Association between gestational weight gain and birth weight: NISAMI Cohort

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Abstract

Objectives: this study aims to evaluate the association between gestational weight gain and the weight of newborns from one municipality in Recôncavo Baiano region.

Methods: this is a prospective cohort (NISAMI Cohort), conducted with 185 pregnant women living in the urban area of the municipality of Santo Antônio de Jesus, using the prenatal service of the Family Health Units, between April 2012 and June 2013. The pre-gestationalBMI and the third trimester of pregnancy were used to assess maternal anthropometric status.Birth weight data were collected from the Epidemiological Surveillance of the municipality. Stata 12.0 software was used for statistical analysis. Logistic regression analysis was used to evaluate to assess the association.

Results: among the 185 women evaluated, 33.5% presented inadequate weight gain during pregnancy. The prevalence of inadequate birth weight was 20% (birth weight ≤ 2.999g and ≥ 4.000 g).
It was observed that inadequate weight gain during pregnancy is considered an embarrassing factor for birth weight (OR= 2.6; CI95%= 1.5-3.5); adjusted for the following variables: alcohol consumption, duration of pregnancy, and gestational complications.

Conclusion: the research results suggest that weight gain throughout pregnancy influences the weight of the conceptus, indicating the need for nutritional interventions in all trimesters of pregnancy, promoting a healthy weight gain throughout the gestational cycle.

Key words *Gestational weight gain, Child health, Maternal and child health*

http://dx.doi.org/10.1590/1806-93042020000200005

Introduction

Birth weight is considered a relevant event in the health issue because it is related to health and nutrition conditions of children in their first months of life. Thus, it is a determining factor for the development of neonatal morbidity and mortality. Epidemiological studies have recorded those disparities in birth weight, both low weight (birth weight <2.500g)[1] and macrosomia (birth weight >4.000g),[2] are associated with a higher incidence of neonatal complications[1] and are risk factors for overweight, obesity, *diabetes mellitus*, metabolic syndrome and other chronic non-communicable diseases in later life cycles.[3]

Regarding epidemiological data on outcomes studied in 2001, a prevalence of 5.9% of macrosomia was recorded in Brazil, with the Northeast (7.5%) and North (7.3%) regions, the ones with higher prevalence when compared to the national data. Thirteen years later, there was a decrease in national rates (5.5%) in the Northeast (6.9%) and North (6.5%) regions.[4]

Regarding the prevalence of low birth weight (LBW), this is lower in regions where access and quality of health is adequate, and nutrition conditions and socioeconomic status is favorable.[5] In societies where the population has low purchasing power and access to health services is unwarranted, the prevalence of LBW tends to be high. In Brazil, there is a decrease in this parameter over the years, with a record of 8.0% in 2005. In the North and Northeast and more impoverished regions of Brazil, the recorded prevalence was 9.7% in 1994[6] and it decreased, mainly in the Northeast Region, to 6.8% in 2000.[7]

Numerous factors are considered determinants of the weight of newborns, for example, biological, genetic, social, and environmental factors. Among these maternal health and nutrition conditions during the gestational period have a relevant impact on the nutritional and health conditions of the conceptus.[8,9] Some studies have indicated evidence that nutritional disorders (low weight and overweight) have a negative influence on the outcome of pregnancy,[10,11] associated with birth weight inadequacies.[12] In this sense, the present study aims to analyze the association between gestational weight gain and weight of newborns in a cohort of one municipality in Recôncavo Baiano region.

Methods

This study is a prospective, dynamic cohort, NISAMI Cohort (*Núcleo de Investigação em Saúde Materno Infantil* - NISAMI), conducted with pregnant women that are part of the project entitled "Maternal risk factors for low birth weight, prematurity, and intrauterine growth retardation, in the Recôncavo Baiano region" developed in the municipality of Santo Antônio de Jesus.

