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BEAN CONSUMPTION IS ASSOCIATED WITH LOWER OBESITY PREVALENCE: A POPULATION-BASED STUDY

O CONSUMO DE FEIJÃO ESTÁ ASSOCIADO A UMA MENOR PREVALÊNCIA DE OBESIDADE: UM ESTUDO DE BASE POPULACIONAL

EL CONSUMO DE FRIJOLES SE ASOCIA CON UNA MENOR PREVALENCIA DE OBESIDAD: UN ESTUDIO POBLACIONAL

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ABSTRACT

Objective: To examine the association between the weekly frequency of bean consumption and obesity, according to body mass index (BMI) and waist circumference (WC), among adults. Methods: This was a cross-sectional, household-based, population-based study. A total of 1,204 individuals aged 20–59 years of both sexes participated. Demographic, socioeconomic, lifestyle, dietary intake and anthropometric data were collected. The χ^2 test and Poisson regression, expressed as prevalence ratios, were used to assess associations. The study was approved by the Research Ethics Committee (approval no. 2,552,426). Results: 58.6% of the study population consumed beans at least six times per week. The prevalence of obesity according to BMI and WC was 25.6% and 31.6%, respectively. Individuals who consumed beans more frequently presented lower triceps skinfold thickness and arm circumference measurements. The prevalence ratios for obesity according to BMI and WC were, respectively, 38% and 23% lower in the group with more frequent bean consumption. Conclusion: The results show that regular bean consumption is associated with a lower prevalence of obesity. Thus, this study supports current recommendations for regular bean consumption.

KEYWORDS: *Dietary intake; Obesity; Abdominal fat.*

RESUMO

Objetivo: Examinar a associação entre a frequência semanal de consumo de feijão e a obesidade, de acordo com o índice de massa corporal (IMC) e a circunferência da cintura (CC), em adultos. Métodos: Trata-se de um estudo transversal, domiciliar e de base populacional. Participaram 1.204 indivíduos de ambos os sexos, com idades entre 20 e 59 anos. Foram coletados dados demográficos, socioeconômicos, de estilo de vida, de ingestão alimentar e antropométricos. O teste χ^2 e a regressão de Poisson, expressos como razões de prevalência, foram utilizados para avaliar as associações. O estudo foi aprovado pelo Comitê de Ética em Pesquisa (aprovação nº 2.552.426). Resultados: 58,6% da população estudada consumia feijão pelo menos seis vezes por semana. A prevalência de obesidade, de acordo com o IMC e a CC, foi de 25,6% e 31,6%, respectivamente. Indivíduos que consumiam feijão com maior frequência apresentaram menor espessura da prega cutânea tricipital e menor circunferência do braço. As taxas de prevalência de obesidade, de acordo com o IMC e a CC, foram, respectivamente, 38% e 23% menores no grupo com consumo mais frequente de feijão. Conclusão: Os resultados mostram que o consumo regular de feijão está associado a uma menor prevalência de obesidade. Assim, este estudo apoia as recomendações atuais para o consumo regular de feijão.

PALAVRAS-CHAVE: Ingestão alimentar. Obesidade. Gordura abdominal.

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RESUMEN
Objetivo: Examinar la asociación entre la frecuencia semanal de consumo de frijoles y la obesidad, según el índice de masa corporal (IMC) y la circunferencia de la cintura (CC), en adultos. Métodos: Este fue un estudio transversal, basado en hogares, basado en la población. Un total de 1,204 individuos de 20 a 59 años de ambos sexos participaron. Se recopilaron datos demográficos, socioeconómicos, de estilo de vida, ingesta dietética y antropométricos. La prueba χ^2 y la regresión de Poisson, expresadas como razones de prevalencia, se utilizaron para evaluar las asociaciones. El estudio fue aprobado por el Comité de Ética de la Investigación (aprobación n.° 2,552,426). Resultados: El 58.6% de la población estudiada consumió frijoles al menos seis veces por semana. La prevalencia de obesidad según el IMC y la CC fue del 25.6% y del 31.6%, respectivamente. Los individuos que consumieron frijoles con mayor frecuencia presentaron menores medidas de grosor del pliegue cutáneo del tríceps y circunferencia del brazo. Las tasas de prevalencia de obesidad según el IMC y la circunferencia de la cintura fueron, respectivamente, un 38 % y un 23 % menores en el grupo con mayor consumo de legumbres. Conclusión: Los resultados muestran que el consumo regular de legumbres está asociado con una menor prevalencia de obesidad. Por lo tanto, este estudio respalda las recomendaciones actuales sobre el consumo regular de frijoles.

