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# Degree of Food Processing (NOVA Classification) and Blood Pressure in Women with Overweight and Obesity

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**Abstract:** (1) Background: We aimed to associate the degree of food processing with blood pressure levels in adult women. (2) Methods: A cross-sectional study was carried out on 85 adult women. The participants were subdivided into three groups: normal weight (NW: 27.05%), overweight (OW: 34.1%) and obesity (OB: 38.8%). Their anthropometric parameters, food consumption and blood pressure (BP) were evaluated. The groups were compared using one-way ANOVA or the Kruskal–Wallis test, and correlations were established using Spearman's correlation, partial correlations (adjusted for age, medications and pathologies) and simple linear regression. Significance was set at $p < 0.05$. (3) Results: Women with obesity had higher systolic and diastolic blood pressure (SBP = NW: 106.5 ± 11.6; OW: 111.60 ± 11.8; OB: 123.63 ± 14.0; $p < 0.001$ and DBP = NW: 66.5 ± 9.9; OW: 70.2 ± 8.7; OB: 80.6 ± 11.0; $p < 0.001$) and a lower consumption of unprocessed or minimally processed food (MPF) (NW: 0.25 ± 0.1; OW: 0.27 ± 0.09; OB: 0.21 ± 0.07; $p = 0.027$). Moreover, we found an inverse association among the consumption of MPF and diastolic blood pressure that remained after adjustments for covariates (r: −0.27; $p = 0.01$), suggesting that lower consumption of MPF is related to higher levels of DBP. (4) Conclusions: Our data suggest that women with obesity seem to have a lower consumption of MPF. In addition, MPF is negatively correlated with BP, suggesting an association with obesity and cardiovascular health.

**Keywords:** blood pressure; food consumption; obesity; minimally processed foods

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## 1. Introduction

Obesity is a global public health problem with growing prevalence. Epidemiological studies indicate that obesity in adults tripled between 1957 and 2016, reaching 650 million adults worldwide [1]. Most developing countries, such as Brazil, are experiencing a process of nutritional transition, characterized by an increase in the prevalence of obesity among adults, especially among women [2]. It is expected that 3 out of 10 adult Brazilians will be affected by obesity in the year 2030 [1]. In line with this, it is observed that among women, the prevalence of obesity tripled between 1975 and 2019, reaching approximately 30% of adult women in the country [3].

Several studies have described a relationship between obesity and the development of high blood pressure [4–6]. Blood pressure is regulated by the interaction of different mechanisms, including the baroreflex, renal, hormonal and nervous systems. Nevertheless, body mass index (BMI) and body composition, specifically visceral obesity, are described as the main determinants of blood pressure levels [4]. It is important to highlight that women with a BMI between 30 and 35 kg/m$^2$ have a four-fold increased likelihood of hypertension, whereas women with a BMI greater than 35 kg/m$^2$ have a six-fold increased likelihood [5].

Obesity has a multifactorial etiology; nonetheless, environmental factors such as sedentary lifestyles and inadequate eating habits seem to contribute directly to the development of obesity [7,8]. Diet patterns have changed in the world. The consumption of low-nutrient and energy-dense foods is growing, especially in low- and middle-income countries, which may lead to public health problems [9]. To guide consumers in making better food choices, the NOVA classification was developed. This system classifies foods into four categories according to the degree of food processing: unprocessed and minimally processed foods (MPF), culinary ingredients, processed foods (PF) and ultra-processed foods (UPF) [10,11]. Higher consumption of ultra-processed foods (UPFs) seems to mediate hypertension since this food group contributes to increased body weight and consequently to obesity [12].

Several studies have investigated the relationship between the degree of food processing and cardiovascular risk factors [13–15]. Since this relationship is not clear yet, studies on this topic are necessary for comprehension of the impact of UPF and/or MPF intake [16]. In this scenario, this study aims to investigate the relationship between the degree of food processing and blood pressure in women with overweight and obesity. We hypothesize that women with obesity will have worse food consumption, with high UPF and low MPF consumption, contributing to increased blood pressure levels.

## 2. Materials and Methods

### *2.1. Study Design*

This cross-sectional study was carried out with adult women (≥20 and <60 years old) from Vitória de Santo Antão, Pernambuco, Brazil. This study was developed following the Declaration of Helsinki regarding work involving human beings and approved by the Research Ethics Committee of the Federal University of Pernambuco (protocol number 5.120.260). All the study participants signed an informed consent form.

The sample size was calculated by Winpepi software (version 11.65) based on Cavalcante and collaborators (2022) study's, adopting a confidence level of 95%, an acceptable difference of 5%, a proportion of overweight of 62% and a percentage of expected loss of 10% [17]. Thus, 85 women were recommended for this study.

Participants were recruited through a partnership with municipal schools. Women were invited to participate and selected through spontaneous adherence and through a non-probabilistic sampling process. After giving their formal consent, the women were subdivided into three groups, normal weight (NW), overweight (OW) and obesity (OB), according to body mass index (BMI). Women were excluded if they were pregnant or if they had pathologies that could affect their nutritional status and/or consumption, such as cancer, cirrhosis or HIV/AIDS.

