https://doi.org/10.1590/1678-9865202235e210197

ORIGINAL

Association between maternal dietary intake classified according to its degree of processing and sex-specific birth weight for gestational age

Associação entre o consumo alimentar materno na gravidez de acordo com o grau de processamento e peso ao nascer segundo a idade gestacional e sexo

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ABSTRACT

Objective

To assess the association between the maternal diet, according to the degree of processing of food consumption, and birth weight for gestational age and sex.

Methods

A cross-sectional study with 300 women was conducted from February 2009 to 2011 from a maternity ward in *Mesquita, Rio de Janeiro*. The outcome was based on sex-specific birth weight for gestational age: small, adequate,

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Article based on the master's dissertation of GG ROCHA, entitled "*Consumo de alimentos segundo o grau de processamento durante a gestação e sua associação com o peso ao nascer*". Universidade Federal do Rio de Janeiro; 2018.

How to cite this article

Rocha GG, Andrade-Silva A, Alves-Santos NH, Castro MBT. Association between maternal dietary intake classified according to its degree of processing and sex-specific birth weight for gestational age. Rev Nutr. 2022;35:e210197. https://doi.org/10.1590/1678-9865202235e210197

or large. A validated food frequency questionnaire was used to estimate the food consumption during the 2nd and 3rd trimesters of pregnancy. The food intake was classified into three groups according to the degree of processing: 1) unprocessed or minimally processed foods and culinary ingredients (oil, fats, salt, and sugar), 2) processed foods, and 3) ultra-processed foods. Descriptive analyses were made to assess the tertiles of the percentage of energy intake of each food group on the outcome and on maternal and infant characteristics. Multinomial logistic regressions were used to test the association of the tertiles of food according to the degree of processing on the outcome (adequate, small, or large birth weight for gestational age and sex).

Results

The analysis of the food frequency questionnaire from the 300 women indicated that the mean percentage of kcal consumed from unprocessed and minimally processed food and culinary ingredients was 54.0%, while the percentages of energy from processed foods and ultra-processed foods were 2.0% and 44.0%, respectively. The highest tertile of consumption of unprocessed and minimally processed food and culinary ingredients had a protective effect on the prevalence of newborn large for gestational weight in relation to the lowest (OR: 0.13; 95% IC: 0.02 to 0.89; *p*=0.04).

Conclusion

High consumption of unprocessed and minimally processed food and culinary ingredients during the last six months of pregnancy might be a protective factor against having a newborn large for gestational weight when compared to mothers with the lowest consumption.

Keywords: Eating. Healthy eating. Newborn. Ultra-processed food.

RESUMO

Objetivo

Avaliar a associação da dieta materna de acordo com o grau de processamento dos alimentos e o peso ao nascer segundo a idade gestacional e sexo.

Métodos

Estudo transversal com 300 mulheres captadas entre os meses de fevereiro de 2009 e 2011. Utilizou-se a classificação do peso ao nascer segundo sexo e idade gestacional para caracterizar os desfechos: pequeno, adequado ou grande. O questionário de frequência alimentar estimou o consumo durante o 2º e 3º trimestres da gestação. Os alimentos foram classificados segundo o grau de processamento: 1) alimentos in natura ou minimamente processados e ingredientes culinários (óleos, gordura, sal e açúcar), 2) alimentos processados e 3) alimentos ultraprocessados. Os tercis de energia das categorias descritas acima foram distribuídos segundo o desfecho e as características maternas e do recém-nascido. Adotou-se a regressão logística multinomial para analisar a associação do consumo de alimentos segundo o grau de processamento sobre os desfechos do peso ao nascer segundo a idade gestacional e o sexo (pequeno, adequado ou grande).

Resultados

A análise do questionário de frequência do consumo alimentar das 300 mulheres indicou que a contribuição de alimentos in natura ou minimamente processados e ingredientes culinários foi de 54,0%, enquanto que os percentuais dos grupos de alimentos processados e ultraprocessados foram 2,0% e 44,0%, respectivamente. O maior tercil de alimentos in natura ou minimamente processados e ingredientes culinários obteve efeito protetor para a prevalência de recém-nascidos grandes para a idade gestacional e o sexo em relação ao menor tercil (OR: 0,13; IC 95%: 0,02;0,89; p=0,04).

Conclusão

O maior consumo de alimentos in natura ou minimamente processados e ingredientes culinários durante a gestação pode ser um fator de proteção contra a ocorrência de recém-nascidos grandes para a idade gestacional e o sexo quando comparado com mães classificadas no menor tercil de consumo.