PALABRAS CLAVE: *Ingesta dietética. Obesidad. Grasa abdominal.*

1. INTRODUCTION

The global increase in the intake of ultra-processed foods rich in fats and sugars, alongside the reduction in the consumption of unprocessed or minimally processed foods and decreased physical activity levels, has contributed to the rising prevalence of obesity, defined as an abnormal or excessive accumulation of body fat that may impair health[1]. According to the latest estimates from the World Health Organization, worldwide more than 1.9 billion adults aged 18 years or older were overweight, of whom more than 650 million were obese[2]. In Brazil, obesity affects 24.8% of adult women and 23.8% of adult men[3].

One of the main consequences of obesity, particularly abdominal obesity, is the development of cardiovascular diseases[2,4]. It is estimated that these conditions were responsible for 17.9 million deaths in 2019, accounting for 32% of all global deaths[5].

Waist circumference, used as a parameter of abdominal obesity, is a predictor of cardiovascular disease regardless of the degree of obesity and is associated with the presence of diabetes, hypertension, dyslipidemia and higher mortality[6–8]. Moreover, the use of more than one measure in the assessment of obesity is important, as it provides a better estimate of body fat beyond body mass index (BMI) and waist circumference (WC). Other measures, such as arm circumference and triceps skinfold thickness, have been used as alternatives to quantify body fat and to assess cardiovascular risk[7,9–13].

In this context, a healthy diet plays a significant role in health promotion and disease prevention[14]. In recent years, the consumption of beans has gained prominence for its role in the prevention and modulation of obesity and cardiovascular diseases[15–18].

Beans are traditional legumes in the Brazilian diet[16,19], being widely available, low-cost, versatile and nutritious, and are notable for their content of proteins, complex carbohydrates, dietary fibre,

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vitamins and minerals[20,21]. Their consumption is associated with a healthy dietary pattern[15, 22, 23]. Data from the Brazilian Household Budget Survey (2017–2018) show that beans are the third most consumed food in Brazil, ranking only behind rice and coffee[16].

Regular bean consumption exerts several beneficial effects, including increased satiety, maintenance of body weight, glycemic control and reductions in blood lipid concentrations[24, 25]. Corroborating these findings, the study by Papanikolaou *et al*[26] showed that bean consumption was associated with lower sugar intake, lower BMI and lower WC.

Although beans are one of the main components of the traditional Brazilian diet, recent changes in dietary patterns have contributed to a gradual decline in bean consumption in Brazil. Although experimental and epidemiological evidence suggests beneficial effects of bean consumption on body weight regulation and cardiometabolic health, population-based studies evaluating the association between the frequency of bean consumption and obesity markers among Brazilian adults remain limited. This knowledge gap is particularly relevant in Northeastern Brazil, a region undergoing an increasing nutritional transition while still preserving important regional dietary characteristics. Investigating this association may provide evidence to support national dietary guidelines and reinforce the role of traditional foods in obesity prevention. The present study aimed to assess the association between weekly frequency of bean consumption and obesity, according to BMI and WC, among adults from two cities in Northeastern Brazil.

2. METHODOLOGY

The data for this study were derived from the *Inquérito de Saúde Domiciliar no Piauí* (ISAD - PI; Household Health Survey in Piauí, 2018 - 2019)[27], a population-based cross-sectional survey conducted in a representative sample of the municipalities of Teresina and Picos, aimed at analysing living conditions and health status of the urban population through visits to private households.