### *2.2. Socioeconomic, Lifestyle and Clinical Conditions Asseessment*

A semi-structured questionnaire was used to evaluate their socioeconomic characteristics, lifestyle and clinical conditions. The questionnaire included questions about marital status, education and income (using the minimum wage as a reference).

Physical activity practices, smoking habits and the consumption of alcoholic beverages were investigated and self-declared by the participants. All of these parameters were investigated for the past three months and categorized into dichotomous variables: yes or no. We categorized the absence of moderate or vigorous physical activity, smoking or the consumption of alcoholic beverages in the last three months as no. For clinical conditions, the questionnaire investigated diagnoses of previous pathologies and the use of medications. The medication use was grouped into three categories: no medications, medications for cardiometabolic diseases and others.

### *2.3. Anthropometric Assessment*

In the anthropometric assessment, weight, height and waist (WC), arm and hip (HC) circumferences were measured, as well as the biceps, triceps, supra-iliac and subscapular skinfolds. Body weight was obtained using a digital scale with a precision of 100 g and a maximum capacity of 150 kg (Omron®, Singapore, HBF-214LA). Height was measured using a compact portable stadiometer, fixed to the wall, with a measurement range of 0 to 200 cm and a precision of 0.1 cm (MD®, Hong Kong, HT-01). BMI was calculated by the ratio between weight (kg) and height$^2$ (m). BMIs ≥18.5 kg/m$^2$ and <25 kg/m$^2$ were considered normal weights, >25 kg/m$^2$ and <30 kg/m$^2$ corresponded to overweight and >30 kg/m$^2$ indicated obesity [18].

The circumferences were measured using a 200 cm inelastic measuring tape (Cescorf®, Porto Alegre, Brazil). WC was classified as indicative of low (<80 cm) or high cardiovascular risk (≥80 cm). The waist–hip ratio (WHR) was obtained by dividing the WC and HC in centimeters, and the cut-off point used was proposed by Balkau (2007) considering the women's age. Three categories were established: low, moderate and high/very high [19].

Biceps, triceps supra-iliac and subscapular skinfolds were measured to assess the percentage of body fat (%BF) using a digital adipometer with 0.1 mm precision (Cescorf®) in the right hemibody, and this was repeated twice in each location in all the individuals analyzed. A third measurement was taken whenever the difference between the first and second measurements exceeded 5%. At the end, the arithmetic average between the two closest values obtained was extracted, according to Lohman (1986). The % BF was classified as adequate, raised to very high or excessively high according to Pollock and Wilmore (1993) [20,21].

### *2.4. Food Consumption Assessment*

Food consumption was assessed using the Food Frequency Questionnaire (FFQ), adapted for adults from Pernambuco [22]. It was applied in a single day to investigate the participants' food consumption for the last three months. The frequency of consumption was recorded (1 to 10 times) in five periods: daily, weekly, monthly, in the last three months or never. The scoring method was applied, so the frequency of consumption of each food was treated as a quantitative variable. For each food, the number of times it was consumed was divided by the number of days (day = 1; week = 7; month = 30; last 3 months = 90). Thus, for example, if an individual ate a certain food once a day, the score was 1; if 3 times a week, it was 0.42; if 3 times a month, it was 0.1; and so on for all frequencies reported [23].

Three trained nutritionists categorized the food presented in the FFQ according to the degree of food processing following the NOVA classification and the instructions of the Food Guide for the Brazilian Population (2014). The food was grouped into one of four categories: unprocessed or minimally processed food (MPF), processed food (PF), ultra-processed food (UPF) and culinary ingredients. The categorization was applied individually by the three trained nutritionists, and when uncertainty existed about a food's categorization, a consensus was reached according to the most common pattern of consumption based on local food practices and other authors [11,24,25]. The definitions of the degree of food processing and the food included in each category are described in Table 1.

**Table 1.** Classification of foods from the Food Frequency Questionnaire according to the degree of processing food.

| Degree of Processing Food | Definition | Foods |
|---|---|---|
| Unprocessed or minimally processed foods | Obtained from plants or animals without having been altered after leaving nature or undergoing minimal alterations | Rice, brown rice, corn/couscous, oats, potatoes, sweet potatoes, cassava flour, cassava, yams, tapioca, beans, green beans, soybeans, natural/salted peanuts, chestnuts/walnuts, almonds, whole milk, skimmed milk or semi-skimmed milk, beef (stewed, roasted, grilled or fried), pork, liver, chicken/beef or pork giblets, chicken with skin, chicken without skin, fish in sauce, fried fish, seafood, boiled chicken egg, fried chicken egg, raw salad, cooked salad, chayote, carrot, pumpkin, okra/gherkin, green beans, cauliflower/cabbage/chard, spinach/kale leaves/broccoli, beetroot, banana, orange, acerola, passion fruit, mango, apple, papaya, avocado, guava, melon, jackfruit, grape, seriguela, pineapple, umbu, cajá, pine cone, pear, soursop, cashews, carambola, tamarind, strawberry/kiwi, coffee, tea, coconut water, sugar-free fruit juice |