Palavras-chave: *Consumo alimentar. Dieta saudável. Recém-nascido. Alimentos ultraprocessados.*

INTRODUCTION

Birth weight is considered an indicator of the development of the fetus, and its inadequacy is one of the main risk factors for neonatal and perinatal mortality, with immediate and long-term effects on the health of the newborn, such as the incidence of allergic and respiratory diseases in the first years after birth [1-4]. In 2014, Villar *et al.* [5] proposed new charts of birth weight segmented by gestational age, weight and sex, and the cut-offs of below the 10th and above the 90th percentiles have been used to classify infants as Small for the Gestational Age (SGA) and Large for the Gestational Age (LGA), respectively [5]. Both extreme percentiles are associated with the occurrence of chronic non-communicable disease during adult life, such as obesity, coronary heart diseases, and type 2 diabetes mellitus [2,3,6].

Studies have shown that there is an association between healthy dietary patterns, mostly composed of vegetables and less processed food, and a low prevalence of SGA births [7,8]. On the other hand, maternal dietary patterns composed mostly of industrialized foods were positively associated with inadequate or increasing birth weight [9-11]. However, it is still difficult to evaluate these results in relation to Adequate birth weights for the Gestational Age and Sex (AGA), and maternal diet, because studies that use dietary patterns usually include food that may be considered healthy or unhealthy depending on the level of processing of the item [12].

One way to overcome this is to use the method of evaluating the dietary intake based on the NOVA food classification proposed by Monteiro *et al.* [13], which was adopted by the second edition of the Dietary Guidelines for the Brazilian population [14]. The main idea is to classify food items according to the degree of industrial processing, as: unprocessed and Minimally Processed Foods (MPF), Culinary Ingredients (CI), Processed Foods (PF), and Ultra-Processed Foods (UPF) [15,16].

Studies using the NOVA classification system have found associations between the high consumption of UPF and gestational weight gain, newborn fat mass, and maternal diet quality and gestational weight gain [15-18], besides excess weight, obesity, inadequate intake of micronutrients and chronic diseases in late life stages [19-25], but there is a gap in the literature about the relationship of UPF on SGA and LGA. Scientific studies are necessary to evaluate the association between the degree of food processing and the adequation of birth weight for the age and sex. Since maternal dietary intake is essential for fetal development and AGA, and because this relationship has impacts on childhood and during adult life, the aim of this study is to investigate the association of the maternal dietary intake based on the NOVA food classification on birth weight according to the gestational age and sex.

METHODS

This cross-sectional study was based on research carried out between February 2009 and February 2011. The interviews were conducted in a maternity ward in the *Leonel de Moura Brizola* Public Hospital located in *Mesquita*, a city in the state of *Rio de Janeiro*, Brazil, during the first week after the delivery. Women who met the following eligibility criteria were invited to participate in the study: being in the immediate postpartum period (one week), aged between 18 to 45 years old, residing in the area or close to the county, with a singleton pregnancy, and absence of non-communicable chronic diseases such as diabetes mellitus, systemic arterial hypertension, and hypothyroidism (except for overweight and obesity). From 338 postpartum women, 334 agreed to participate in the study. Three were excluded (0.90%) because the gestational age at the delivery was less than 33 weeks (n=2) or greater than 42 weeks (n=1), and 31 (9.3%) had missing data. The sample of the study was based on 300 (89.8%) pairs of women/newborn children (Figure 1).

This study was approved by the Ethics Committee of the Institute of Social Medicine from *Rio de Janeiro* State University under CAAE protocol nº 0022.0.259.000-09. The participation in the study was voluntary and all women received information regarding the procedures and objectives of the research. All the participants signed written consent forms.

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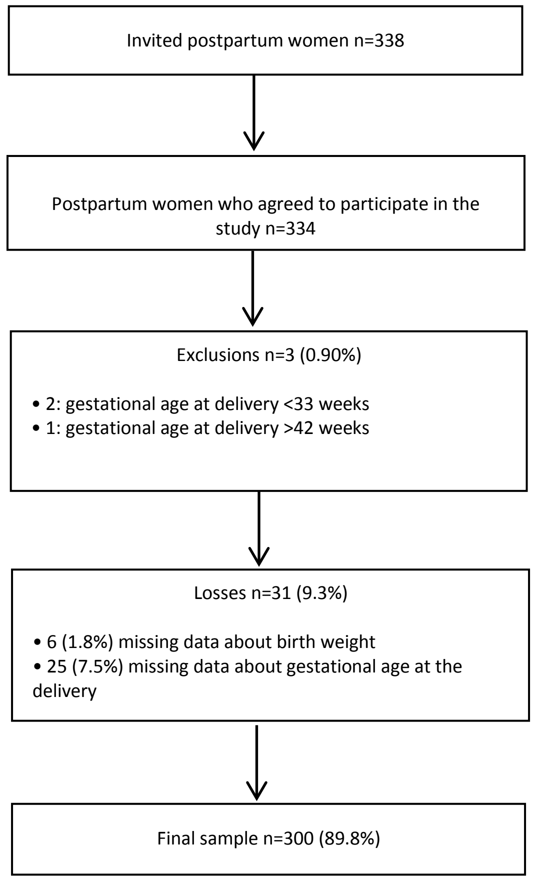