The study population included 185 pregnant women aged 19 years or older, living and domiciled in the urban area of the municipality. Those women were enrolled in the prenatal service of the Family Health Units (FHU), between April 2012 and June 2013. They were in the first gestational trimester and followed for 6 to 7 months, comprising the period of enrollment until the birth of the child.

Santo Antônio de Jesus islocated in the Recôncavo Baiano region, State of Bahia, 187 km from the capital, Salvador. According to the Demographic Census conducted in 2010, 90.985 of the inhabitants of this city (91.7%) lived in the urban area and only 8.3% in the rural area. From this population, 48.020 were female (52.7%). From the economic point of view, the main activities of the municipality are agriculture, livestock, and trade. Regarding the health care network, it was composed of 23 basic health units.[13]

Prenatal care in the municipality is provided by a multidisciplinary team of the unit (doctor, nurse, and dentist), recommending a minimum of 6 consultations during the gestational period. Nevertheless, it is observed that a considerable percentage of mothers search for prenatal care after the first trimester of pregnancy, and this late search makes it impossible to monitor women's health and nutrition conditions adequately.

For the sample calculation of the study, the equation of the mean test for cross-sectional studies was used. As suggested by Siqueira *et al.*,[14] it is noteworthy that this equation was adopted because it considers that the response variable has a unique event characteristic. For this purpose, the mean birth weight of 3.196g was taken as a reference with a standard deviation of 456g,[15] assuming a difference of 100g in birth weight when associated with weight gain during pregnancy, sampling error of 2%, and acceptable loss of 15%. Thus, a sample of 175 pregnant women was estimated. However, it was opted to include the 185 pregnant women already enrolled and who met the inclusion criteria in the sample.

During the enrollment of pregnant women in prenatal services in the FHU, the first-trimester preg-

nant women answered a semi-structured questionnaire. In this way, based on the questionnaire, information about the socio-economic, demographic, reproductive, and/or obstetric history and lifestyle were answered. Besides, data regarding weight and height measurements were evaluated. In the second and third trimesters, anthropometric measurements were taken at the pregnant woman's home. Adequately trained researchers performed all measurements and application of the instrument.

The measurement of height and weight of pregnant women followed the guidelines proposed by the Brazilian Ministry of Health according to the Food and Nutrition Surveillance System (SISVAN – Portuguese acronym) - basic guidelines for the collection, processing, analysis of data and information in health services, published in 2004.[16]

To measure the weight, a portable digital scale was used, validated for use in Brazil's research, according to the manufacturer, MARS brand, calibrated periodically, with a capacity of 150 Kg, sensitivity of 100 g. Height was measured using the Welmystadiometer with a capacity of 2.000 mm and a sensitivity of 0.5 cm. Anthropometric measurements were taken in duplicate. A maximum variation of 0.5cm was accepted for length measurement and 100g for weight.

Body mass index (BMI) - by weight in Kg/height^2- pre-gestational, was used to assess pre-gestational anthropometric status, and this was classified based on the parameters of the Institute of Medicine (IOM).[17]

- Low weight for height: BMI < 18.5 Kg/m^2; (1)
- Adequate weight for height: BMI = 18.5 to 24.9 Kg/m^2; (2)
- Overweight for height: BMI = 25 to 29.9 Kg/m^2; (3)
- Obesity for height: (BMI >30 Kg/m^2) (4).

Gestational BMI, according to the Atalah *et al*.[18] curve, was used to assess the gestational anthropometric status and was classified into the following categories: (1) low weight, (2) adequate, (3) overweight and (4) obesity.

The total gestational weight gain (Kg) was considered as the primary exposure, defined as the difference between gestational weight and pre-gestational weight. Thus, it was classified based on the preconception anthropometric state, following the recommendations of the IOM.[17] Thus, if the woman started the pregnancy with low weight, a gain of 12.5Kg to 18Kg was expected. For eutrophic pregnant women, the gain of 11.5Kg to 16Kg was expected. In overweight case, the weight gain margin was from 7 Kg to 11.5Kg and, if the pregnant woman was obese, the expected gain was from 5Kg to 9Kg. For women who had weight gain outside these values, it was considered inadequate gain (1), and those that remained within these recommendations were categorized as having adequate gain (0).

