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Relation between the pattern of dietary intake and visceral fat deposits in pregnant women

Relação entre o padrão de consumo alimentar e os depósitos de gordura visceral em gestantes

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ABSTRACT

Objective
To assess the association between the pattern of dietary intake and visceral fat deposits.

Methods
This is an observational study with pregnant women during a prenatal appointment in Porto Alegre, Brazil. The gestational dietary intake was assessed using a usual food recall, questioning every food consumed on a usual weekday, and their respective amounts. Fat deposits were measured by ultrasonography. The correlation between symmetric variables was assessed using Pearson's correlation and the correlation between asymmetric variables was assessed using Spearman's correlation. The association between variables was assessed using multivariate linear regression, in which variables with asymmetric distribution were transformed into logarithms.

Results
A total of 154 pregnant women were included in the sample; the mean visceral fat thickness was 44.17 mm±15.03 and the median daily total energy intake was 2,149.25 kcal [1,676.53–3,051.72]. A significant positive correlation (r=0.165) was found between visceral fat thickness and the consumption of processed culinary ingredients (p=0.049).

Conclusion
Our findings suggest that the consumption of processed culinary ingredients may be positively associated with visceral fat deposits in pregnant women.

Keywords: Dietary intake. Intra-abdominal fat. Obesity. Pregnancy.

RESUMO

Objetivo

Avaliar a associação entre padrão de consumo alimentar e gordura visceral materna.

Métodos

Estudo observacional realizado durante consulta pré-natal com gestantes de Porto Alegre, Brasil. O padrão de consumo alimentar gestacional foi estimado através de recordatório alimentar habitual, questionando sobre todos os alimentos consumidos em um dia de semana normal e suas respectivas quantidades. Os depósitos de gordura foram aferidos por ultrassonografia. A correlação entre variáveis simétrica foi avaliada por correlação de Pearson e a acorrelação entre variáveis assimétrica foi avaliada por correlação de Spearman. A associação entre as variáveis foi avaliada por regressão linear multivariada, sendo as variáveis com distribuição assimétricas transformadas em logarítimo.

Resultados

Foram incluídas 154 gestantes, com média da espessura da gordura visceral de 44,17 mm±15,03 e mediana do valor energético total diário de 2149,25 kcal [1676,53–3051,72]. Foi encontrada uma correlação positiva e significativa (p=0,049; r=0,165) entre a espessura da gordura visceral e o consumo de ingredientes culinários.

Conclusão

Os achados do presente estudo sugerem que o consumo de ingredientes culinários processados pode estar diretamente associado aos depósitos de gordura visceral em gestantes.

Palavras-chave: *Consumo alimentar. Gestação. Gordura intra-abdominal. Obesidade.*

INTRODUCTION

The level of processing to which foods are subjected can impact their quality and four levels of processing are established by the Nova classification: unprocessed or minimally processed foods, processed culinary ingredients, processed foods and ultra-processed foods [1], being the latter the most discussed in recent researches. Ultra-processed food consumption represents 20.3% of the daily caloric intake of Brazilian adult women [2], even during pregnancy [3,4]. Due to their high caloric density, the high consumption of ultra-processed foods leads to an imbalance of energy intake [5] and it's been associated with excessive gestational weight gain in pregnant women [6–8], as well as worsening of glycemic parameters in the third trimester in pregnant women with pre-existing diabetes mellitus [8]. In 2018, 20.7% of brazilian women of reproductive age were obese [9]. The Body Mass Index (BMI) assessment is the most widely used tool to analyze nutritional status [10,11], as well as the associated metabolic risks [12]. However, BMI has limited predictive power over health risks, considering its inability to assess different body fat deposits [11–14].

The Subcutaneous Adipose Tissue (SAT) stores body fat next to the skin, whereas Visceral Adipose Tissue (VAT) stores fat inside the abdominal cavity, accumulating fat between the organs [13,14]. Studies concluded that assessing metabolic risks, such as insulin resistance and increased triglycerides, using VAT measurements provides a more precise correlation than using the BMI [14–17]. The VAT measurement is easily obtained with ultrasonography [17,18], which corresponds to a routine method for assessing maternal-fetal health during pregnancy. Thus, VAT measurement represents an accessible and effective method to identify possible gestational comorbidities [17,19]. In the adult population, increases in VAT deposits are associated with long-term consumption of added sugar [20] and with an increase in consumption of ultra-processed foods [21], however, to our knowledge, no research has studied the relationship between the level of food processing and VAT deposits in pregnant women.