**Table 1.** *Cont.*

| Degree of Processing Food | Definition | Foods |
|---|---|---|
| Processed foods | Made by adding salt or sugar to an unprocessed/minimally processed food (MPF) | French bread/white bread, wholemeal bread, sliced bread, pasta, French fries, curd/Prato cheese /mozzarella or butter/ricotta cheese, Minas cheese, light curd, beef jerky/sun-dried meat, tuna, canned sardines, bacon, fruit in syrup or candied fruit, oven-baked snacks, simple homemade cake, fruit juice with sugar, beer, wine, tequila/whiskey |
| Ultra-processed foods | Products that involve several stages, processing techniques and various ingredients in their manufacture | Cream cracker biscuits, wholemeal biscuits, Japanese peanuts or nuts with a caramelized topping or another topping, milk or soy extract, cream, full fat yogurt, light yogurt, full fat cream cheese, light cream cheese, mortadella, ham, sausage, preserved meat, breaded meat, chocolate, candies and sweets, pudding/delicacies/ice cream/chocolate, packaged snacks, coxinhas/pie/rissoles/pasteis, pizza/sandwiches/McDonalds, ketchup/mustard, cornstarch and maria biscuits, biscuits with filling or butter, cake mixes, frosted cakes and pies, instant noodles, granola bars, sugary breakfast cereals, soda, diet soda, artificial juice |
| Cooking ingredients | Extracted from nature or taken directly from nature to season and cook food | Butter, margarine, olive oil, oil, mayonnaise, light mayonnaise, sugar, honey/rapadura |

### *2.5. Blood Pressure Measurement*

A stethoscope and an aneroid sphygmomanometer (Premium®Medical Instruments, Wenzhou, China) were used to measure blood pressure (BP). Two measurements were taken on the left arm with an interval of 1 min in a sitting position. The measurements were taken after the women remained at rest for five minutes. If there was a difference greater than 2 mmHg between the two measurements, a third measurement was performed. This procedure was repeated on two different days, with a maximum of a 15-day interval, to allow for greater confidence in the values, reducing the possibility of occasional factors such as stress. The final value was obtained through the simple arithmetic of the means of the two closest values for each day. BP classification was performed according to the Brazilian guidelines as normal when SBP $\leq$ 120–129 and DBP $\leq$ 80–84 mmHg. The values SBP $\geq$130 and DBP $\geq$ 85 mmHg were considered prehypertensive/hypertensive [26].

### *2.6. Statistical Analysis*

Exploratory data analysis was used to identify possible inaccurate information and the presence of outliers. The normality and homogeneity of the data were confirmed by the Kolmogorov–Smirnov and Levene's tests, respectively. Qualitative data were presented as percentages, and the differences among the groups were compared by Pearson's chi-square test.

Descriptive statistics were calculated for the quantitative data. The data were presented as means and standard deviation of the means. Intergroup comparison was performed using a one-way ANOVA test followed by Tukey's post hoc test in the case of parametric data or the Kruskal–Wallis test followed by Dunn's post hoc test for non-parametric data. The relationships between the degree of food processing, the anthropometric measures and blood pressure were analyzed using Spearman's correlation, partial correlation (with adjustment for age, medications and pathologies) and simple linear regression. All the analyses were performed using SPSS version 20.0 (SPSS, Inc. Chicago, IL, USA), and significance was set at $p < 0.05$.

## **3. Results**

### *3.1. Socioeconomic Characterization, Lifestyle and Clinical Conditions*

Table 2 shows the socioeconomic characterization, lifestyle and clinical conditions of the volunteers. A total of 85 adult women were included, of whom 23 (27.05%) were of a normal weight, 29 (34.1%) were overweight and 33 (38.8%) had obesity. No differences between the groups were found in terms of the socioeconomic parameters. In general, there was a predominance of single women (57.6%) with a high school education (48.2%) and a monthly family income corresponding to the minimum wage (51.2%). Thus, our data suggest a homogeneous population with a similar socioeconomic status.

