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ORIGINAL ARTICLE

Interrelation between dietary carbohydrate quality and nutritional status of a community of settlers in the municipality of Limoeiro do Norte, Ceará, Brazil

Inter-relação entre qualidade do carboidrato da dieta e estado nutricional de uma comunidade de assentados do município de Limoeiro do Norte, Ceará

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KEYWORDS
Glycemic Index
Glycemic Load
Nutritional Status

ABSTRACT
Objective: To evaluate the glycemic index (GI) and glycemic load (GL) of the diet of a community of settlers in the municipality of Limoeiro do Norte/Ceará, Brazil, and to verify whether there is a relationship between these variables and the nutritional status of these individuals. **Method:** This cross-sectional study included 77 adults. Nutritional status was assessed using waist circumference (WC), Body Shape Index (ABSI), and Body Roundness Index (BRI). Then, 24-h food recalls (R24h) were applied, and the GI and GL were calculated. Correlations between the glycemic index, BRI, and WC anthropometric variables were assessed using Pearson's correlation coefficient. The correlation between GL and the ABSI anthropometric variable was evaluated using Spearman's correlation test. Variables were assessed for association using the Chi-squared test. **Result:** Inadequacies in the GI (60.38±2.65), GL (139.46±53.45) and WC (94.23±10.99) predominated in the study population, with higher values observed in men. There was greater adequacy for the most recent ABSI (0.0755±0.0040) and BRI markers (3.411±0.8593), which presented prominent values among women. The statistical analysis demonstrated no correlation or association between the crossed variables. **Conclusion:** It is inferred that inadequate dietary markers were prevalent among men, whereas women presented with more inadequate anthropometric markers. GI and GL were not associated with WC, ABSI, or BRI.

PALAVRAS-CHAVE
Índice Glicêmico
Carga Glicêmica
Estado Nutricional

RESUMO
Objetivo: Avaliar o índice glicêmico (IG) e a carga glicêmica (CG) da dieta de uma comunidade de assentados no município de Limoeiro do Norte/Ceará, Brasil e verificar se existe relação entre essas variáveis e o estado nutricional desses indivíduos. **Método:** Estudo transversal com amostra composta por 77 indivíduos adultos. O estado nutricional foi avaliado através de circunferência da cintura (CC), A *Body Shape Index* (ABSI) e *Body Roundness Index* (BRI). Recordatórios alimentares de 24 horas (R24h) foram aplicados e o índice glicêmico (IG) e a carga glicêmica (CG) foram calculados. A investigação de correlações de índice glicêmico com as variáveis antropométricas BRI

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e CC foi realizada por meio da utilização de teste de correlação de Pearson. A avaliação de correlação entre a carga glicêmica e a variável antropométrica ABSI foi feita através do teste de correlação de Spearman. As variáveis foram avaliadas quanto à associação através do teste Qui-quadrado. **Resultado:** Na população do estudo, predominaram as inadequações de IG (60,38±2,65), CG (139,46±53,45) e CC (94,23±10,99) com valores mais elevados entre os homens. Houve maior adequação para os marcadores mais recentes ABSI (0,0755±0,0040) e BRI (3,411±0,8593), que apresentaram valores proeminentes entre as mulheres. A análise estatística demonstrou ausência de correlação ou associação entre as variáveis cruzadas. **Conclusão:** Infere-se que os marcadores dietéticos inadequados prevaleceram entre os homens, enquanto as mulheres apresentaram mais marcadores antropométricos inadequados. IG e CG não se associaram com os marcadores CC, ABSI e BRI.

INTRODUCTION

Settlements are representative components of rural communities characterized by their development and living in the countryside, their links to the primary sector of the economy and their precarious infrastructure, making them dependent on investments in integrative public policies[1]. Thus, the socioeconomic characterization of Brazilian settled communities developed in parallel with Agrarian Reform[2].