It's been established that a balanced diet consisting of a variety of vegetables, fruits, cereals and legumes helps to promote a healthy pregnancy [22] and that pregnancy is a potential moment for changing lifestyle habits since the pregnant woman wishes to provide a healthy uterine environment to ensure optimal fetal development [23]. Therefore, it is essential to recognize the factors that aim to reduce risks, such as the quality of dietary intake during pregnancy and the measurement of fat deposits.

Our study aims to assess the association between gestational dietary intake and maternal visceral fat deposits measured by ultrasonography.

METHODS

This is a cross-sectional and observational study as part of a larger project entitled "Ultrasonographic assessment of visceral fat: a new outcome marker in pregnancy?" Previous articles were published based on the data collected for this project [10,17,24]. The study included voluntary pregnant women from 2016 to 2018 whose prenatal care was conducted in the Murialdo Health Center, a Health Unit affiliated with the Brazilian Unified Health System in Porto Alegre, Brazil. The study excluded pregnant women with more than 20 gestational weeks, who had a twin pregnancy, with known fetus malformation, individuals with some disability, or with scars on the abdominal wall that limited the ultrasound scanning. Pregnant women who had missing information on the usual food recall or the VAT measurement were also excluded.

Clinical data includes measurements of weight, height, VAT by ultrasound, and usual food recall. The gestational weight gain was estimated, as well as the pre-pregnancy and current BMI (kg/m^2).

For the usual food recall, an adapted version of the 24 hours food recall was used, where, instead of questioning their diet in the 24-hour period prior to the interview, participants self-reported all their meals, with their respective foods and quantities consumed in a day usual for the week, which would make up your food choice at least 3 times a week. The observation of variability in dietary habits during pregnancy is crucial. The choice of the usual food recall as the data collection method in our study was strategically oriented to address this variability. The authors acknowledge that dietary intake during pregnancy can be influenced by various factors, such as changes in preferences, temporary food aversions, and adaptations across different gestational phases [25-27].

By opting for the Habitual Dietary Recall, our aim was to obtain a more comprehensive and representative insight into dietary patterns over the course of gestation, minimizing potential biases associated with short-term recalls. This method allowed for a more in-depth analysis of temporal variability in participants' dietary habits, contributing to a more precise understanding of dietary influences during pregnancy. The *Tabela Brasileira de Composição de Alimentos* [28] was used as the primary source of information for the nutritional composition. If food was not included in the table, *Instituto Brasileiro de Geografia e Estatística* [29] table of nutritional composition was used. As a last source of information, food labels were consulted. The reported household measures were converted into grams using the *Tabela para Avaliação do Consumo Alimentar em Medidas Caseiras* [30]. The Total Daily Energy Value (TEV) was calculated and, subsequently, the percentage of the TEV that corresponded to each food group was estimated according to the Nova classification [1]. The Nova classification proposes four food groups considering the nature, extent, and purpose of industrial processing [1]. Unprocessed or minimally processed foods are represented by fruits, vegetables, grains, legumes, pasta, eggs, milk, and meats. Processed culinary ingredients are represented by oils, fats, salt, and sugar. Processed foods are represented by bottled vegetables, canned fish, fruits

in syrup, and freshly made bread and cheese. Some examples of ultra-processed foods are cookies, sugar breakfast cereals, packaged snacks, yogurt and bread with food additives, and ice creams [1].

For VAT measurement, the method described by Armellini was used [31], assessed with a multi-frequency convex transducer, at the level of the xipho-umbilical line, located 1.0 cm from the maternal umbilical scar, with minimal pressure on the maternal abdomen to avoid underestimation of the thickness. The measure of Armellini's VAT represents the largest space between the internal face of the linea alba or the internal face of the rectus abdominis muscles to the anterior wall of the aorta artery. The anatomical structures are easily identified by ultrasound.

The maternal sociodemographic data included age (years), schooling level (completed Secondary education or not), reported ethnicity (white or not white), marital status (married or not), parity (number), current Gestational Age (GA) (in weeks), and GA of interruption (in weeks). Data regarding the newborn (NB) was collected on the maternal hospital charts at the childbirth hospital, such as type of delivery (vaginal or cesarean), birth weight (grams), and NB sex (male or female).

Statistical analyses were performed using IBM®SPSS® 18.0. The significance level was set at $p<0.05$. Categorical variables were described as absolute frequencies (n) and percentages (%), continuous variables with symmetrical distribution were described as mean and standard deviation (±SD), and continuous variables with asymmetric distribution were described as a median and interquartile range [25^{th}–75^{th} percentile].