**Table 2.** Characterization of socioeconomic, lifestyle and health conditions of adult women classified according to BMI in Vitória de Santo Antão—PE, 2022.

| **Parameters** | **Normal Weight** ***n*** **= 23** | **Overweight** ***n*** **= 29** | **Obesity** ***n*** **= 33** | **Total** ***n*** **= 85** | ***p*** **Value** |
|---|---|---|---|---|---|
| | ***n*** **(%)** | ***n*** **(%)** | ***n*** **(%)** | ***n*** **(%)** | |
| **Marital status** | | | | | |
| Single/divorced | 14 (16.4%) | 16 (18.8%) | 19 (22.3%) | 49 (57.6%) | 0.804 |
| Married | 9 (10.6%) | 12 (14.1%) | 15 (17.6%) | 36 (42.4) | |
| **Education** | | | | | |
| Elementary school | 5 (5.9%) | 11 (12.9%) | 17 (20.0%) | 33 (38.8%) | 0.149 |
| High school | 14 (16.5%) | 12 (14.1%) | 15 (17.6%) | 41 (48.2%) | |
| Technical education or higher | 4 (4.7%) | 6 (7.05%) | 1 (1.17%) | 11 (12.9%) | |
| **Income** | | | | | |
| <1 minimum wage | 7 (8.3%) | 7 (8.3%) | 13 (15.5%) | 27 (32.1%) | 0.498 |
| 1 minimum wage | 11 (13.1%) | 17 (20.2%) | 15 (17.9%) | 43 (51.2%) | |
| ≤2 minimum wages | 4 (4.8%) | 5 (6.0%) | 2 (2.4%) | 11 (13.1%) | |
| Not specified | 1 (1.2%) | - | 2 (2.4%) | 3 (3.6%) | |
| **Pathologies** | | | | | |
| Without pathology | 17 (20.0%) | 16 (18.8%) | 17 (20.0%) | 50 (58.8%) | 0.098 |
| Hypertension | 0 (0.0%) | 0 (0.0%) | 6 (7.1%) | 6 (7.1%) | |
| Dyslipidemia | 0 (0.0%) | 2 (2.4%) | 2 (2.4%) | 4 (4.8%) | |
| Anxiety/depression | 2 (2.4%) | 3 (3.5%) | 0 (0.0%) | 5 (5.9%) | |
| Others | 4 (4.8%) | 8 (9.4%) | 8 (9.4%) | 20 (23.6%) | |
| **Medications** | | | | | |
| Cardiometabolic | 1 (1.2%) | 5 (5.9%) | 10 (11.8%) | 16 (18.8%) | 0.194 |
| Others | 4 (4.7%) | 4 (4.7%) | 4 (4.7%) | 12 (14.1%) | |
| No medications | 18 (21.2%) | 20 (23.5%) | 19 (22.4%) | 57 (67.1%) | |
| **Smoker** | | | | | |
| Yes | 1 (1.2%) | 1 (1.2%) | 1 (1.2%) | 3 (3.5%) | 0.966 |
| No | 22 (25.9%) | 28 (32.9%) | 32 (37.6%) | 82 (96.5%) | |
| **Alcoholic beverage** | | | | | |
| Yes | 9 (10.6%) | 11 (12.9%) | 13 (15.3%) | 33 (38.8%) | 0.555 |
| No | 14 (16.5%) | 18 (21.2%) | 20 (23.6%) | 52 (61.2%) | |
| **Physical activity** | | | | | |
| Yes | 7 (8.2%) | 10 (11.8%) | 8 (9.4%) | 25 (29.4%) | 0.672 |
| No | 16 (18.8%) | 19 (22.4%) | 25 (29.4%) | 60 (70.6%) | |
| **WC** | | | | | |
| Without risk | 21 (24.7%) | 9 (10.6%) | - | 30 (35.3%) | <0.001 |
| At risk/high-risk | 2 (2.4%) | 20 (23.5%) | 33 (38.8.0%) | 55 (64.7%) | |
| **WHR Rating** | | | | | |
| Low | 2 (2.4%) | 1 (1.2%) | 4 (4.7%) | 7 (8.2%) | <0.001 |
| Moderate | 16 (18.8%) | 10 (11.8%) | 4 (4.7%) | 30 (35.3%) | |
| High/very high | 5 (5.9%) | 18 (21.2%) | 25 (29.4%) | 48 (56.5%) | |
| **%BF Rating *** | | | | | |
| Adequate | 1 (1.2%) | - | - | 1 (1.2%) | <0.001 |
| Raised to very high | 17 (21.0%) | 8 (9.4%) | 5 (5.9%) | 30 (35.3%) | |
| Excessively high | 4 (4.7%) | 21 (24.7%) | 26 (30.6%) | 51 (60.0%) | |
| **Blood Pressure** | | | | | |
| Normotensive | 22 (25.9%) | 26 (30.6%) | 22 (25.9%) | 70 (82.4%) | 0.042 |
| Prehypertensive/ hypertensive | 1 (1.2%) | 3 (3.6%) | 11 (13.0%) | 15 (17.7) | |

* Missing data: ($n$ = 6) 7.1%; $n$: number; %: percentage; <: minor; WC: waist circumference; WHR: waist–hip ratio; GC: body fat; other pathologies: diabetes, CVD, kidney disease, bone problems and epilepsy. Groups were compared by Pearson's chi-square test.

The groups had a similar lifestyle: most of the women were non-smokers (96.5%) and presented a sedentary lifestyle (70.6%). Consumption of alcoholic beverages was reported in 38.5% of the women.