The study sample was selected using a two-stage cluster sampling process: primary sampling units (PSU), consisting of census tracts, and, at the second stage, households, based on data from the *Instituto Brasileiro de Geografia e Estatística* (IBGE - Brazilian Institute of Geography and Statistics) census for the year 2010[28].

For the calculation of sample size, the population size and the number of private households in Teresina (767,557 inhabitants; 210,093 households) and Picos (58,321 inhabitants; 16,944 households) were considered. Based on these data, the mean number of individuals of both sexes per household was calculated for each of the following age groups: children under 2 years; children aged 3 - 4 years; children aged 5 - 9 years; adolescents aged 10 - 14 years; adolescents aged 15–19 years; adults aged 20 - 59 years; and older adults aged ≥60 years. The required total was then estimated at 578 households in Teresina and 620 households in Picos. The final sample size for this study was adjusted using the

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formula n = n_0/0.90, assuming a 90% response rate, resulting in approximately n ≅ 642 households in Teresina and n ≅ 688 households in Picos.

Upon completion of the survey, the final sample comprised 497 households in Teresina and 441 households in Picos. The number of individuals with data collected in each city was considered satisfactory, as it allowed the estimation of proportions with *Cv-$\hat{p}$* of around 20% and a design effect (deff) of approximately 1.5. Further details regarding the sample size and sampling design of the ISAD - PI have been published by Rodrigues *et al*.[27].

Of a total of 1,248 adult participants in the ISAD-PI, those who reported the Weekly Frequency of Bean Consumption (WFBC) were included in the present study, comprising 1,204 individuals.

Demographic and socioeconomic data (municipality of residence and address, age, sex, education and household income), lifestyle characteristics (alcohol consumption, smoking and physical activity) and dietary intake (weekly frequency of consumption of beans, red meat, fruit, raw salad and cooked salad) were investigated using structured questionnaires administered by trained interviewers, using mobile devices through the Epicollect 5® application (Imperial College London)[29]. All questionnaires used in the survey were developed based on those employed in the *Pesquisa Nacional de Saúde* (National Health Survey) conducted in 2013[30].

Data on participants' physical activity were collected using the Portuguese version of the International Physical Activity Questionnaire (IPAQ) - the long form for adults and the short form for older adults - covering the duration, frequency, and intensity of occupational, leisure, domestic, and transport-related physical activities. Classification as active or insufficiently active was based on WHO (2020) recommendations, which establish a minimum of 150 minutes of light-to-moderate activity or 75 minutes of vigorous activity per week for individuals aged 18 and older.

In addition, anthropometric data were collected, including weight, height, waist circumference, triceps skinfold thickness and arm circumference. Body weight (kilograms) and height (metres) were measured according to the recommendations of Cameron[31] and Jelliffe, Jelliffe[32], and were used to assess obesity through calculation of body mass index (BMI), applying the WHO cut-off points for adults[33] (non-obese: BMI < 30 kg/m²; obese: BMI ≥ 30 kg/m²).

Waist circumference (WC) was measured in accordance with WHO recommendations[6], and cardiovascular risk was classified as proposed by the WHO[6] (WC_{Men} ≥ 94 cm; WC_{Women} ≥ 80 cm). Arm circumference (AC; cm) was measured using a flexible, non-elastic measuring tape, and triceps skinfold thickness (TSF; mm) using a Lange® skinfold calliper; both were assessed following the recommendations of Frisancho[34].

The consumption of red meat, fruit and salads was assessed using the following questions: (1) “Do you usually eat red meat?”; (2) “Do you usually eat fruit?”; (3) “Do you usually eat raw salad?”; and (4) “Do you usually eat cooked salad?”. Response options were “yes” or “no”. Bean consumption was assessed by the question: “How many days a week do you usually eat beans?”, with response options

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ranging from 0 to 7 days per week. For clearer presentation of the data, the WFBC was categorised into three groups: 0–2 days per week; 3 - 5 days per week; and 6 - 7 days per week.