In the analysis, the VAT measurement was considered the response variable, and different levels of food processing were the exposure variable. As half of the exposure variables had symmetrical distribution (ultra-processed foods and unprocessed or minimally processed foods) and the other half had asymmetrical distribution (processed foods and processed culinary ingredients). For the correlation of symmetric variables, Pearson's correlation was used and for correlations of asymmetric variables, Spearman's correlation was used. For multivariate models with continuous outcomes, asymmetric variables were transformed in logarithm and linear regression was used. The variables that presented a significant result ($p<0.20$) in the bivariate analysis were selected as confounding variables and included in the multivariate tests, namely: age, the number of pregnancies, gestational age, and pre-pregnancy BMI.

The study was approved by the Hospital das Clínicas Porto Alegre under the number 2021-0313 (CAAE: 51384221.7.0000.5327) and the major project was approved by the Research Ethics Committee of the Health Department of Porto Alegre under the number 2018-0385 (CAAE: 55913516.7.2002.5327). All participants provided written informed consent in duplicates.

RESULTS

A total of 154 pregnant women were included in the sample and most participants were overweight (62.1%; n=95) at the time of data collection. In total, 55.3% of the pregnant women were white, and 85.3% were not married. The median current GA was 16.0 [13.0-18.1] weeks and maternal age was 25 years [21–31]. Table 1 shows the sociodemographic and clinical data of the participants and Chart 1 shows the most consumed foods in each level of food processing in a decrescent order.

Table 1 – Sample sociodemographic and clinical characterization.

Characteristic (n=154)	Median [P25–P75]
Maternal age (years)	25 [21–31]
Parity (number)	2 [1–3]
Gestational age (weeks)	16.0 [13.0–18.1]
Pre-pregnancy BMI (kg/m²)	26.26 [22.2–31.2]
Total daily energy value (kcal)	2.149.25 [1.676.53–3.051.72]
Gestational age of interruption (weeks)	39.4 [38.3–40.3]
Newborn weight at birth (g)	3.220 [2.940–3.610]
Characteristic	Mean±SD
Gestational weight gain (kg)	13.31±6.57
Visceral adipose Tissue (mm)	44.17±15.03
Characteristic	Frequency n (%)
Reported ethnicity	152 (98.7)
White	84 (55.3)
Not white	68 (44.7)
Marital status	95 (61.6)
Married	14 (14.7)
Other	81 (85.3)
Schooling level	94 (61.0)
Complete high school	33 (35.1)
Incomplete high school	61 (64.9)
Type of delivery	131 (85.0)
Cesarean	40 (30.5)
Vaginal	91 (69.5)
Newborn sex	127 (82.4)
Female	67 (52.8)
Male	60 (47.2)

Note: Results expressed in median (percentile 25–75), mean±standard deviation or frequency (n), and percentual (%).

Chart 1 – Characterization of the most consumed foods in each level of food processing.

Most consumed foods	Unprocessed or minimally processed foods	Processed culinary ingredients	Processed foods	Ultra-processed foods
1	White rice	Refined sugar	*"pão francês"*	Powdered juice
2	Black beans	Salt	Cheese	Margarine with salt
3	Coffee	Olive oil	Mozzarella cheese	Chocolate milk
4	Whole milk	Soy oil	Prato cheese	Sausage (*linguiça*)
5	Tomato	Milk cream	Homemade bread	Ham

Within the group of unprocessed or minimally processed foods, there was greater consumption of white rice, followed by black beans, coffee, whole milk and tomato. In group processed culinary ingredients the highest consumption was refined sugar, salt, olive oil, soy oil and milk cream. In processed foods there was greater consumption of "pão francês", cheese, mozzarella cheese, "prato cheese" and homemade bread. In ultra-processed foods, the foods that topped the list were powered juice, margarine with salt, chocolate milk, sausage and ham, respectively.

The VAT thickness mean was 44.17 mm±15.03 and the gestational TEV median was 2,149.25 kcal [1,676.53-3,051.72]. Table 2 presents the percentage of consumption (%TEV) that corresponded to each level of food processing; unprocessed or minimally processed foods represented the highest percentage (52.64% TEV).

Table 3 shows the correlation between VAT thickness and the different levels of food processing. The authors found a positive (r=0.160) and significant (p=0.049) correlation between the consumption of processed culinary ingredients and VAT thickness.

Linear regression analysis between VAT and the different levels of food processing was shown in Table 4 no significant association was found.

Table 2 – Characterization of the sample's dietary intake (n=154).