The blood pressure results indicated that prehypertension or hypertension reached 13% of the women with obesity. The groups were similar in terms of previous pathologies and the use of medications. The majority of the women reported not having a previous diagnosis of a pathology (58.8%). However, the most prevalent pathologies were hypertension (7.1%), anxiety/depression (5.9%) and dyslipidemia (4.8%). In addition, 67.1% of the women denied using medication, while 18.8% reported the use of medication for cardiometabolic diseases (Table 2).

### *3.2. Anthropometric Parameters, Blood Pressure and Food Consumption*

Table 3 shows the anthropometric parameters, blood pressure and food consumption of the groups. They were similar in terms of age and differed in their anthropometric parameters, as expected, due to the criteria for characterizing the groups. Thus, women with obesity presented a higher WC, WHR and %BF. We emphasize that despite the group with obesity presenting with higher body fat when compared to the other groups, this parameter was considered above the normal range in all of the groups (Table 2). SBP and DBP were higher in the group with overweight and obesity when compared to those of a normal weight (SBP = NW: 106.5 ± 11.6; OW: 111.60 ± 11.8; OB: 123.63 ± 14.0; $p < 0.001$ and DBP = NW: 66.5 ± 9.9; OW: 70.2 ± 8.7; OB: 80.6 ± 11.0; $p < 0.001$), suggesting an association between excess weight and blood pressure levels.

**Table 3.** Demographic, anthropometric and blood pressure characterization of adult women classified according to BMI in Vitória de Santo Antão—PE, 2022.

| **Parameters** | **Normal Weight (*n* = 23)** | **Overweight (*n* = 29)** | **Obesity (*n* = 33)** | ***p* Value** |
|---|---|---|---|---|
| | **Mean ± SD** | **Mean ± SD** | **Mean ± SD** | |
| **Age (Years)** [2] | 35.48 ± 7.36 | 37.37 ± 8.0 | 39.36 ± 8.80 | 0.233 |
| **WC (cm)** [1] | 73.5 ± 4.91 | 84.21 ± 6.55 [a] | 100.71 ± 10.84 [ab] | <0.001 |
| **WHR** [1] | 0.77 ± 0.03 | 0.81 ± 0.05 [a] | 0.84 ± 0.76 [a] | <0.001 |
| **BF (%)** [1] | 30.33 ± 3.91 | 36.79 ± 3.88 [a] | 40.29 ± 3.84 [ab] | <0.001 |
| **SBP (mmHg)** [2] | 106.55 ± 11.65 | 111.60 ± 11.85 [a] | 123.63 ± 14.04 [ab] | <0.001 |
| **DBP (mmHg)** [2] | 66.52 ± 9.91 | 70.28 ± 8.78 [a] | 80.6 ± 11.03 [ab] | <0.001 |

WC: waist circumference; cm: centimeter; WHR: waist–hip ratio; BF: body fat; %: percentage; SBP: systolic blood pressure; DBP: diastolic blood pressure; mmHg: millimeters of mercury; n: number; SD: standard deviation. (a): When $p < 0.05$ compared to the normal weight group; (b): when $p < 0.05$ compared to the overweight group. Values were expressed as means ± standard deviation of the mean; [1] one-way ANOVA test with Tukey's post hoc test for parametric data and [2] Kruskal–Wallis test with Dunn's post hoc test for non-parametric data.

Regarding food consumption, our results suggest that the group with obesity had a lower intake of MPF (NW: 0.25 ± 0.1; OW: 0.27 ± 0.09; OB: 0.21 ± 0.07; $p = 0.027$) when compared to the overweight group. The groups had a similar consumption of PF (NW: 0.18 ± 0.1; OW: 0.23 ± 0.05; OB: 0.16 ± 0.06; $p = 0.370$) and UPF (NW: 0.36 ± 0.11; OW: 0.17 ± 0.14; OB: 0.10 ± 0.06; $p = 0.084$). The intake of cooking ingredients was similar among the groups (NW: 0.65 ± 0.3; OW: 0.71 ± 0.43; OB: 0.54 ± 0.23; $p = 0.482$); however, we should highlight that it presented the highest score for food consumption (Figure 1).

### *3.3. Association between the Degree of Food Processing, Anthropometric Variables and Blood Pressure*

BMI was positive correlated with SBP and DBP, suggesting a strong correlation between a higher BMI and blood pressure (Figure 2).

Negative correlations were found between MPF consumption and BMI (r: −0.23; $p = 0.03$) and DPB (r: −0.36; $p = 0.001$), suggesting that a decrease in the consumption of MPF is related to higher levels of blood pressure. After adjusting our data for age, medications and pathologies, these correlations remained, suggesting that independently of these covariates, the consumption of MPF seems to influence BP. A negative correlation between MPF and body fat (r: −0.27; $p$ = 0.01) was found after the adjustments, suggesting that a lower intake of MPF is related to high body fat. Furthermore, a negative correlation was found among UPF, age and DBP (r: −0.23; $p$ = 0.03); however, after adjusting our data for covariates, no correlations were found, suggesting the influence of the covariates in this analysis (Table 4).