The study was submitted to the Ethics Committee of the *Universidade Federal do Piauí* (Federal University of Piauí) and approved under approval nº. 2,552,426. After clarification, all participants took part in the survey upon signing informed consent forms (ICF).

For variables with missing values, imputation was performed using the Predictive Mean Matching method, not exceeding 20%. Missing data were imputed for the following variables analysed in this study: income, education, alcohol consumption and smoking, using as predictors variables related to household geographical location, sex, age, employment status and marital status.

All analyses were conducted using the survey module of Stata software, version 14, which accounts for the sampling design (equiprobabilistic) in the estimation of results. The normality of variable distributions was assessed using the Kolmogorov-Smirnov test. A 95% confidence interval (95% CI) was adopted, and a p value < 0.05 was considered statistically significant.

The chi-squared test was used to examine the association between WFBC and the explanatory variables in the bivariate analysis. TSF and AC values according to WFBC categories were compared using one-way analysis of variance (ANOVA) with Bonferroni post hoc tests.

Multiple analysis of the association between obesity, cardiovascular risk and frequency of bean consumption was performed using prevalence ratios (PR), estimated by Poisson regression with robust variance adjustment (95% CI). The selection of confounding variables was based on a theoretical model including exposure, outcome and confounder variables, which was constructed using Directed Acyclic Graphs (DAGs) in Dagitty software, version 3.2. After construction of the DAG, a minimal sufficient adjustment set of confounders was identified using the back-door criterion, comprising age, sex, education, income, alcohol consumption, smoking and physical activity[35].

3. RESULTS AND DISCUSSION

A total of 1,204 adult individuals of both sexes were included in this study. Table 1 shows that the sample was predominantly composed of residents of Teresina (53.7%), women (62.6%), Black, Brown or Indigenous (74.9%), with secondary education or lower (72.3%), living with a partner (59.9%). In addition, most participants had a household income of two minimum wages or less (76.8%), were employed (62.5%), did not consume alcohol (56.9%), did not smoke (90.3%), consumed red meat (92.7%), consumed raw salad (83.0%) and consumed cooked salad (67.6%). Moreover, the prevalence of obesity observed in the sample was 25.6% (95% CI: 22.8–28.6).

A higher WFBC (6-7 days per week) was associated with residing in the municipality of Picos (70%; p < 0.0001), being male (60.7%; p = 0.003), having lower education level (secondary education

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or lower) (63.0%; p < 0.0001), consumption of raw salad (58.2%; p = 0.019) and not being obese (61.0%; p = 0.017) (Table 1).

Regarding the anthropometric variables TSF and AC (Figure 1), it was found that individuals who consumed beans 6–7 days per week exhibited lower TSF and AC measurements compared with those who consumed beans 0-2 days and 3-5 days per week.

Furthermore, Table 2 shows that individuals who consumed beans 6–7 days per week had a lower prevalence ratio of obesity according to BMI in the crude analysis (PR: 0.71; 95% CI: 0.54–0.95). After adjustment, the prevalence ratio of obesity among these individuals was 38% lower compared with those who consumed beans 0-2 days per week. With regard to the prevalence ratio of obesity according to WC, a 23% lower prevalence ratio was observed in the group consuming beans 6-7 days per week.

Habitual bean consumption remains part of the Brazilian diet[16]. Although a decline in bean consumption among Brazilians over recent years has already been documented[36, 37], this intake remains substantial, as confirmed by the present study, given the high prevalence of bean consumption 6-7 days per week (58.6%). Similarly, the VIGITEL Brasil study[38], which assessed the frequency of bean consumption in Brazilian state capitals, reported a prevalence of bean consumption of five or more times per week of 58.6%.

In the present study, bean consumption was observed to be a predominantly male habit, corroborating findings from other studies that also reported a higher frequency of bean consumption among men compared with women[37, 38].

