight gain							
	n**	Brazil[13]	n**	Bolivia[14]	n**	Colombia[15]	n**	Peru[16]
Population sampe size*	2,321		7,257		13,918		8,406	
0 – 12	387	33.5	1,576	21.5	2,811	30.2	1,733	27.0
13 – 24	492	33.5	1,563	15.3	2,799	21.2	1,679	20.8
25 – 36	460	39.4	1,434	14.3	2,823	17.6	1,764	19.4
37 – 48	489	40.5	1,444	11.1	2,848	16.7	1,739	20.8
49 - 60	493	30.8	1,240	11.8	2,637	17.7	1,491	17.1
*p****		0.274		<0.001		<0.001		<0.001

*Complex sampling plan. The results correspond to the total number of mother-child binomials considered for analysis in this survey, with exception of post-stratification weights; **n total equivalent to age group, with exception of post-stratification weights; *** Pearson's chi-square. Source: Data from *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher* (PNDS) in Brazil from November 2006 to May 2007;[13] *Encuesta Nacional de Demografía y Saludof Bolivia* (ENDSA), from February to June 2008;[14] Colombia (ENDS), to November 2009 to November 2010;[15] and Peru (ENDES), from March to December 2012.[16]

Figure 3

Odds Ratio and 95% Confidence Interval for obesity in children aged 0-5 years, according to rapid weight gain, adjusted for duration of breastfeeding and stratified by age groups in Brazil, Bolivia, Colombia and Peru.



Wald test by age group; * $p < 0.001$. A) OR and CI95% for obesity in children aged 0 to 12 months and rapid weight gain (RWG), adjusted for duration of breastfeeding; B) OR and CI95% for obesity in children aged 13 to 24 months and RWG, adjusted for duration of breastfeeding; C) OR and CI95% for obesity in children aged 25 to 36 months and RWG, adjusted for duration of breastfeeding; D) OR and CI95% for obesity in children aged 37 to 48 months and RWG, adjusted for duration of breastfeeding; E) OR and CI95% for obesity in children aged 49 to 60 months and RWG, adjusted for duration of breastfeeding.

Source: Data from *Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher* (PNDS) in Brazil from November 2006 to May 2007;[13] *Encuesta Nacional de Demografía y Saludof Bolivia* (ENDSA), from February to June 2008;[14] Colombia (ENDS), to November 2009 to November 2010;[15] and Peru (ENDES), from March to December 2012.[16]

feeding and public policies are potential reasons to explain the heterogeneity of variations of association.

Evidence suggests that the child's postnatal nutritional pattern,[3] in addition to maternal factors, such as maternal weight and smoking,[9] may present a relevant impact. Importantly, other studies have confirmed this association using anthropometric measures of adipose tissue distribution, such as waist circumference, skinfolds and visceral adiposity.[3]

The prevalence of OW in the world population is increasing[1,2] and, in this context, RWG during childhood is also a potential determinant for future overweight or obesity.[3,8,9,12] It is important to identify the decisive periods of OW risks and, with this, specify the susceptible events for intervention.[9,29] Also in this study, we observed that the greater chances of OW among children who presented RWG were greater during the first two years of life, with the exception of Colombia. According to Zheng *et al.*,[3] the first two years of life are strongly related to excessive weight gain. However, a Brazilian study reported that children between 2 and 5 years of age, that presented accelerated weight gain, were the same children who also were at a greater risk of becoming OW.[30]

Systematic reviews highlight the importance of the child's first thousand days of life for the prevention of childhood obesity, such as high pre-pregnancy maternal BMI, high maternal gestational weight gain, prenatal exposure to tobacco, high birth weight and RWG9 in terms of important infant intervention target measures.

This study also reinforces the need to explore non-modifiable determinants of biological factors,[7] including genetic factors that may be involved. Investigations such as the one in the present study, using representative data from children from Latin American countries, and demonstrating consistent results, bear relevance to the results in terms of plausibility and external validity of the presented associations.

The study presented several important limitations intrinsically common to a cross-sectional design, which does not allow for assessing the temporality of the relationships between exposure and outcome. The differences in surveys dates, taken from the studied target populations, was an additional methodological weakness, but the associations proved to be very strong and in the same direction. Without considering the potential heterogeneity of the values of the strength of association between populations, a subject that warrants further studies with more robust outcomes, it was clear that the observed associations would not have alternative explanations due to confusion, selection or measurement biases.

The variability of the odds ratio estimates between the populations and stratification groups (age and country) can be partially explained by the different sample sizes, this according to the amplitude of the 95% confidence intervals. Therefore, we should emphasize that the consistency of this association was observed across countries and age groups. These associations remained significant even after adjusting for duration of breastfeeding, which also acts as an important confounding variable.

Based on the results of the present study, the importance of preventing RWG during early childhood should be considered an important measure for reducing the incidence of OW in childhood. Child growth monitoring, including weight and height measures, is routinely done at primary care facilities using growth curves as a strategy for preventing risks to child health. Additionally, it has been suggested that monitoring the occurrence of RWG can also be considered a possible control measure.

We may conclude that there was an association between the occurrence of RWG in children born with adequate weight and the increased chance of childhood overweight, observed from the studied Latin American countries, namely Brazil, Bolivia, Colombia and Peru. Although the association values vary for each age group and country, the observed data were statistically significant, adding to and reinforcing the findings in the literature of the relationship between RWG and childhood OW. Attention must be given to ages that include early childhood, in order to promote a balanced and healthy child development. Thus, new exploratory studies on risk factors for RWG are crucial, since these are also presented as risk factors for childhood OW.

Author's contribution

All authors contributed to the design, data interpretation, writing and critical review of this article. Temponi HR performed the statistical analysis of the data. All authors approved the final version of this article. The authors declare no conflict of interest. The authors declare no conflict of interest.

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Received on December 18, 2020
Final version presented on November 10, 2021
Approved on November 30, 2021