The results from the simple linear regression are described in Table 5. We found an association between the consumption of MPF and DPB (B: −0.26; CI 95% −60.43–5.00; $p$: 0.021); thus, our data reinforce the association between the consumption of MPF and BP.

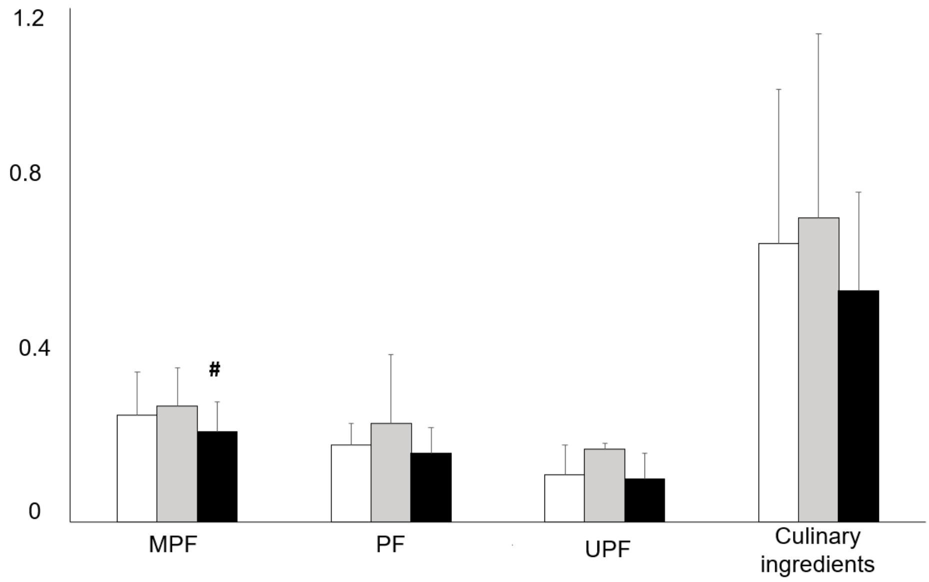


**Figure 1.** Food consumption according to the degree of food processing in adult women classified according to BMI in Vitória de Santo Antão—PE, 2022. MPF: unprocessed/minimally processed food; PF: processed food; UPF: ultra-processed food; white bar: women with a normal weight; gray bar: overweight women; black bar: women with obesity. (#): When $p < 0.05$ compared to the overweight group; values were expressed as means ± standard deviation of the mean. Kruskal–Wallis test with Dunn's post hoc test.

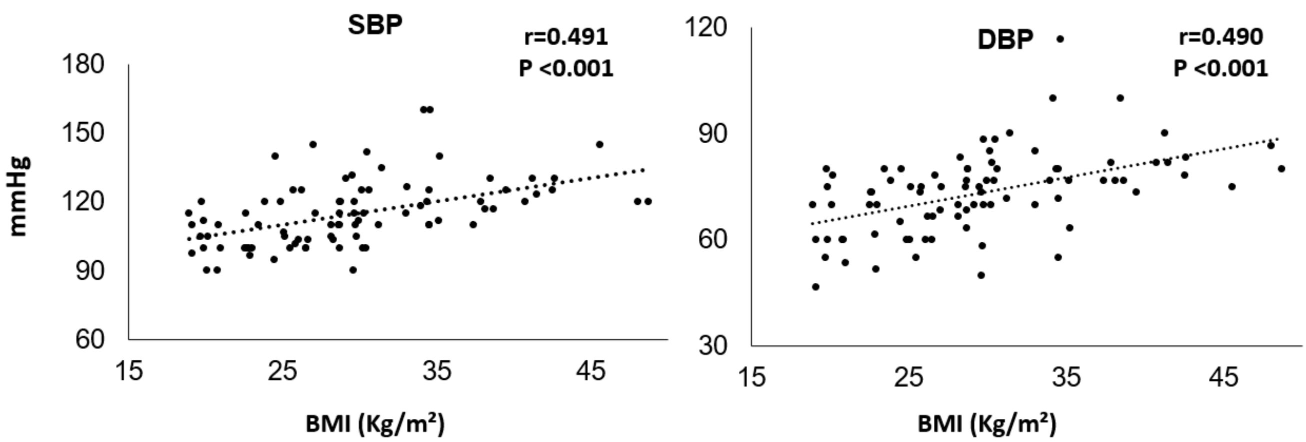


**Figure 2.** Correlation between body mass index and systolic and diastolic blood pressure in adult women in Vitória de Santo Antão—PE, 2022. BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure. r: Spearman's correlation coefficient; $p$: value. Spearman's correlation.