Saes *et al*.[37] and Costa *et al*.[22], as in the present study, observed a higher frequency of bean consumption among individuals with lower education levels and among those residing outside the state capital, respectively. This finding may be explained by the fact that, although beans are a staple and traditional component of the Brazilian diet, cultural, social and economic factors can influence their consumption[16, 20]. Furthermore, an association was also observed between higher frequency of bean consumption and consumption of raw salad, indicating that these individuals, in general, exhibit a healthier dietary intake profile[22].

In the present study, a higher frequency of bean consumption was identified as a protective factor for the presence of obesity, considering that the prevalence ratio of obesity was 29% lower among individuals who consumed beans more frequently (6-7 days per week) compared with those who consumed beans less frequently (0-2 days per week). In addition, TSF and AC - measures used as indicators of body adiposity and cardiovascular risk[10-12, 39, 40] - were lower among individuals with more frequent bean consumption.

Corroborating these findings, Melo *et al*.[41], when investigating adults from a socioeconomically deprived community in Northeastern Brazil, found that the prevalence ratio of overweight was 23% higher among individuals with low weekly bean consumption (0-2 days per week) compared with those who consumed beans more frequently (5-7 days per week).

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Higher frequency of bean consumption (6-7 days per week) was also shown to be protective against the presence of obesity according to WC measurements[6].

These findings may be explained by the high dietary fibre content present in beans[21]. Mattos and Martins[42] conducted a study assessing dietary fibre intake among the adult population of a city in the state of São Paulo and identified beans as the main source of fibre in the typical Brazilian diet. Numerous studies indicate that a diet rich in fibre promotes increased satiety, reduces the glycemic response and assists with weight loss[43-46].

Reverri *et al*.[47] conducted a randomised cross-over clinical trial to evaluate the effect of adding extrinsic fibre to a mixed meal versus the use of common beans (*Phaseolus vulgaris*) as a source of intrinsic fibre in the meal. The authors concluded that incorporating whole beans into a meal promotes beneficial metabolic and hormonal responses and is preferable to adding equivalent amounts of isolated dietary fibre in the form of supplements.

Moreover, beans are protein-rich legumes[21]. Several studies on beans have highlighted that one of the main components responsible for their protective health effects are proteins and their bioactive peptides formed after digestion[15, 16, 47-50]. Bioactive peptides are inactive when they are part of the protein sequence but become active after release through enzymatic processing, gastrointestinal digestion, food processing or fermentation. Studies have shown that these peptides exert hypocholesterolaemic, antidiabetic, antihypertensive, antioxidant and anti-inflammatory effects[48, 51, 52].

Some limitations of the present study related to its methodological design should be acknowledged, particularly the self-reported assessment of weekly frequency of bean consumption and the absence of data on portion size. On the other hand, a strength of the study is the use of a representative sample of the adult population from two cities in the state of Piauí, Teresina (state capital) and Picos (non-capital municipality).

4. FINAL REMARKS

The present findings indicate that a higher weekly frequency of bean consumption was associated with a lower prevalence of obesity among adults from Northeastern Brazil. Although these results add to the evidence on the potential role of traditional dietary patterns in obesity prevention, they should be interpreted with caution due to the cross-sectional design, which precludes causal inference, and the assessment of bean consumption based on self-reported frequency rather than the amount consumed. Future longitudinal studies are needed to confirm these associations.

Table 1. Distribution of the sample according to weekly frequency of bean consumption, by socioeconomic, demographic, lifestyle, dietary, nutritional status and cardiovascular risk characteristics among adults. Teresina and Picos, Piauí, Brazil, 2018/2019 (n = 1,204)