Birth weight and height were measured by health service professionals trained for this purpose using a digital pediatric scale, Welmy brand, with a capacity of 15Kg and an interval of 10g. This information was then recorded in a standardized instrument and forwarded to the Epidemiological Surveillance (VIEP – Portuguese acronym) of the municipality. Finally, birth weight data were collected from the VIEP system.

Birth weight is the response variable of this study. For the description of the sample and to know the distribution of this variable in the study population, birth weight was categorized according to the criteria of the World Health Organization, as determined: low weight (<2.500 g), underweight (2.500g to 2.900g), adequate weight (2.900 g to 3.999 g), and overweight (> 4.000 g).[19] For statistical analysis, this variable was categorized as adequate (birth weight $\geq$ 3.000 g to $\leq$ 3.999 g) [0] or inadequate (birth weight $\leq$ 2.999 g and $\geq$ 4.000 g) [1].

The following covariates of interest were considered: sociodemographic conditions (maternal age, schooling, race/color), lifestyle (sedentary lifestyle, alcohol use, smoking), maternal nutritional factors (pre-gestational and gestational anthropometric status), prematurity (duration of pregnancy <37 weeks) and child gender.

Data analysis was performed in Stata 12.0 software. At first, descriptive analyses were performed, being mean and standard deviation for quantitative variables and the proportion for categorical variables. To analyze the presence or not of association between the exposure of the main variable, the covariates and the outcome studied, the crude and adjusted OR (*odds ratio*) was estimated for each association of interest, adopting a 95% confidence interval (CI95%). In the bivariate analysis, Pearson's chi-square test (χ^2) was used to compare the proportions of sociodemographic, obstetric, and anthropometric characteristics of pregnant women according to birth weight.

In statistical modeling, the variables that presented *p*-values $\leq$0.20 in the crude analysis (association between independent variables and outcome) were introduced in the Logistic Regression model using the *backward* selection criterion. The variables that presented *p*-value $\leq$0.05 were maintained in the model, after adjustment by covariates. Subsequently, the estimates of *odds ratios* and their respective

CI95% were obtained.

For the identification of interaction and confounding, stratified analysis was performed, with estimates of stratum-specific measures for each covariate and its CI95%.

A term product was constructed (multiplication of the main predictor variable with the possible effect-modifying variables – pre-gestational anthropometric state). Effect modifiers were those that presented statistically significant results in the Maximum Likelihood Ratio test, based on comparisons between saturated and reduced models. Effect confounders were those that implied a relative difference between the adjusted measurements of each covariate and the measure of gross association equal to or higher than 20%.

The Research Ethics Committee of the School of Nutrition (CEPNUT) of the Federal University of Bahia evaluated and approved the study's ethical relevance (permit number:16/12). The pregnant women who agreed to participate in the study signed a free and informed consent form.

Results

The study population included 185 pregnant women with an average age of 27 years (SD=5.5) and average pregnancy total weight gain of 10.8 Kg (SD=5.76). Of these, 33.5% had inadequate weight gain (excess and deficit weight). In Table 1 is described the characterization of the study population, according to sociodemographic, obstetric, and anthropometric information. A predominance of women with low educational level (85.9%), brown/black (83.8%) primiparous (75.7%) sedentary (91.4%) could be observed. The anthropometric status characterized by overweight (overweight/obesity) was 44.0% in the preconception period and 48.1% in the gestational period.

Regarding newborns, 51.4% were female. The prevalence of inadequate birth weight was 20% (data not shown in table).

The categories of birth weight, according to total pregnancy weight gain, are depicted in Figure 1. It was observed that 28.6% of the women who had weight gain below the recommendations and 18.2% of those with excessive weight gain, had children with inadequate birth weight.