**Table 4.** Correlation between the degree of food processing, anthropometric variables, sociodemographic data and blood pressure of adult women, with and without adjustment for age, medications and pathologies, in Vitória de Santo Antão—PE, 2022.

| **Degree of food processing** | **Without Adjustment [1]** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age | | BMI | | %BF | | WHR | | SBP | | DBP | |
| | R | P | r | p | r | p | R | p | r | p | r | p |
| MPF | −0.21 | 0.05 | **−0.23** | **0.03** | −0.20 | 0.07 | −0.18 | 0.09 | −0.15 | 0.15 | **−0.36** | **0.001** |
| PF | −0.04 | 0.69 | −0.05 | 0.61 | −0.01 | 0.88 | −0.08 | 0.37 | −0.08 | 0.45 | −0.10 | 0.33 |
| UPF | **−0.24** | **0.02** | −0.17 | 0.12 | −0.15 | 0.17 | −0.11 | 0.28 | −0.09 | 0.37 | **−0.23** | **0.03** |
| Cooking ingredients | −0.12 | 0.24 | −0.09 | 0.39 | −0.04 | 0.66 | 0.07 | 0.48 | 0.04 | 0.69 | −0.02 | 0.05 |
| | **With Adjustement [2]** | | | | | | | | | | | |
| **Degree of food processing** | | | BMI | | %BF | | WHR | | SBP | | DBP | |
| | | | r | p | r | p | R | p | r | p | r | p |
| MPF | | | **−0.29** | **0.009** | **−0.27** | **0.01** | −0.16 | 0.13 | −0.13 | 0.24 | **−0.29** | **0.01** |
| PF | | | −0.01 | 0.89 | 0.53 | 0.63 | −0.06 | 0.56 | −0.009 | 0.93 | −0.10 | 0.35 |
| UPF | | | −0.88 | 0.43 | −0.09 | 0.38 | 0.03 | 0.74 | 0.08 | 0.46 | −0.08 | 0.45 |
| Cooking ingredients | | | −0.10 | 0.36 | −0.01 | 0.89 | 0.09 | 0.38 | 0.07 | 0.53 | −0.19 | 0.09 |

MPF: unprocessed/minimally processed food; PF: processed food; UPF: ultra-processed food; BMI: body mass index; kg/m$^2$; WC: %BF: body fat percentage; %: percentage; SBP: systolic blood pressure; DBP: diastolic blood pressure; r: Spearman's correlation coefficient; *p*: value; **bold** when $p < 0.05$; [1]: Spearman's correlation. [2]: Partial correlation test with adjustment for age, medications and pathology.

**Table 5.** Simple linear regression of degree of food processing and blood pressure in women.

| | **MPF** | | | **PF** | | | **UPF** | | | **Cooking Ingredients** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **B** | **IC (95%)** | ***p*** | **B** | **IC (95%)** | ***p*** | **B** | **IC (95%)** | ***p*** | **β** | **IC (95%)** | ***p*** |
| SBP | −0.15 | −60.39–12.22 | 0.19 | −0.04 | −38.87–26.43 | 0.70 | 0.02 | −30.29–37.18 | 0.84 | 0.06 | −6.96–12.12 | 0.59 |
| DBP | **−0.26** | **−60.43–5.00** | **0.02** | −0.005 | −25.44–24.41 | 0.96 | −0.034 | −29.54–21.96 | 0.77 | 0.15 | −12.30–2.26 | 0.17 |

MPF: unprocessed/minimally processed food; PF: processed food; UPF: ultra-processed food; SBP: systolic blood pressure; DBP: diastolic blood pressure. **Bold** when $p < 0.05$. Simple linear regression test.

## 4. Discussion

In the present study, women with obesity presented higher cardiovascular risk parameters, such as WC, % BF, SBP and DBP, when compared to women of a normal weight and overweight women. In line with this finding, the majority of the women who had blood pressure classified as prehypertension or hypertension belonged to the group with obesity. In addition, the women with obesity had a lower consumption of MPF. We found an association between MPF consumption and higher DBP in the women. These findings strengthen the relationship between obesity and cardiovascular risk [24] and also highlight the importance of having healthy eating habits and an adequate consumption of MPF.

The prevalence of obesity is considered a global public health problem [1]. In Latin America, the trend in overweight and obesity is also increasing, especially in Mexico and Brazil, which reached an increase in BMI of 1.27 kg/m$^2$ per decade between 1975 and 2014 [27]. The prevalence of obesity among women of reproductive age in Brazil was around 55% in 2013 [28]. In the present study, 72% of women had overweight or obesity, reinforcing this increase in prevalence over the years. In line with this, the prevalence of chronic diseases has also increased, especially hypertension. Here, a diagnosis of hypertension was present in 7.1%; however, blood pressure was indicative of prehypertension or hypertension in 17.7% of the women. The global prevalence of hypertension doubled from 1990 to 2019 and reached 626 million women [29]. In 2015, a hypertension prevalence of 27.4% was found in the northeast of Brazil [30].