Figure 1 – Flowchart of invitation, losses, and exclusions from this study. *Mesquita* (RJ), Brazil, 2009-2011.

The information about birth weight, birth length, gestational age at birth, and sex were obtained from each child's health records. The children's birth weight was classified according to sex (male or female) and gestational age (weeks) into three categories: SGA (birth weight <10th centile); LGA (birth weight >90th centile), and AGA (≥10th birth weight ≤ the 90th centiles) according to the charts elaborated by Villar *et al.* [5]. These categories of birth weight for gestational age and sex were considered the outcome of this study.

A structured questionnaire was applied by trained nutritionists in the maternity ward in the first week after birth to obtain sociodemographic, nutritional, and clinical information: maternal age (years), total family income (in US dollars), parity (one or more than one children), maternal education (schooling years), marital status (married/stable union or single and others), self-reported skin color (white, yellow or black/brown), smoking habit during pregnancy (yes or no) and alcohol consumption during pregnancy (yes or no).

To measure the height, we used a stadiometer (AlturaExata®, Brazil) with a precision of 0.1 centimeters, and for weight a scale (533 model, Tanita, Brazil) with a capacity of 150 kg and a precision of 100 grams. The Pre-Pregnancy Body Mass Index (PPBMI) was calculated with the information of the pre-gestational weight that was measured until the 13th week of gestation and recorded in the patient's health chart. If it was not recorded, we used the pre-gestational weight provided by the women. PPBMI was classified as recommended by the World Health Organization [26]. The Gestational Weight Gain during pregnancy (kg) was obtained from the difference between the last measured gestational weight and the informed pre-gestational weight, and this measure of body weight was classified according to the Institute of Medicine guidelines [27].

A validated semi-quantitative Food Frequency Questionnaire (FFQ) was applied in the maternity ward during the first postpartum week to assess the usual food consumption of the mothers during the second and third gestational trimesters before giving birth [28,29]. We used this FFQ because it was the instrument validated for adults in the state of Rio de Janeiro at the time when the interviews were carried out. Then, it was also relatively validated to use with pregnant women by Giacomello *et al.* [29].

The FFQ included 81 food items and had eight categories of frequency: "less than once a month", "1 to 3 times a month", "once a week", "2 to 4 times a week", "5 to 6 times a week", "once per day", "2 to 3 times per day" and "more than 3 times per day". Each food item had options of daily servings as household measures. The daily dietary intake was obtained by multiplying the household measures of each food into grams [30] by the consumption frequencies. The nutritional composition of the dietary intake was calculated using the Brazilian Food Composition Table, and when the nutritional value of a food was not found in the table, we used the table from the United States Department of Agriculture National Nutrient Database for Standard Reference [31,32].

The food items present in the FFQ were categorized into four groups, as described in the study by Alves-Santos *et al.* [33], and according to the NOVA food classification [13,14]: (i) MPF (*i.e.* whole foods, vegetables and fruits, animal items which are not processed, such as fish, meat and eggs); (ii) CI (*i.e.* culinary and basic ingredients to prepare meals such as vegetable oil, butter, salt, sugar); (iii) PF (*i.e.* salty meat, desserts made with fruits and sugar, canned fish with oil and salt); and (iv) UPF (*i.e.* candies, snacks, soft drink, chocolates, ice cream as well as sausages, processed meats, fast-foods). We then combined the unprocessed and minimally processed food adding culinary ingredients such as oils, fats, salt, and sugar items in the same group [14], called the MPFC (unprocessed and minimally processed food and culinary ingredients). The percentage of relative energy intake from each food group according to the degree of processing were distributed into tertiles (% kcal). The first tertiles were classified as the lowest consumption percentages, and the third tertiles have the highest percentages of consumption.