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Weekly frequency of bean consumption	Sample n (%)	95% CI	0-2 days/week n (%)	3-5 days/week n (%)	6-7 days/week n (%)	p*
Municipality						
Teresina (State Capital)	647 (53.7)	46.3–60.7	105 (16.2)	226 (34.9)	316 (48.9)	<0.0001
Picos (Non-capital municipality)	557 (46.3)	39.0–53.6	66 (11.9)	101 (18.1)	390 (70.0)	
Sex						
Male	450 (37.4)	35.2–39.7	44 (9.8)	133 (29.5)	273 (60.7)	0.0030
Female	754 (62.6)	60.3–64.8	127 (16.8)	194 (25.7)	433 (57.5)	
Skin color						
White, Asian or other	302 (25.1)	21.9–28.6	48 (15.9)	93 (30.8)	161 (53.3)	0.0940
Black, Brown or Indigenous	902 (74.9)	71.4–78.1	123 (13.6)	234 (25.9)	545 (60.4)	
Education						
Secondary education or lower	870 (72.3)	67.2–76.8	106 (12.2)	216 (24.8)	548 (63.0)	<0.0001
Higher education or above	334 (27.7)	23.2–32.8	65 (19.5)	111 (33.2)	158 (47.3)	
Marital status						
With a partner	721 (59.9)	55.6–64.0	95 (13.2)	183 (25.4)	443 (61.4)	0.0540

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Without a partner	483 (42.1)	35.9–44.4	76 (15.7)	144 (29.8)	263 (54.4)	
Household income (minimum wage)**						
≤ 2 minimum wages	925 (76.8)	71.0–81.1	136 (14.7)	241 (26.1)	548 (59.2)	0.2530
>2 minimum wages	279 (23.2)	18.9–28.9	35 (12.5)	86 (30.8)	158 (56.6)	
Employment status						
Employed	753 (62.5)	59.6–65.3	103 (13.7)	209 (27.7)	441 (58.6)	0.7220
Unemployed	451 (37.5)	34.6–40.3	68 (15.1)	118 (26.2)	265 (58.7)	
Alcohol consumption						
Yes	519 (43.1)	40.0–46.2	73 (42.7)	158 (48.3)	288 (40.8)	0.0750
No	685 (56.9)	53.8–60	98 (14.3)	169 (24.7)	418 (59.2)	
Smoking status						
Yes	117 (9.7)	8.2–11.5	13 (11.1)	29 (24.8)	75 (64.1)	0.4060
No	1087 (90.3)	88.4–91.8	158 (14.5)	298 (27.4)	631 (58.1)	
Red meat consumption						
Yes	1116 (92.7)	91.1–94.0	156 (14.0)	327 (27.2)	706 (58.6)	0.1380
No	88 (7.3)	6.0–8.8	15 (17.1)	16 (18.2)	57 (64.8)	