The main sociodemographic, obstetric, and anthropometric characteristics of pregnant women and newborns according to birth weight are presented in Table 2. It was detected that women with positive alcohol consumption, gestational complications, inadequate pregnancy weight gain, and gestational age <37 weeks had a higher frequency of newborns with inadequate birth weight compared to women who presented these characteristics within normal standards. The differences observed were statistically significant (p<0.01).

The results of bivariate and multivariate analyses of the association between pregnancy total weight gain, covariates, and inadequate birth weight are presented through the *odds ratio* and respective CI95% (Table 3). It was observed that women who presented inadequate weight gain during pregnancy had 2.6 (OR= 2.6; CI95%= 1.5-3.5) times more chances to have children with inadequate birth weight when compared to women with adequate gestational weight gain. In the crude analysis, other associations with positive and significant outcomes were observed for the following variables: alcohol consumption, prematurity, and presence of gestational complications. The associations were maintained when adjusted by covariates; however, a slight reduction in magnitude was detected. This reduction did not affect the statistical significance of the association (Table 3). For the other variables analyzed, no statistically significant associations were observed.

Discussion

The results of this study indicate that inadequate weight gain during pregnancy, both low and overweight, are considered embarrassing factors of birth weight.

These results corroborate the thesis of other national[20-22] and international studies,[23-25] that reveal weight gain during pregnancy as a factor that influences birth weight.

Maternal weight gain is also influenced by different factors, being these environmental, genetic, obstetric and nutritional.[26] Among the nutritional factors, food intake is highlighted (deficit in intake of food that are sources of macronutrients and micronutrients), as a sensitive condition of maternal nutritional status, as observed in this investigation. Also, it is relevant to mention that the food inadequacy registered during this period may favor maternal-fetal competition. Consequently, it reduces the avai-lability of essential nutrients for pregnancy development, as well as for fetal growth,[13] impacting the adequate birth weight.[27]

Results of epidemiological studies indicate that gestational weight gain below and/or above the recommendations of IOM[16] may negatively influence the health of the conceptus. Evidence indicates that low maternal weight and nutrient deficiencies

Table 1

Sociodemographic, obstetric and anthropometric characterization of pregnant women and newborns. Santo Antônio Jesus. Bahia. 2012-2013 (n=185).

Variables	N	%
Maternal age (years)		
≥35	52	28.1
<35	133	71.9
Maternal education		
<High school	159	85.9
≥High school	26	14.1
Family income (minimum wage)		
≤1	46	24.9
>1	139	75.1
Color		
White	30	16.2
Brown/black	155	83.8
Smoking		
Smoker/ex-smokers	16	8.6
Non-smoker	169	91.4
Alcohol consumption		
Yes	24	13
No	161	87
Physical activity		
No	169	91.4
Yes	16	8.6
Number of pregnancies		
Primiparous	140	75.7
Multiparous	45	24.3
Gestational complications		
Yes	49	26.5
No	136	73.5
Pre-gestational anthropometric status		
Overweight	82	44.0
Eutrophy/thinness	103	56.0
Gestational anthropometric status		
Overweight	89	48.1
Eutrophy/thinness	96	51.9
Total gestation weight gain		
Inappropriate	62	33.5
Suitable	123	66.5
Gender of the child		
Male	90	48.6
Female	95	51.4