Descriptive analyses were made to assess the distribution of the outcome (SGA, AGA, LGA) and social, nutritional, and clinical characteristics of the mothers and neonates among the tertiles (%kcal) from each food group according to the degree of processing: MPFC, PF, and UPF groups. The analyses were made using ANOVA test for means [± standard deviation (SD)], using Bonferroni as *post hoc test*, and the Chi-squared test or Fisher's Exact test for proportions.

Logistic multinomial models were applied to assess the odds ratio (OR) of the association of the tertiles of food groups according to the degree of processing with the categories of birth weight (SGA, AGA and LGA), considering a confidence interval (CI) of 95%. Each model was adjusted considering the literature review and by the variables which had $p \leq 0.20$ in the univariate multinomial regression model: maternal age, years of schooling, total family income, self-reported skin color, smoking and alcohol consumption during pregnancy, parity, pre-pregnancy body mass index, and energy contribution from the other food groups. We considered the results significant when the p was $\leq 5\%$. The statistical program Stata version 12.0 (StataCorp, 2011, College Station, TX, USA) was used for all the analysis.

RESULTS

The final sample contained 300 (89.8%) pairs of women/newborn children. The mean maternal age was 24.8 years (SD±5.5) and 8.7 years (SD±3.0) for schooling. Among newborn children, 5.7% were considered SGA and 13.7% were LGA. The mean percentage of energy contribution from the maternal diet during the second and third gestational trimesters of MPFC was 54.0% (SD±13.0%), that of PF were 2.0% (SD±2.9%), and that of UPF was 44.0% (SD±13.2%) (data not shown in table).

In the MPFC group, the mean energy intake was 3,260 kcal (SD±1,379 kcal) (data not shown in table) and mothers in the highest tertile were older (mean 27.1; SD±6.1; *p*<0.01) and had the lowest energy intake (mean 2,824; SD±1,233; *p*<0.01) (Table 1).

The mean energy intake from PF was 3,260 kcal (SD±1,379 kcal) (data not shown in table). In the same way, mothers who consumed more PF (third tertile) were older (mean 25.9; SD±5.6; *p*=0.05) and presented the highest maternal education (mean 9.4; SD±2.6; *p*<0.01) and family income (mean 417; SD±264; *p*<0.01) in the sample (Table 2). Also, mothers who were classified in the highest tertile of the consumption of processed foods showed the lowest proportion of smoking during pregnancy (n=8; 8.0%; *p*=0.02).

Table 1 – Description of newborn and maternal characteristics according to the Unprocessed and minimally processed foods and culinary ingredients group tertiles (energy contribution). *Mesquita* (RJ), Brazil, 2009-2011. (n=300).

Newborn and maternal variables	Unprocessed and minimally processed foods and culinary tertiles						p[b]
	1st group (<47.9%)		2nd group (47.9% to 60.8%)		3rd group (>60.8%)		
	M	SD[a]	M	SD[a]	M	SD[a]	
Birthweight (g)	3,310	498	3,333	433	3,390	426	0.44
Length (cm)	50.1	2.4	50.2	2.2	50.4	2.1	0.52
Gestational weight gain (kg)	13.5	6.6	13.1	6.4	12.2	6.1	0.38
Gestational age (week)	39.4	1.3	39.4	1.1	39.3	1.2	0.89
Maternal age (years)	23.3	4.7[f]	24.2	5.0[g]	27.1	6.1[h]	<0.01
Maternal education (years)	8.6	2.9	8.8	2.8	8.6	3.4	0.86
Total family income (US $)[c]	332	201	326	210	358	209	0.53
Total energy consumption (Kcal)[d]	3,857	1,538[f]	3,099	1,133[g]	2,824	1,233[h]	<0.01
Newborn and maternal variables	n	%	n	%	n	%	*p*[b]
Newborn sex							
Male	53	53.0	49	49.0	56	56.0	0.61
Female	47	47.0	51	51.0	44	44.0	
Marital status							
Married/Stable union	70	70.0	79	79.0	72	72.0	0.30
Single or other	30	30.0	21	21.0	28	28.0	
Self-reported skin color							
White	16	16.0	22	22.0	18	18.0	0.54
Black/brown	84	84.0	78	78.0	80	82.0	
Smoking during pregnancy							
No	82	82.0	84	84.0	92	92.0	0.11
Yes	18	18.0	16	16.0	8	8.0	
Alcohol consumption during pregnancy							
No	80	80.0	85	85.0	88	88.0	0.29
Yes	20	20.0	15	15.0	12	12.0	
Pre-pregnancy BMI (kg/m^2)[e]							
< 25	69	69.0	63	63.0	59	59.0	0.33
≥ 25	31	31.0	37	37.0	41	41.0	
Parity							
1	36	36.0	34	34.0	28	28.0	0.43
>1	64	64.0	66	66.0	72	72.0	