Food consumption in Northeast Brazil is characterized by a greater likelihood of natural and minimally processed foods, such as wheat, rice, corn, beans, cassava, and their derivatives[3]. Even so, there is a frequent choice of processed and ultra-processed food items, such as sausages, salami, and ham, which, in addition to their low monetary cost, have inadequate nutritional compositions in terms of energy value, macronutrients, and micronutrients[4].

Studies on the characterization of nutritional status in rural communities are scarce. However, they point to the continuity of the nutritional transition process among individuals in which overweight and obesity predominate, along with Food and Nutritional Insecurity (FNI), rather than protein-energy malnutrition resulting from the region's climatic conditions[5].

Overweight and obesity are defined as excessive body fat levels that pose a risk to human health. These conditions are mainly caused by consumption of foods with high caloric density, which can even be used as a measure to combat hunger, especially in developing countries[6].

Dietary reeducation is the main recommendation for combating excess weight, along with physical activity[7]. In relation to this, various dietary approaches are constantly being researched to investigate the influence of different nutrients in patients with this condition, such as diets with low glycemic index (GI)[8].

The concept of GI was proposed by Jenkins in 1981, and it represents glycemic elevation in response to consumption of a carbohydrate-rich food compared with 50 g of a standard food, such as glucose or wheat bread. GI has been extensively studied in relation to different endocrine-metabolic diseases, such as type II diabetes, hypercholesterolemia, and cancer. However, the conclusions since its development have been controversial. Thus, the concept of glycemic load (GL) was proposed, a mathematical measure of the amount of carbohydrates in a food multiplied by its GI. However, this result has controversial conclusions related to healthy populations[8].

Furthermore, it is interesting to evaluate the glycemic index and glycemic load of the diets of adult settlers and to verify the relationship between these variables and the nutritional status of these individuals. Thus, it is possible to characterize their food consumption, which is generally scarce and has not been developed in relation to the quality of carbohydrates in the diet, and to determine the nutritional status of this population from a technical perspective.

Finally, it is possible to observe how these indicators change according to the particularities of this public. The findings of this investigation will contribute to establishing effective strategies for Food and Nutrition Education (FNE), among others included in nutritional care, considering that carbohydrates are the basis of diet, especially in populations with regional and culturally marked eating habits, such as settlers.

METHODS

This quantitative, cross-sectional, descriptive, and analytical study originated from a research project entitled "*Insegurança Alimentar e Nutricional e Indicadores antropométricos, dietéticos e sociais das famílias de trabalhadores sem-terra em Limoeiro do Norte – CE*". Data were collected from October 2018 to April 2019.

The original study was intended to cover all 281 people living in the settlements, excluding the need for a sample size calculation. However, the low participation of the population in relation to the insecurity experienced in irregular settlements and logistical limitations for timely data collection resulted in an initial sample of 129 individuals aged 0–83 years; therefore, the sample was very heterogeneous in terms of age, gender, habits, and metabolic characteristics.

In turn, the target population of the present study was restricted to the adult population to represent a more homogeneous stratum in terms of the aforementioned characteristics. Individuals aged 20 to 59 years were included according to the classification of the Ministry of Health for adults of both sexes, comprising 79 individuals[9].

Two individuals without complete anthropometric measurements were excluded, resulting in a final sample of 77 participants. This corresponds to a representative sample according to the results of the sample calculation with a margin of error of 2.5% and a confidence level of 99%. All participants in the sample signed the Informed Consent Form (ICF).

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The anthropometric data were measured at the time of the first visit. The weight was measured on a Tec-Silver® digital platform-type electronic scale with a maximum capacity of 180 kg and sensitivity of 100 g, in addition to a calibration standard verified for each use. Height was measured in centimeters using a Personal Capriche Sanny® portable stadiometer. Waist circumference was measured using Sanny® inextensible measuring tape with a precision of 1 mm[10].

Nutritional status was classified using waist circumference (WC) classifications according to parameters of the World Health Organization[11] related to the risk of developing metabolic complications associated with chronic non-communicable diseases (NCDs), such as obesity[12].