Characteristic	Mean±SD
Ultra-processed foods %TEV	29.42±17.73
Unprocessed or minimally processed foods %TEV	52.64±19.65
Characteristic	Median [P25–P75]
Processed foods %TEV	13.47 [4.73–21.55]
Processed culinary ingredients %TEV	2.10 [0.00–5.40]

Note: TEV: Total Daily Energy Value. Results expressed in mean (standard deviation) and median [percentile 25–75].

Table 3 – Correlation between visceral adipose tissue thickness and the different levels of food processing.

Characteristic	Coefficient of correlation (r)	*p*-value
Ultra-processed foods %TEV	-0.103	0.208
Processed foods %TEV	0.145	0.077
Processed culinary ingredients %TEV	0.160	0.049*
Unprocessed or minimally processed foods %TEV	-0.045	0.584

Note:*Significant correlation when *p*-value <0.05. Statistical Analyses: Pearson's correlation (in simetric variables: ultra-processed foods % TEV and Unprocessed or minimally processed foods %TEV) and Spearman's Correlation (in assimetric variables: Processed foods %TEV and Processed culinary ingredients %TEV). TEV: Total Daily Energy Value.

Table 4 – Association between VAT visceral adipose tissue thickness and the different levels of food processing.

Characteristic	Crude analysis		Adjusted analysis	
	Beta (B)	*p*-value	Beta (B)	*p*-value
Ultra-processed foods %TEV	4.200	0.093	2.680	0.166
Processed foods %TEV	-0.590	0.556	-0.116	0.660
Processed culinary ingredients %TEV	-0.072	0.648	0.002	0.987
Unprocessed or minimally processed foods %TEV	4.758	0.089	2.965	0.171

Note: *Significant regression when *p*-value <0.05. Statistical Analyses: Linear regression; Adjusted for age, the number of pregnancies, gestational age, and pre-pregnancy body mass index. TEV: Total Daily Energy Value.

DISCUSSION

The pattern of gestational dietary intake characterized by higher percentages of processed culinary ingredients is correlated with higher VAT deposits

The pre-pregnancy nutritional status of our sample reflects Brazil's reality, in which more than half of adult women are overweight [9]. The literature shows that women who initiate pregnancy with a BMI higher than 40 kg/m² have higher risks of developing Gestational Diabetes mellitus (GDM), hypertension during pregnancy, and cesarean section; impairing maternal and fetal health [32]. Elevated VAT deposits are also associated with an increased risk of developing GDM [17,33]. The observed median of 44.17 mm in the VAT deposits in our sample was similar to results from previous studies [34,35]; albeit inferior to results found in Brazilian pregnant women, in which the mean (±SD) corresponds to 54.4 mm (±12.7) [36].

Eating habits also have a key role in maternal health since it has been associated with gestational outcomes [6–8,37]. The dietary intake of the participants consisted mostly of unprocessed or minimally processed foods (52,64% of the TEV), making this food group the basis of the participants' diet, according to the Dietary Guideline for the Brazilian Population [38]. Ultra-processed foods represented 29,42 % of the TEV, followed by processed foods (13,47% of the TEV), and processed culinary ingredients (2% of the TEV). Graciliano et al. found a similar pattern of dietary intake in Brazilian pregnant women [4].

Pregnant women who consumed proportionally more processed culinary ingredients had greater VAT deposits, and refined sugar represented 71.9% of the calories from this food group. The longitudinal and multicentric study carried out with 3,070 participants in the United States corroborates these findings. They observed that long-term consumption of added sugar was associated with greater deposits of VAT in young adults of both sexes [20]. An American study found that most pregnant women consumed more sugar than recommended by the Dietary Guidelines for Americans 2020–2025 [39]. This finding is reinforced by a Brazilian study that observed that most pregnant women do not meet the recommendations of the Primary Care Notebook for Low-Risk Prenatal Care regarding adequate daily sugar consumption [40], which is relevant data since maternal consumption of sugar is related to excess gestational weight gain, as well as poor fetal outcomes [41].

The negative effects of sugar on overall health have already been stablished in the literature, as its association with insulin resistance [42]. So the authors hypothesize that the pregnant women who consumed a higher percentage of processed culinary ingredients had a higher insulin resistance and therefore a higher accumulation of fat in the visceral deposits, as it has been associated in previous studies [16,43].