Note: M: Mean;[a]SD: Standard Deviation; [b]*p*: ANOVA test for mean and Chi-square test for proportions; [c]US $: American dollar; [d]Kcal: Kilocalorie; [e]BMI: Body Mass Index; [f,g,h]: They indicate differences in the ANOVA test among the categories of the same line by the Bonferroni test.

Table 2 – Description of newborn and maternal characteristics according to the Processed Food group tertiles (energy contribution). *Mesquita* (RJ), Brazil, 2009-2011. (n=300).

Newborn and maternal variables	Processed Food tertiles						
	1st group (<0.31%)		2nd group (0.31% to 2.06%)		3nd group (>2.06%)		p[b]
	M	SD[a]	M	SD[a]	M	SD[a]	
Birthweight (g)	3,310	424	3,360	479	3,362	456	0.66
Length (cm)	50.1	2.3	50.4	2.6	50.1	1.9	0.57
Gestational weight gain (kg)	12.9	16.7	12.9	6.3	13.0	6.2	0.99
Gestational age (week)	39.2	1.3	39.5	1.1	39.3	1.2	0.16
Maternal age (years)	24.6	5.6	24.1	5.3[f]	25.9	5.6[g]	0.05
Maternal education (years)	7.8	3.2[f]	8.9	3.1	9.4	2.6[g]	<0.01
Total family income (US $)[c]	287	132[f]	309.2	159[g]	417	264[h]	<0.01
Total energy consumption (Kcal)[d]	3,338	1,565	3,104	1,215	3,339	1,337	0.385
Newborn and maternal variables	n	%	n	%	n	%	p[b]
Newborn sex							
Male	57	57.0	53	53.0	48	48.0	0.44
Female	43	43.0	47	47.0	52	52.0	
Marital status							
Married/Stable union	65	65.0	79	79.0	76	76.0	0.08
Single or other	35	35.0	21	21.0	24	24.0	
Self-reported skin color							
White	14	14.0	20	20.0	22	22.0	0.32
Black/brown	86	86.0	80	80.0	78	78.0	
Smoking during pregnancy							
No	79	79.0	87	87.0	92	92.0	0.02
Yes	21	21.0	13	13.0	8	8.0	
Alcohol consumption during pregnancy							
No	84	84.0	85	85.0	84	84.0	0.97
Yes	16	16.0	15	15.0	16	16.0	
Pre-pregnancy BMI (kg/m^2)[e]							
<25	69	69.0	65	65.0	57	57.0	0.20
≥25	31	31.0	35	35.0	43	43.0	
Parity							
1	30	30.0	39	39.0	29	29.0	0.26
>1	70	70.0	61	61.0	71	71.0	

Note: M: Mean; [a]SD: Standard Deviation; [b]p: ANOVA test for mean and Chi-square test for proportions; [c]US $: American dollar; [d]Kcal: Kilocalorie; [e]BMI: Body Mass Index; [f,g,h]: They indicate differences in the ANOVA test among the categories of the same line by the Bonferroni test.

In the UPF group, mothers presented 3,260 kcal (SD±1,379 kcal) (data not shown in table) of mean energy intake and in the third tertile, they were younger (mean 23.1; SD±4.3; p<0.01) and had the highest intake of energy (mean 3,749 Kcal; SD±1,512; p<0.01) when compared with the first and second tertiles (Table 3). Also, the percentage of mothers who reported drinking alcoholic beverages (n=23, 23%; p=0.01) and smoking (n=20, 20%; p=0.01) during pregnancy was higher among mothers in the third tertile of the UPF group (Table 3).

In the adjusted logistic multinomial models (Table 4), it was observed that the high consumption of unprocessed, minimally processed foods, and culinary ingredients (MPFC) was associated with a lower likelihood of having LGA neonates. Women in the third tertile of this group (OR=0.13, 95% CI=0.02; -> to 0.89, p=0.04) were less likely to have LGA babies compared to women in the first tertile. It was also found that women in the second tertile (OR=4.8, 95% CI=1.89 to 1,200; p=0.02) and third tertile (OR=10.4, 95% CI=1.33 to 8,090; p=0.04) of the ultra-processed group were more likely to have SGA babies when compared to women in the first tertile.