In addition to this nutritional status marker, the recent A Body Shape Index (ABSI)[13] and Body Roundness Index (BRI) [14] indicators were used, which, unlike the Body Mass Index (BMI)[11], specifically represent body composition for adiposity. The first approach uses height, WC, and BMI in Equation 1 to assess the risk of early mortality and visceral adiposity[13]. The second method proposed by Thomas et al.[14] was calculated from Equation 2, which includes WC and height, as demonstrated in Equation 3. Hence, when using traditional variables, in addition to relating to visceral adipose tissue (VAT), this index reflects cardiometabolic risk (CMR).

Equation 1: ABSI

$$ABSI = \frac{CC(m)}{BMI^{\frac{2}{3}} \text{ x height}(m)^{\frac{1}{3}}} \qquad (1)$$

Equation 2: Body roundness

$$\in = \sqrt{1 - \frac{((CC)/(2\pi))^2}{(0.5\,x\,height)^2}} \qquad (2)$$

Equation 3: BRI

$$\text{BRI} = 364.2 - (365.5 \text{ x roundness}) \qquad (3)$$

ABSI classification was performed considering the gender variation criteria of Krakauer and Krakauer[13] and using the averages confirmed by Biolo et al.[15], which are r♂ = 0.083 and r♀ = 0.08, for the Italian and Slovenian populations, to verify the reproducibility of these maximum limits, although it is known that there are differences between populations. Thus, according to the ABSI concept, a higher value indicates greater deposition of visceral fat.

The BRI parameter does not have a standardized cut-off point, and its values vary between 1 and 16, where values closer to 1 indicate less body roundness and higher values characterize greater body roundness. Thus, gender criteria and means were drawn from Thomas et al.[14], which are r♂ = 4.66 and r♀ = 4.96. Although there are similarities between the criteria used, populations have high variability, especially in Brazil.

Dietary data were obtained by applying three 24-h food recalls (R24h) collected on non-consecutive days to cover two weekdays and one weekend day[16]. Daily food intake from the previous day was reported through visual identification using the Photographic Manual of Food Quantification[17], with subsequent conversion into grams and milliliters. Other tools were also used to standardize reported household measurements and to describe the composition of typical foods consumed by the population studied to ensure greater representation of behavior[12,18,19].

Glycemic index was calculated according to the protocol of the Food and Agriculture Organization of the United Nations (FAO)[20]. The amounts of total carbohydrates and dietary fiber in the composition of the foods[21] reported by the participants were initially identified and, by subtracting the latter, the glycemic carbohydrate content of each was determined. Next, the proportion of this carbohydrate in the food portions in the daily total was calculated. Then, these values were multiplied by the GI of the respective food items listed in the International Glycemic Index Tables. Finally, the sum of food GIs was calculated to determine individual dietary glycemic index[22].

GL was calculated by multiplying the absolute glycemic carbohydrate content of the foods by their GI and dividing by 100. The individual Dietary Glycemic Load was determined by the sum of the GLs of the foods[22]. An adaptation of the International Tables in Excel® format (2013) was used to calculate these indexes for practical purposes. The same GI values for foods with similar characteristics and compositions were used for foods with no established glycemic index. The GI and GL values of the random 24hR were translated into usual food consumption using the online Multiple Source Method® (MSM) software and were adjusted for age and sex using the Stat Transfer software®.

Diets were classified according to their usual GI and cutoff points as defined by Brand-Miller et al.[22] as low (≤55), medium (>55-69) or high (>69), which are the same ranges as those mentioned by ABESO[8], given that adequate dietary intake is characterized by low GI. Then, according to the cutoff points regarding usual GL of the same authors, the diets were classified as low (<80), moderate (80-120) or high (>120); therefore, diets with low GL were considered adequate, whereas diets with moderate or high GL were classified as inadequate.

The usual GI, GL, WC, ABSI, and BRI of each participant were organized in an Excel® spreadsheet (2013). The statistical analysis was performed using SPSS® version 20.0. The Kolmogorov-Smirnov statistical test was used to verify the normality of data for continuous variables.