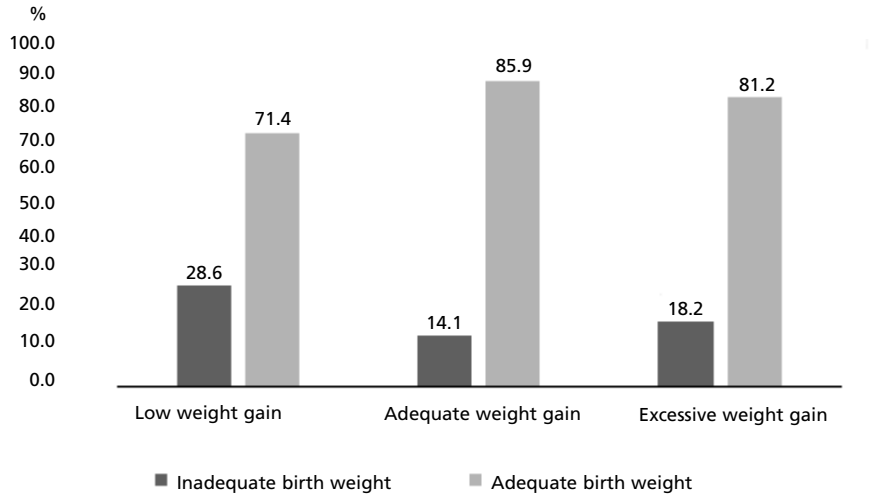
can directly affect the outcome studied. They also indicate that excessive weight gain (overweight/obesity) can indirectly influence the newborn's weight, i.e., it is associated with the development of gestational diabetes and/or hypertensive syndromes (gestational complications), and these negatively affect the child's weight.[12]

Epidemiological studies such as that carried out by Fonseca *et al*.[21] reported a significant association between total gestational weight gain and the weight status of the newborn (NB). According to this study, pregnant women with insufficient weight gain had a 2.15 times higher risk of having newborns with insufficient weight (CI95%= 1.40-3.30) and 2.85 times higher risk of low weight (CI95%= 1.51-5.38).

Wen *et al*.[24] also observed that women with ina-

Figure 1

Total weight gain of pregnant women attended in prenatal services in the health networks of the municipality of Santo Antônio de Jesus, BA, 2012 - 2013.



dequate gestational weight gain had a higher chance of births of children with low weight (OR = 2.13; CI95%= 1.75-2.86).

It was also recorded in a sample of 1,617 women that 15.2% of them had gestational weight gain below, and in 52.1 %, the gestational weight gain was above the IOM guideline. Overweight and maternal obesity were associated with increased risk of macrosomia (OR = 1.7; CI95% = 1.2 - 2.6) and large NB for gestational age (OR= 1.7; CI95% = 1.1 - 2.5). On the other hand, women who had insufficient gestational weight gain were more likely to have NB with low weight (OR=2.2; CI95%= 1.1 - 4.4) and small for gestational age (OR = 2.0; CI95%= 1.2 -3.4), when compared to women who had adequate gestational weight gain.[27]

The results of this study also indicate that prematurity (duration of pregnancy <37 weeks), alcohol consumption, and gestational complications are factors that negatively influence obstetric outcomes. Other epidemiological studies have also reported an association of these factors with adverse outcomes for maternal health, with consequent negative programs for children's health,[29,30] and thus, reflecting on health in all life cycles.

Meta-analysis results indicate that excessive alcohol consumption (consumption higher than 10 g of pure alcohol/day) during pregnancy increases the risk of low weight and prematurity. In contrast, mild alcohol consumption may not affect these neonatal outcomes.[29]

It is also recorded that eclampsia, anemia, and hemorrhage are gestational complications that increase the risk of prematurity and low birth weight.[30]

Thus, the evidence indicates that the weight of the newborn is influenced by nutritional predictors, health status, and lifestyle of women. As mentioned before and observed in the current study, weight gain during pregnancy was the predictor most strongly associated with birth weight even when adjusted for other variables, influencing the birth condition and child health.

The use of the Atalah curve for categorizing the gestational anthropometric state is considered as a presumable limitation of this study, due to the possibility of over estimating maternal excess and low weight classification. However, this method was used in the study because the Ministry of Health recommends it for the anthropometric evaluation of pregnant women in prenatal care of the Unified Health System (SUS – Portuguese acronym).

It can also be credited as a limitation the measurement of the child's weight by the maternity health professional. However, it is unlikely that this item constitutes a bias towards thestudy results since the cohort team trained the professionals. Besides, the equipment is validated and used in other studies of the research group.

The results of the current study suggest that gestational weight gain influences the conceptus weight and indicates that nutritional interventions

Table 2

Sociodemographic, obstetric and anthropometric characteristics of pregnant women and newborns according to birth weight. Santo Antônio Jesus, Bahia, 2012-2013 (n=185).