Table 3 – Description of newborn and maternal characteristics according to the Ultra-processed Food group tertiles (energy contribution). *Mesquita* (RJ), Brazil, 2009-2011. (n=300).

Newborn and maternal variables	Ultra-processed Food tertiles						p^b
	1st group (<37.7%)		2nd group (37.7% to 49.7%)		3rd group (>49.7%)		
	M	SD[a]	M	SD[a]	M	SD[a]	
Birthweight (g)	3,420	432	3,298	423	3,315	495	0.12
Length (cm)	50.4	2.1	50.3	2.3	50.0	24	0.44
Gestational weight gain (kg)	12.5	6.2	12.8	6.6	13.5	6.3	0.58
Gestational age (week)	39.3	1.1	39.5	1.1	39.3	1.3	0.39
Maternal age (years)	27.3	6.1[f]	24.1	5.2[g]	23.1	4.3[h]	<0.01
Maternal education (years)	9.0	3.2	8.4	2.9	8.7	2.9	0.34
Total family income (US $)[c]	371	222	322	198	323	181	0.18
Total energy consumption (Kcal)[d]	2,867	1,257[f]	3,165	1,215[g]	3,749	1,512[h]	<0.01
Newborn and maternal variables	n	%	n	%	n	%	p^b
Newborn sex							
Male	55	55.0	48	48.0	55	55.0	0.52
Female	45	45.0	52	52.0	45	45.0	
Marital status							
Married/Stable union	75	75.0	74	74.0	72	72.0	0.86
Single or other	25	25.0	26	26.0	28	28.0	
Self-reported skin color							
White	18	18.0	24	24.0	14	14.0	0.19
Black/brown	82	82.0	76	76.0	86	86.0	
Smoking during pregnancy							
No	94	94.0	85	85.0	80	80.0	0.01
Yes	6	6.0	15	15.0	20	20.0	
Alcohol consumption during pregnancy							
No	92	92.0	84	84.0	77	77.0	0.01
Yes	8	8.0	16	16.0	23	23.0	
Pre-pregnancy BMI (kg/m^2)[e]							
<25	58	58.0	64	64.0	69	69.0	0.27
≥25	42	42.0	36	36.0	31	31.0	
Parity							
1	24	24.0	40	40.0	35	35.0	0.06
>1	76	76.0	60	60.0	65	65.0	

Note: M: Mean; [a]SD: Standard Deviation; [b]*p*: ANOVA test for mean and Chi-square test for proportions; [c]US $: American dollar; [d]Kcal: Kilocalorie; [e]BMI: Body Mass Index; [f,g,h]: They indicate differences in the ANOVA test among the categories of the same line by the Bonferroni test.

Table 4 – Association between the tertiles of the food groups according to the degree of industrial processing relative energy contribution) and birth weight categories. *Mesquita* (RJ), Brazil, 2009-2011. (n=300).

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Food groups	SGA[a] (n=17)						LGA[b] (n=41)					
	Crude			Adjusted			Crude			Adjusted		
	OR[c]	CI 95%[d]	p^e	OR[c]	CI 95%[d]	p^e	OR[c]	CI 95%[d]	p^e	OR[c]	CI 95%[d]	p^e
MPFC[1]												
1st tertile		Ref.			Ref.			Ref.			Ref.	
2nd tertile	0.97	0.34; 2.73	0.96	1.33	0.20; 8.96	0.77	0.83	0.36; 1.92	0.67	0.37	0.11; 1.26	0.11
3rd tertile	0.12	0.14; 0.95	0.04	0.06	0.00; 2.69	0.15	0.99	0.45; 2.19	0.99	0.13	0.02; 0.89	0.04
PF[2]												
1st tertile		Ref.			Ref.			Ref.			Ref.	
2nd tertile	1.05	0.29; 3.76	0.94	0.56	0.12; 2.70	0.47	1.47	0.62; 3.49	0.38	0.84	0.31; 2.33	0.74
3rd tertile	1.56	0.48; 5.14	0.46	1.37	0.32; 5.81	0.67	1.90	0.82; 4.40	0.13	1.28	0.47; 3.49	0.63

Table 4 – Association between the tertiles of the food groups according to the degree of industrial processing relative energy contribution) and birth weight categories. *Mesquita* (RJ), Brazil, 2009-2011. (n=300).