Thus, correlation analysis between GI, BRI, and WC was performed using Pearson's correlation test. Spearman's correlation test was used to analyze the correlation between GL and ABSI. The chi-square test was used to verify the association between GI and GL adequacy of nutritional status variables. A $p<0.05$ was considered statistically significant.

This study followed the recommendations of Resolution 466/2012 and was approved by the Research Ethics Committee (CEP) of the Instituto Federal do Ceará (IFCE) under opinion no. 2.933.675.

RESULTS

The final sample consisted of 77 adults of both genres, whose general characteristics are presented in Table 1. The average age of the population was 42±12 years. The average weight was similar between men (72.2±12.7 kg) and women (70.4±21.6 kg), with the latter presenting a greater standard deviation, despite a lower average height (1.54±0.06 m); this contributes to an increase in BMI among them, where obesity predominated (32.53±7.69 kg/m^2) to the detriment of overweight among men (28.86 ± 3.31 kg/m^2). The values of GI, GL, ABSI, BRI, and WC are listed in Table 2. Averages of 0.077±0.007 for ABSI, 4.4395±1.7463 for BRI and 88±12 for WC were found for the anthropometric data. The discrimination of anthropometric markers indicated fewer inadequacies regarding the ABSI parameter; thus, 80% of men (n=28) and 90.48% of women (n=38) are below the cutoff value used.

There was a contradiction between the BRI and WC parameters in relation to ABSI. While the BRI showed slightly higher adequacy among men (65.71%; n=23), the inadequacy among women reached 40.48% (n=17).

The WC values showed the greatest discrepancy in adequacy. Among men, 31.43% (n=11) of WC cases were above the cutoff points, with a mean of 100.58±6.27. However, inadequacy was observed in 76.19% (n=32) for WC in women, with a mean of 92.05±11.48.

The GI and GL means regarding the characterization of carbohydrate quality were 60.32±2.69 and 121.52±56.24, respectively. It is observed that the parameters demonstrate tendencies toward foods with high glycemic responses. The lowest GI values were 55.54 for men and 56.23 for women, whereas GL values were to the order of 59.15 for men and 39.59 for women. The highest GIs were 70.51 and 67.18, while the GLs were 306.29 and 290.45, respectively.

According to the average value, it is possible to observe the predominance of inadequate GI in both sexes. A result of 94.24% (n=33) was obtained among men, whereas women presented inadequacy in their entirety (n=42), marked by moderate GI.

In the case of GL, inadequacy also predominated according to the average value for both genres. The highest average values among men prevailed with standard deviation, characterizing them as individuals with reasonably moderate (n=9) to significantly high (n=17) GL diets. The percentage of inadequacy was slightly higher among women, but absolute values varied between slightly

Table 1 – General characterization of the sample by age, weight and height. Limoeiro do Norte, Brazil, 2019.

	Male			Female			Total		
	n	%	M ± SD	n	%	M ± SD	n	%	M ± SD
Age (years)	35	100	41 ± 13	42	100	42 ± 11	77	100	42 ± 12
Weight (kg/m^2)	35	100	72.2 ± 12.7	42	100	70.4 ± 21.6	77	100	71.2 ± 18.0
Height (m)	35	100	1.68 ± 0.08	42	100	1.54 ± 0.06	77	100	1.60 ± 0.10
Low BMI (<18.5kg/m^2)	1	2.86	17.18 ± 0.00	1	2.38	17.66 ± 0.00	2	2.60	17.42 ± 0.34
Adequate BMI (18.5 - 24.9kg/m^2)	17	48.57	22.89 ± 2.29	12	28.57	22.79 ± 1.57	29	37.66	22.85 ± 1.99
Elevated BMI (≥25kg/m^2)	17	48.57	28.86 ± 3.31	29	69.05	32.53 ± 7.69	46	59.74	31.18 ± 6.62

BMI = Body Mass Index. M = mean. SD = standard deviation.

Table 2 – Adequacy levels of dietary and anthropometric markers. Limoeiro do Norte, Brazil, 2019.