Characteristics	Adequate birth weight		Inadequate birth weight		*p*
	n	%	n	%	
Total gestation weight gain					
Inadequate	81	54.7	26	70.2	*<0.001
Adequate	67	45.3	11	29.8	
Maternal education					
<High school	22	14.9	4	10.8	0.4
≥High school	126	85.1	33	89.2	
Maternal age (years)					
≥35	104	70.3	29	78.4	0.2
<35	44	29.7	8	21.6	
Income (minimum wage)					
≤1	114	77	25	67.6	0.2
>1	34	23	12	32.4	
Color					
Brown/black	122	15.9	32	86.5	0.5
White	23	84.1	5	13.5	
Smoking					
Smoker/ex-smokers	12	8.1	33	89.2	0.4
Non-smoker	136	91.8	4	10.8	
Alcohol consumption					
Yes	134	90.5	27	73	*<0.001
No	14	9.5	10	27	
Physical activity					
No	136	91.9	33	89.2	0.4
Yes	12	8.1	4	10.8	
Number of pregnancies					
Primiparous	74	50	17	45.9	0.2
Multiparous	74	50	20	54.1	
Gestational complications					
Yes	33	22.3	21	56.8	*<0.001
No	115	77.7	16	43.2	
Pre-gestational anthropometric status					
Overweight	66	44.6	15	40.5	0.4
Eutrophy/thinness	82	55.4	22	59.5	
Gestational anthropometric status					
Overweight	39	26.4	13	35.1	0.2
Eutrophy/thinness	109	73.6	24	69.9	
Duration of pregnancy (weeks)					
<37	140	94.6	28	75.7	*<0.001
≥37	8	5.4	9	24.3	
Sex of the child					
Male	75	50.7	15	40.5	0.2
Female	73	49,3	22	59,5	

*Pearson´s Chi-square test.

Table 3

Crude and adjusted analysis for the association between inadequate weight gain during pregnancy and inadequate birth weight according to the covariates. Santo Antônio de Jesus, BA, 2012 - 2013.

Variables	N	Crude analysis		Adjusted analysis	
		OR	CI95%	OR	CI95%
Total gestation weight gain					
Inadequate	62	2.2	1.2-3.9	2.6**	1.5-3.5
Adequate	123				
Alcohol consumption					
Yes	24	3.5	1.4-8.8	3.5	1.1-5.5
No	161				
Gestational complications					
Yes	49	2.6	1.2-5.6	2.6	1.1-5.3
No	136				
Duration of pregnancy (weeks)					
<37	17	5.6	2.0-5.2	3.7	1.3-5.0
≥37	168				

** Adjusted for alcohol consumption, gestational complications, and pregnancy duration.

are necessary for all trimesters of pregnancy. So, it is crucial to monitor the weight of pregnant women by promoting a healthy weight gain throughout the cycle of pregnancy. Furthermore, monitoring other risk factors such as alcohol consumption and pregnancy complications during the prenatal period contributes significantly to the decrease in birth weight inadequacies.

The implementation of studies that identify risk situations for the birth of children with low weight provides subsidies for the implementation of health actions. These researches focus on the quality of nutritional assistance for women in the reproductive period. Consequently, they can foster intersectoral actions that result in favoring ideal conditions for fetal growth and development.

Acknowledgments

The authors are thankful to the Research Support Foundation of the State of Bahia (FAPESB – Portuguese acronym), and the National Council for Scientific and Technological Development (CNPQ – Portuguese acronym) for financial support.

Authors' contribution

Santana JM and Santos DB contributed to the design of the project, analysis and interpretation of data, preparation and critical review of the article. Assis AMO participated in the project design and critical review of the article. Alves WPO collaborated in the preparation and critical review of the article. All authors approved the final version of the article.

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Received on October 22, 2018

Final version presented on February 6, 2020

Approved on March 10, 2020