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Food groups	SGA[a] (n=17)						LGA[b] (n=41)					
	Crude			Adjusted			Crude			Adjusted		
	OR[c]	CI 95%[d]	p^e	OR[c]	CI 95%[d]	p^e	OR[c]	CI 95%[d]	p^e	OR[c]	CI 95%[d]	p^e
UPF[3]												
1st tertile		Ref.			Ref.			Ref.			Ref.	
2nd tertile	6.51	0.78; 54.10	0.08	4.8	1.89; 1,200	0.02	0.34	0.14; 0.86	0.02	0.42	0.10; 1.78	0.24
3rd tertile	9.47	1.17; 76.57	0.03	10.4	1.33; 8,090	0.04	0.83	0.39; 1.75	0.63	1.31	0.19; 8.98	0.78

Note: [a]SGA: Small for Gestational Age; [b]LGA: Large for Gestational Age; [c]OR: Odds Ratio; [d]95% CI: Confidence Interval of 95%; [e]*p* for multinomial logistic regression. [1]Unprocessed and minimally processed foods and culinary ingredients (MPFC): adjusted for maternal age, years of schooling, total family income, self-reported skin color, smoking and alcohol consumption during pregnancy, parity, pre-pregnancy body mass index, and energy contribution from ultra-processed food; [2]Processed foods (PF): adjusted for maternal age, years of schooling, total family income, self-reported skin color, smoking and alcohol consumption during pregnancy, parity, pre-pregnancy body mass index, and energy contribution from ultra-processed food; [3]Ultra-processed foods (UPF): adjusted for maternal age, years of schooling, total family income, self-reported skin color, smoking and alcohol consumption during pregnancy, parity, pre-pregnancy body mass index and energy contribution from unprocessed and minimally processed foods and culinary ingredients.

DISCUSSION

The main finding of the present study is that the maternal diet with a higher consumption of MPFC during the second and third trimester of pregnancy was possibly protective against the occurrence of LGA among newborns when compared to the first tertile of consumption. This could be understood as a result of the protective effect of a maternal diet composed mainly of vegetables, fruits, eggs, rice, and beans, similar to the traditional Brazilian diet [14,34]. In addition, it was also identified that the moderate to high consumption of the UPF group might increase the chances for delivering SGA newborns when compared to the lowest tertile of consumption, but this information must be considered with precaution, since the SGA sample is too small, resulting in a wider confidence interval.

Then, social and demographic aspects should also be mentioned. All cases of SGA were observed among brown and black mothers. Being a younger mother and smoking during pregnancy were also associated with higher intakes of UPF. The pregnant women in the second (intermediate) and third tertile (higher consumption) of the UPF consumption group in this study are younger, with an average age between 24.1 and 23.1 years old, while those who consumed less ultra-processed foods have an average age of 27.3 years old.

In addition, pregnant women in the second and third tertiles of the UPF consumption group have a higher proportion of primiparous women, who smoked and drank alcoholic beverages during pregnancy.

Other studies in Brazil also found an association between young maternal age and higher consumption of UPF [10,35,36]. Parity was also negatively associated with the healthy pattern (β=-0.1044, CI 95%: -0.1665; -0.0423) in a study by Castro *et al.* [37] with 421 pregnant women in *Rio de Janeiro*, Brazil. Even though the association between smoking during pregnancy and SGA births is well established, only our study pointed out the possible association of smoking in pregnancy and the consumption of UPF [38]. Perhaps, this result is not related to the caloric consumption itself, because our results indicate that pregnant women in the second and third tertiles of the ultra-processed food group present a higher average total energetic consumption in relation to the first tertile. It may reflect poor lifestyle practices, as seen in the high prevalence of smoking and consumption of alcoholic beverages in this birth weight category.

In relation to the maternal diet and birth weight, studies that evaluated this association have used food groups and dietary patterns, but none of them considered the maternal diet using the NOVA food classification, limiting comparisons. However, some studies found a protective effect of eating healthy food on low birth weight. Knudsen *et al.* [7], in a population study of 44,612 Danish women, reported that mothers who consumed a "health-conscious" diet pattern were less likely to have SGA newborns (OR=0.74; 95% CI=0.64, 0.86). This health-conscious food pattern was composed mainly of natural foods such as vegetables, fruits, poultry, and fish. A study from Ghana by Abubakari *et al*. [39] in a population of 578 pregnant women also found that women with adherence to a "health-conscious" food pattern (OR=0.23; 95% CI=0.12, 0.45) were less likely to deliver low birth weight newborns.