	Male			Female			Total		
	n	%	M ± SD	n	%	M ± SD	n	%	M ± SD
Adequate GI	2	5.71	55.31 ± 0.32	0	0	-*	2	2.60	55.31 ± 0.32
Inadequate GI	33	94.29	60.25 ± 2.99	42	100	60.49 ± 2.37	75	97.40	60.38 ± 2.65
Adequate GL	9	25.71	68.49 ± 6.90	10	23.81	65.15 ± 12.37	19	24.68	66.73 ± 10.03
Inadequate GL	26	74.29	159.35 ± 57.15	32	76.19	123.3 ± 44.93	58	75.32	139.46 ± 53.45
Adequate ABSI	28	80	0.0766 ± 0.0040	38	90.48	0.0747 ± 0.0039	66	85.71	0.0755 ± 0.0040
Inadequate ABSI	7	20	0.0870 ± 0.0035	4	9.52	0.0918 ± 0.0163	11	14.29	0.0888 ± 0.0097
Adequate BRI	23	65.71	3.1069 ± 0.7825	25	59.52	3.6910 ± 0.8454	48	62.34	3.4111 ± 0.8593
Inadequate BRI	12	34.29	5.4910 ± 0.7952	17	40.48	6.6010 ± 1.7072	29	37.66	6.1417 ± 1.4911
Adequate WC	24	68.57	83.03 ± 7.45	10	23.81	73.06 ± 4.16	34	44.16	80.10 ± 8.04
Inadequate WC	11	31.43	100.58 ± 6.27	32	76.19	92.05 ± 11.48	43	55.84	94.23 ± 10.99

GI: glycemic index. GL: glycemic load. ABSI: body shape index. BRI: body roundness index. WC: waist circumference. M = mean. SD = standard deviation. *Impossible to calculate mean ± SD.

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moderate (n=20) and high (n=13) diets. Table 3 presents the results of the correlation analysis of GI and GL levels with nutritional status markers. Table 4 presents the results of the association analysis of GI and GL according to the adequacy of nutritional status markers. No correlation or association was observed between the variables investigated ($p>0.05$).

Table 3 – Statistical analysis of correlation of the variables studied. Limoeiro do Norte, Brazil, 2019.

Crossed variables	Correlation coefficients	p
GI x BRI	-0.030	0.799*
GI x WC	-0.037	0.750*
GI x ABSI	-0.054	0.643**
GL x BRI	-0.194	0.091*
GL x WC	-0.125	0.277*
GL x ABSI	-0.100	0.387**

GI: glycemic index. GL: glycemic load. ABSI: body shape index. BRI: body roundness index. WC: waist circumference. *Pearson's correlation. **Spearman's correlation.

Table 4 – Statistical association analysis of the variables studied. Limoeiro do Norte, Brazil, 2019.

Crossed variables	p*
GI x ABSI	1.000
GI x BRI	1.000
GI x WC	1.000
GL x ABSI	0.359
GL x BRI	0.366
GL x WC	0.554

GI: glycemic index. GL: glycemic load. ABSI: body shape index. BRI: body roundness index. WC: waist circumference. *Chi-squared test.

DISCUSSION

The results of this study are consistent with the Pan American Health Organization's panorama, which highlighted the increase in overweight in all countries in the region and its prevalence among women.[23] In addition, the current study is highly relevant in characterizing the nutritional status of the target audience, especially due to the inclusion of recent indicators.

The values for ABSI in women in this study are similar to the findings of Trovão[24] for women in Minas Gerais, with representative obesity and cardiometabolic risk (CMR) rates associated or not with mammographic findings. Despite the results of this study, Biolo et al.[15] found an inverse relationship between ABSI, fat-free mass, and SO, with a positive correlation with C-reactive protein (CRP) and a negative correlation with insulin sensitivity in men. However, previous studies have shown that this indicator is less reliable, partly because it is based on height, which compromises sensitivity[13,25].

The literature has identified BRI as the best predictor[25]. However, the inadequacy of BRI stood out among women in this study, which, considering the average age of the sample, is expected, since this indicator is based on WC and is a reflection of the sexual dimorphism of an androgenic nature that predisposes men, as well as women during menopause, to greater cardiovascular risk (CVR).