Overweight and obesity seem to be associated with the development of arterial hypertension at different stages of life [31,32]. Studies suggest that individuals with obesity seem to have higher blood pressure levels when compared to those of a normal weight and overweight individuals, although within the normal range [33,34]. In this scenario, it is important to highlight that the impact of obesity on BP seems to be associated with the length of time of exposure to obesity, as long-term exposure leads to greater cardiometabolic damage [30]. Nonetheless, it is important to emphasize that we found an increase in BP in women who were overweight in this age group, suggesting that even in adults, overweight appears to cause damage to cardiovascular health.

The relationship between being overweight and having high levels of blood pressure is established through the deregulation of control mechanisms. Among these mechanisms, hormonal, baroreflex and autonomic control stand out [34]. The influence of the autonomic nervous system on blood pressure seems to be greater in postmenopausal women, suggesting that in older women, the elevation of sympathetic nervous activity may be an important contributor to the increased incidence of hypertension after menopause [35,36]. Therefore, women who reach postmenopausal age with obesity appear to be more susceptible to increased blood pressure.

Regarding the women's illness profile, the most prevalent pathology was arterial hypertension, followed by anxiety and/or depression and dyslipidemia, with no differences in this prevalence observed when considering their nutritional status. This result corroborates previous studies that indicate that hypertension is considerably prevalent in females [3]. Furthermore, it is important to highlight that in the present study, 70.6% of the women reported not practicing physical activity, a condition that can contribute to the development of overweight/obesity and also a worse illness profile [37].

In this study, no differences were found in the consumption of PF, UPF or cooking ingredients among the groups, suggesting a similar intake of these categories. Nevertheless, the women with obesity presented a lower consumption of MPF when compared to overweight women. In addition, we also found a negative association among MPF, BF and BMI. Thus, our data suggest that a lower consumption of MPF seems to be related to a higher BMI and a worse body composition, even after adjustment for confounding factors. Moreover, we found an inverse association between the consumption of MPF and DBP that remained after the adjustments for confounding factors. A lower consumption of MPF and a higher consumption of UPF appear to be associated with overweight, obesity and increased blood pressure levels [15,38,39]. A longitudinal study carried out on 2496 adults from a state in southeastern Brazil found that a higher consumption of MPF was associated with a lower risk of increased DBP, while a higher consumption of UPF was associated with an increase in DBP [38].

An association was found between UPF and DBP; however, when we adjusted the data for confounding factors, this association was lost. The reason for these results may be explained by the increase in age and the presence of comorbidities. According to Berti et al. (2019), the consumption of UPF tends to decrease proportionally with age among women, as was observed in our data. This dietary change could be related to dietary restrictions, which are sometimes due to the presence of chronic diseases or conditions, such as hypertension, diabetes and dyslipidemia [40].

The frequency of MPF consumption was inversely associated with DBP. Our results suggest that for each 10% increase in the frequency of MPF consumption, there was a reduction of 0.26 mmHg in DBP (β: −0.26; IC 95% −60.43 to 5.00; $p$: 0.021). The consumption of MPF has been associated with a lower risk of cardiovascular disease [41]. Different factors may be associated with the reduction in cardiovascular risk in individuals who have a diet predominantly based on MPF, such as its low caloric density and no or little added sugar, fat or sodium. In addition, MPF is rich in nutrients, non-digestible carbohydrates and water. This group of factors contributes to greater satiety, body weight reduction and consequently a lower cardiovascular risk [25]. Studies carried out on Brazilian adults and children have shown that a lower consumption of UPF and a higher consumption of MPF seem to have a positive impact on blood pressure [14,25].

We highlight that the absence of a correlation between blood pressure and UPF may be due to under-reporting of the consumption of these foods by women with overweight or obesity, or it may be due to changes in eating habits that may occur in this population due to the presence of chronic diseases or even the goal of weight loss [40].

This study has some limitations; firstly, it had a cross-sectional design, which did not allow us to establish causal relationships. We also emphasize that the present study is not a population-based study, which does not allow the findings to be generalized to the entire population. Furthermore, the use of the Frequency Food Questionnaire to assess food consumption made it difficult to classify foods according to their degree of processing due to the low level of detail on the items. Equally, we believe that to provide more accurate data, a quantitative method for investigating food consumption should be used. Finally, despite these limitations, the present study showed important data on women's food consumption, which may be useful for the development of public policies that combat overweight, obesity and high blood pressure in this population.

## 5. Conclusions

Our findings suggest that women with overweight and obesity had higher blood pressure levels and higher WC, WHR and %BF values, which seem to contribute to higher systolic and diastolic blood pressure. Regarding food consumption, women with obesity seem to have a lower consumption of MPF. Furthermore, an inverse association between MPF and diastolic blood pressure was observed, suggesting that a lower consumption of MPF seems to contribute to an increase in arterial blood pressure.

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**Informed Consent Statement:** Informed consent was obtained from all the subjects involved in this study.

**Data Availability Statement:** The data presented in this study are available on request from the corresponding author due to ethical reasons.

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