Fats and oils used in food preparations and recipes represented 29.1% of the energy intake from processed culinary ingredients consumed by the sample (data not shown). Curiously, olive oil was the most consumed, followed by soy oil, both mostly composed of unsaturated fats [44,45]. Due to its beneficial effects on cardiovascular health, the consumption of poly and monounsaturated fats is encouraged by health agencies as opposed to saturated and trans fats [38,46], however, the few studies analyzing the effect of unsaturated fat consumption on VAT accumulation present conflicting results [47,48]. Moreover, while 1g of carbohydrates or proteins represents 4 kcal, 1g of fat represents 9 kcal, easily increasing the TEV. A recent cross-sectional study in Jordan involving 167 individuals found that healthy adults that had a higher TEV presented an increase in VAT deposits [49].

Even though our study did not find an significant association between the consumption of ultra-processed foods and VAT deposits, this result has already been reported in the literature in a non-pregnant population [21]. A Spanish cohort followed overweight older adults of both sexes for 12 months and found that a 10% increase in TEV from ultra-processed foods consumption was associated with an increase in VAT accumulation, in a dose-response relationship [21].

Regarding maternal health outcomes, a Spanish longitudinal study that followed 3,730 women observed a dose-response relationship between the consumption of ultra-processed foods and the risk of developing GDM [50]. Pregnant women aged over 30 years who consumed more ultra-processed foods before pregnancy had doubled the risk of developing GDM compared to those who consumed less ultra-processed foods [50]. This result, however, was not significant among pregnant women younger than 30 years [50], and an observational study with 573 Brazilian pregnant women did not find the same association between the consumption of ultra-processed foods and GDM [24].

The hypotheses for the more pronounced impact of culinary ingredients on visceral fat in pregnant women, compared to processed and ultra-processed foods, may be related to the nutritional quality and composition of these foods. Processed culinary ingredients, such as oils and sugars, when consumed excessively and in isolation, can lead to nutritional imbalances and weight gain, given their more prominent presence and less dilution. In contrast, processed foods are formulated with adjusted quantities for various preparations, which may minimize the direct impact of these ingredients on body composition. Additionally, ultra-processed foods, often laden with artificial sweeteners, provide a sweet taste without calories, but the excessive use of these additives may

be associated with long-term metabolic complications in maternal and infant health. Therefore, emphasizing the quality and moderation of culinary ingredient consumption during pregnancy may be crucial for promoting optimal maternal and fetal health.

Our study has some limitations. The ultrasound measurements of the VAT were performed by a single fetal imaging specialist, albeit certified by the Brazilian College of Radiology. The cross-sectional design of the study precludes conclusions of a causal relationship between the pattern of dietary intake and VAT deposits. The usual food recall is a self-reported instrument, therefore, precision in food consumption relies on the participant's ability to measure their usual daily intake. It's susceptible to memory bias and under or overestimation of meals. However, the instrument was applied by trained nutritionists to minimize this limitation. As the usual food recall was applied only on one day, it is fragile to consider that this dietary intake applies to the pregnant woman's dietary lifestyle. Although the result regarding the consumption of processed culinary ingredients was statistically significant, it is important to note that the statistical power was relatively low. We suggest that future studies include a larger sample size to increase statistical power. Additionally, measuring the total daily sugar consumption with greater precision was impossible since most nutritional tables did not report how much of the total carbohydrates corresponded to sugar. However, further studies will be able to reduce this bias as the updated collegiate board resolution (RDC no. 429, of october 8, 2020) requires that the amount of added sugar be specified in the nutritional table in all products.

The method used to measure VAT is a strong point of this study since ultrasound has a strong correlation with CT: it is accessible during prenatal care and safe for pregnant women. The authors also highlight the novelty of the analysis, since the relationship between the pattern of dietary intake and the deposits of VAT, specifically in the pregnant population, has not been fully described in the literature yet.

The relationship between the pattern of dietary intake and VAT deposits is controversial and few studies are focused on pregnant women. Therefore, more studies should be conducted to determine how the pattern of dietary intake may influence VAT deposits in this population. To date, this is the first study to assess the relationship between the gestational pattern of dietary intake using the Nova classification and the VAT deposits. The results are in agreement with the recommendations of the Dietary Guideline for the Brazilian Population to use processed culinary ingredients in small amounts, considering that sugar, oils, fats and salt can be related to negative health outcomes [38].

CONCLUSION

Our findings suggest that the consumption of processed culinary ingredients may be directly associated with VAT deposits in pregnant women. These suggestive results corroborate with the recommendations of the Dietary Guideline for the Brazilian Population and the importance of nutritional support during prenatal care since the pattern of gestational dietary intake can be related to greater VAT deposits in pregnant women.

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