It is interesting to note that according to the International Diabetes Federation, the risk for metabolic complications associated with obesity in men is considered to increase with WC ≥90 cm, which is consistent with the greater sensitivity of these individuals to CVR when compared with women of childbearing age[26]. In addition, it is necessary to understand that indicators such as BMI are not specific for discrimination of body compartments, and there is a tendency for BMI to increase throughout life due to physiological characteristics, but its association with mortality due to excess weight tends to decrease, especially after the age of 65[25].

Regarding dietary markers, moderate GI and high GL were found in Sampaio et al.[27] with a population of 80 obese individuals from Ceará, as in the present study; however, a significant correlation between GL and obesity was observed, with a high consumption of starch and a direct proportional to the frequency of meals.

Although high values are frequently observed for these variables, research on glycemic index and glycemic load remains controversial. Thus, their correlation with various anthropometric markers is directly or inversely proportional to ethnicity, gender, age group, diseases studied, alcohol consumption, and intestinal microbiota, considering both biochemical and physiological specificities and adaptations for each variable[8,28]. This is because body weight regulation is subordinated to several interdependent metabolic processes focused on homeostasis at the molecular level. In fact, the limitations of these indexes seem to be insurmountable because they are based on the nature of mono, di, tri, and polysaccharide carbohydrates, which are most closely related to insulinemia[22]. However, insulin is not the only biochemical regulator of body mass control, although it has been shown to be one of the main factors in developing comorbidities associated with or not associated with the controversial concept of obesity, which is represented in different ways in each anthropometric indicator and may differ from the WHO definition[6].

In addition, other nutrients act synergistically with carbohydrates, not just macronutrients. The main micronutrients involved in glucose metabolism and insulin activity are fat-soluble vitamins (A, D, E, K), vitamin C, folate (B9), and the minerals chromium (Cr), magnesium (Mg), vanadium (V), and zinc (Zn). Micronutrients deficiency can contribute to insulin signaling problems and is directly associated with diabetes mellitus and stroke[29].

However, the variability of results has been justified by methodological diversity since several processes during the development of a study, as well as cut-off points and sample size, compromise the data and consequently how they behave in statistical analysis. Therefore, ABESO does not recommend the use of GI and GL as dietary therapy for overweight individuals[8].

Despite this, the evaluation of diets based on GI and GL represents a supplementary strategy for developing FNE materials in the context of public health that encourages the regular consumption of other food groups, such as legumes, whole grains, fruits, and vegetables, which are rich in monounsaturated fats and fibers.

GL has a greater potential for the objective evaluation of diets, particularly those rich in carbohydrates. Furthermore, more recent studies have suggested that indexes derived from these concepts, such as the Dietary Insulin Index (DII) and Dietary Insulin Load (DIL), may be more effective in assessing nutrient quality and controlling insulin responses, which has a greater impact on body weight control[30].

The study presents the following points as limiting factors: sample size; limitations of retrospective dietary surveys; the non-application of gold-standard methods, such as bioimpedance, to assess and compare the general and visceral adiposity levels between markers; and non-quantification of the caloric intake of individuals to confirm that this has a greater impact on weight control than specific nutrients.

It is suggested that more studies be carried out with settler communities to ensure that this public has access to health literacy mechanisms, including intervention research that supports dietary changes associated with traditional customs, which are characteristic of this population's adaptation to their nutritional status.

CONCLUSION

In short, this study performed a unique evaluation of the food consumption of settlers in the national and international literature, which has been limited to a social and non-probabilistic approach to the subject. It can be inferred that the food consumption of the study population was characterized by inadequate GI and GL, with a predominance of moderate values for both sexes and higher GL in men.

Adequate BRI and ABSI were observed regarding nutritional status, but women presented higher values than men in cases of inadequacy. Adequacy regarding WC was predominant among men and inadequacy among women, who exhibited greater variation in SD, leading to the similarity of these values between genres. Finally, no significant correlation or association was observed between the GI and GL dietary markers and BRI, ABSI, and WC.

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