Other studies have identified that mothers who consumed a dietary pattern with more industrialized food items were more likely to have SGA births or babies with an increase in birth weight. In a study by Okubo *et al.* [9] in Japan, with 803 pregnant women, the consumption of bread, soft drinks, and sweets, as well as the lower consumption of fish and vegetables were associated with SGA births (OR=5.2, 95% CI=1.1, 24.4).

In the United States, Starling *et al.* [40] reported that the adherence to a diet with a higher content of eggs, roots, solid fats, processed grains, and a reduced quantity of dairy products, dark green vegetables and whole grains during pregnancy was associated with a greater birth weight. Similarly, other studies found an association between the consumption of a qualitatively poor diet, with more industrialized food (i.e. the presence of candies and soft drinks), and increased birth weight in both adolescent and adult mothers [10,11]. Besides dietary patterns, most studies conducted with pregnant women have evaluated the dietary intake of nutrients and foods, rather than considering the intake according to the degree of food processing [41-44].

Our study minimizes this issue, as it uses the NOVA food groups, which are defined according to the degree of processing. In this classification proposed by Monteiro *et al.* [13], which was adopted by the Food Guide for the Brazilian Population, food consumption is analyzed in terms of the degree of food processing, its nature, extent, and purpose [14,45].

One of the possibilities to explain the relationship between the consumption of MPFC and their protective effect against LGA births may be due to the contribution of healthy meals based on traditional foods as bean, rice, vegetables, cereals, egg, and other sources of protein, besides the contents of dietary fiber from vegetables and green leaves [46]. Although we included the culinary ingredients in this group, it is important to highlight that these foods are rarely consumed in isolation. In general, the high intake of sugar, fats, and sodium are provided by the elevated intake of UPF [46]. Therefore, the moderate intake of the total energy density of MPFC may has impacts on maternal weight gain and consequently on excessive birth weight [20].

Unlike UPF, which contain high amounts of energy, saturated fats, and simple carbohydrates, unprocessed, and minimally processed foods are recognized as having high nutritional content due to the amounts of micronutrients, water, and soluble and insoluble fiber [14,21]. Thus, the consumption of unprocessed and minimally processed foods leads to greater satiety. It is associated with a lower glycemic index and inversely associated with the dietary inflammation index and obesity during pregnancy [23,47,48]. In addition, adequate fiber consumption contributes to the reduction of serum glucose levels both in healthy individuals and in individuals with diabetes [49,50]. On the other hand, the consumption of UPF has been related to overweight/obesity, gestational weight gain, and increased newborn fat mass [18,19,51].

The findings of our study are in line with the recommendations from the Dietary Guidelines for the Brazilian population [14]. In it, the Brazilian Ministry of Health recommends the consumption of the traditional Brazilian diet, composed mainly by unprocessed and minimally processed food plus culinary ingredients, a practice that preserves the national gastronomic culture and the health of the population, and may become a key recommendation to prevent LGA births [14].

This study has some methodological limitations inherent to its cross-sectional design, such as no implication of causality. Regarding the method used to identify food consumption, the FFQ is subject to some limitations, such as depending on the participant's memory and under- or over-estimation of dietary intake; however, it is a recognized method for gathering information about habitual food consumption. Usually, mothers pay more attention to their dietary intake in the reproductive periods, but to minimize any loss of memory, and obtain maximum information about dietary intake from the last six months of pregnancy, the FFQ was applied in the first week after childbirth and our interviewers were nutritionists who received specific training to apply the questionnaire [52].

Our study also has important strengths. First, we used a validated FFQ which has been used in other epidemiological studies to analyze dietary consumption during the gestational period [29,33]. Lastly, to the best of our knowledge, this is the first study that has investigated the association between the dietary intake from the perspective of the NOVA food classification and birth weight.

CONCLUSION

The results of this study indicate that the high consumption of MFPC during pregnancy might be a protective factor for the birth of LGA neonates. These findings reinforce the benefits of a diet based on food with less processing and may add to the understanding about how the maternal diet influences neonatal health, especially birth weight. Therefore, it is recommended that longitudinal studies are carried out and with more individuals to confirm the relationship observed in our study.

CONTRIBUTORS

GG ROCHA performed the statistical analysis and the interpretation of the results and drafted the manuscript. A ANDRADE-SILVA and NH ALVES-SANTOS contributed to the proposal of statistical analysis, interpretation of the results, and reviewed the manuscript. MBT CASTRO collected the data, conceptualized the study, contributed to the proposal of statistical analysis, and reviewed the manuscript. All authors approved the final version of the submitted manuscript.

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Received: October 9, 2021
Final version: February 23, 2022
Approved: March 10, 2022