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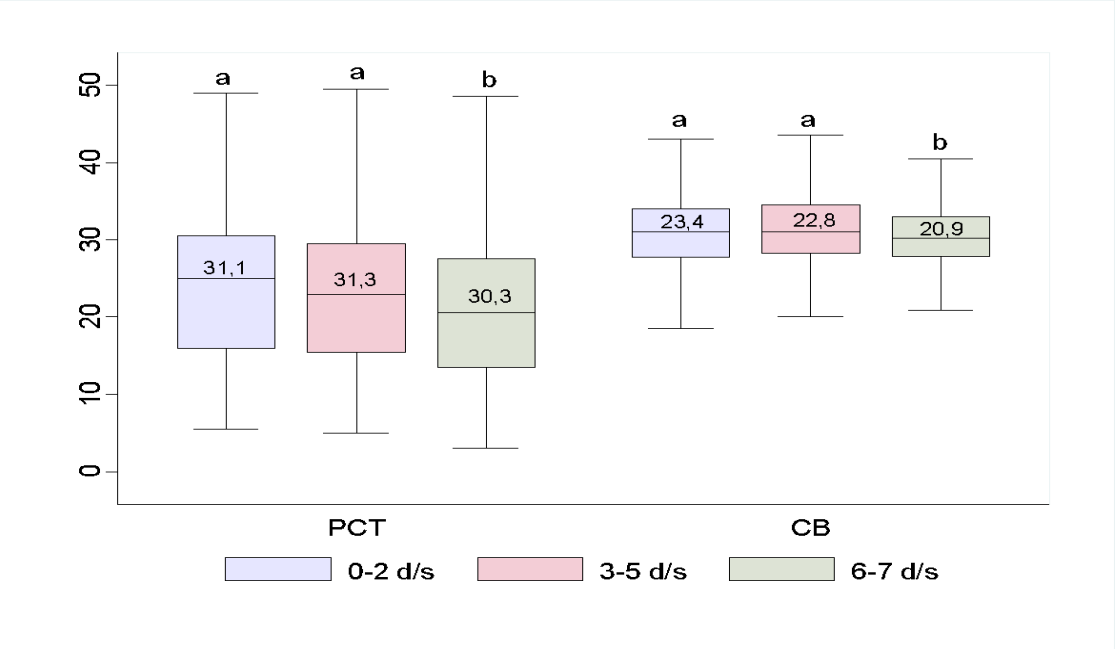
Fruit consumption						
Yes	1073 (89.1)	87.3–90.7	147 (13.7)	299 (27.9)	627 (58.4)	0.1620
No	131 (10.9)	9.3–12.7	24 (18.3)	28 (21.4)	79 (60.3)	
Raw salad consumption						
Yes	999 (83,0)	81,0-84,8	130 (13,0)	281 (28,1)	588 (58,9)	0,0190
No	205 (17,0)	15,2-19,0	41 (20,0)	46 (22,4)	118 (57,6)	
Cooked salad consumption						
Yes	814 (67.6)	65.0–70.1	107 (13.1)	233 (28.6)	474 (58.2)	0.1330
No	390 (32.4)	29.9–35.0	64 (16.4)	94 (24.1)	232 (59.5)	
Obesity[a]						
Non-obese	896 (74.4)	71.4–77.2	117 (13.0)	233 (26.0)	546 (61.0)	0.0170
Obese	308 (25.6)	22.8–28.6	54 (17.5)	94 (30.5)	160 (52.0)	

95% CI – 95% confidence interval. *Pearson's chi-squared test.**Reference minimum wage based on 2019 (R$ 998.00).[a]WHO[30]. Source: ISAD. 2018–2019.

Figure 1. Anthropometric measures according to daily bean consumption among adults. Teresina and Picos, Piauí, Brazil, 2018–2019 (n = 1,204)

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BMI – Body Mass Index; TSF – Triceps Skinfold Thickness; AC – Arm Circumference; d/w – days/week. (Different letters, p < 0.05 ANOVA with Bonferroni test). Source: ISAD, 2018–2019.

Table 2. Prevalence ratios of obesity according to BMI and WC by weekly frequency of bean consumption. Teresina and Picos, Piauí, Brazil, 2018–2019 (n = 1,204)

WFBC	**Obesity by BMI†**			
	***Crude analysis**		***Adjusted analysis**	
	PR [95% CI]	**p**	**PR [95% CI]**	**p**
0 - 2 days	1	-	1	-
3 - 5 days	0.91 [0.68–1.22]	0,525	0.89 [0.64–1.22]	0,478
6 - 7 days	0.71 [0.54–0.95]	**0,019**	0.62 [0.47–0.83]	0,002
WFBC	**Obesity by WC‡**			
	***Crude analysis**		***Adjusted analysis**	

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	PR [95% CI]	p	PR [95% CI]	p
0 - 2 days	1	-	1	-
3 - 5 days	0.88 [0.67–1.15]	0,329	0.92 [0.70–1.20]	0,532
6 - 7 days	0.84 [0.64–1.10]	0,183	0.77 [0.60–0.97]	0,027

† BMI > 30kg/m2; ‡ WC> 80cm for women ; WC> 94 cm for men; WFBC = weekly bean consumption frequency; PR = prevalence ratio; 95% CI = 95% confidence interval. *Poisson regression, crude analysis. **Poisson regression, analysis adjusted for age, sex, education, income, alcohol consumption, smoking status, and physical activity. **Source:** ISAD, 2018–2019.

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