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Correlation between external influences and the degree of food processing on the nutritional status of individuals with type 2 diabetes *mellitus*

Correlação entre as influências externas na alimentação com o grau de processamento alimentar e o estado nutricional em adultos com diabetes mellitus tipo 2

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ABSTRACT

Objective
Lifestyle modifications stimulate external influences on diet, which can impact food choices, thus improving the practice of mindful eating. Mindful eating can help identify behaviors related to eating and assist in the recovery of more nutritionally adequate dietary patterns. This cross-sectional study aimed to analyze the relationship between external environmental influences on the consumption of ultra-processed foods and the food choices of individuals with type 2 diabetes *mellitus*.

Methods
Adult and elderly patients with type 2 diabetes *mellitus* and HbA1C were included. Dietary intake was assessed using a 24-hour recall and categorized according to the NOVA Food Classification. The Mindful Eating Questionnaire and its domains were used to identify external influences. Anthropometric data such as weight, body mass index, and waist circumference were analyzed.

Results
The sample consisted of 325 individuals, 60% of whom were female, with a mean age of 60.85±9.3 years; 58.8% were married and 49.2% were white. Regarding nutritional status,

the body mass index was 30.3 ± 4.6 kg/m² and the waist circumference was 103.1±11.7 cm. The NOVA Food Classification identified a higher score in the consumption of unprocessed and minimally processed foods at 64.4% (53.4–73.5) and a lower score in the processed culinary ingredients group at 1.8% (0–5.3). There was a statistically significant positive correlation between the external domain of the Mindful Eating Questionnaire and body mass index (r=0.124; *p*<0.01), weight (r=0.119; *p*<0.01), and waist circumference (r=0.151; *p*<0.01); as well as a significant negative association in the consumption of minimally processed foods however, these correlations were weak.

Conclusion
Our study found a correlation between the consumption of unprocessed or minimally processed foods and the external domain of the Mindful Eating Questionnaire. Additionally, the findings show that the greater the external influences on eating, the higher the values of weight, body mass index, and waist circumference.

Keywords: Diabetes *mellitus*, type 2. Feeding behavior. Mindful eating.

RESUMO

Objetivo
As modificações no estilo de vida estimulam influências externas na alimentação, que pode ter impacto nas escolhas alimentares, melhorando assim a prática de alimentação consciente. O Mindful eating pode auxiliar a identificar comportamentos relacionados com o ato de se alimentar e auxiliar no resgate de padrões alimentares nutricionalmente mais adequados. Este estudo transversal objetivou analisar a relação da influência do ambiente externo no consumo alimentar de alimentos ultra processados, das escolhas alimentares de indivíduos com diabetes mellitus tipo 2.

Métodos
Foram incluídos pacientes adultos e idosos com diabetes mellitus tipo 2, HbA1C . Para avaliação do consumo alimentar por aplicado do Recordatório 24 horas e categorizado pela Classificação Alimentar NOVA. Foi utilizado o Mindful Eating Questionnaire e seus domínios para identificação das influências externas. Dados antropométricos de peso, índice de massa corporal e circunferência da cintura foram analisados

Resultados
A amostra foi composta por 325 indivíduos, sendo 60% do sexo feminino, com idade média de 60,85 ± 9,3 anos, 58,8% casados e 49,2% de raça branca. Com relação ao estado nutricional, o índice de massa corporal foi 30,3±4,6 kg/m² e circunferência da cintura 103,1±11,7 cm. A Classificação Alimentar NOVA identificou maior pontuação no consumo de alimentos in natura e minimamente processados de 64,4% (53,4–73,5) e menor no grupo de ingredientes culinários processados 1,8% (0–5,3). Houve correlação positiva, estatisticamente significativa, entre o domínio external do Mindful Eating Questionnaire com índice de massa corporal (r=0,124; p<0,01), no peso (r=0,119; p<0,01) e na circunferência da cintura (r=0,151; p<0,01); bem como uma associação negativa significativa no consumo de alimentos minimamente processados, essas correlações foram fracas.

Conclusão
Nosso estudo encontrou correlação entre o consumo de alimentos in natura ou minimamente processados com o domínio external do Mindful Eating Questionnaire. Ainda, os achados mostram que quanto maiores as influências externas na alimentação, maiores foram os valores de peso, índice de massa corporal e circunferência da cintura.

Palavras-chave: *Diabetes mellitus tipo 2. Comer com atenção plena. Comportamento alimentar.*

INTRODUCTION

The causes of the exponential increase in people with Type 2 Diabetes *Mellitus* (T2DM) are multifactorial. The main contributors include population aging, sedentary lifestyles, and the high prevalence of overweight and obesity [1].

Currently, there is a substantial body of evidence regarding diabetes and its treatment, aimed at improving patients' quality of life. Non-pharmacological strategies have been continuously evaluated to achieve better metabolic control of the disease. However, a significant number of

patients fail to reach the established therapeutic targets [1]. Therefore, adopting a healthy lifestyle, particularly with an emphasis on improving dietary habits, is crucial in managing these patients. It is essential to assess nutritional behavior while considering individual food habits, preferences, and specific therapeutic goals (such as glycemic control, lipid profile, blood pressure, and body weight) [2].

The consumption of Ultra-Processed Foods (UPFs) is associated with poor diet quality, which leads to negative metabolic outcomes [3]. High consumption of UPFs contributes to an imbalanced dietary pattern within the population due to their high energy content and significant levels of sodium, saturated fats, and trans fats [4]. The NOVA Classification System [5] categorizes foods into four groups based on the extent of processing they undergo. This classification considers the physical, biological, and chemical methods used during food production, including the use of additives.

In addition to diet quality, other factors play a crucial role in managing T2DM, such as mindful eating [6]. Mindfulness involves maintaining present-moment awareness and attention without judgment, emotion, or distraction, particularly during eating [7]. This practice is often referred to as conscious eating, mindful eating, or compassionate eating.

Mindful eating involves eliminating or minimizing external influences that can lead to distractions or impulsive eating. For example, advertisements for ultra-processed foods or environments like dinner parties or movie theaters can encourage overeating through enticing smells [6,7]. Another example is eating simply because others around are eating. By reducing these triggers, the urge to eat diminishes, which slows down eating speed and helps maintain weight control [8].

This mindful approach positively influences eating habits, promoting the consumption of foods that satisfy physiological needs and naturally lead to healthier eating patterns. As a result, mindful eating can contribute to healthier weight control by reducing overeating and excessive calorie intake [9,10]. Considering the growing prevalence of T2DM, understanding the impact of factors that influence eating behavior is crucial.

Given this context, understanding how external influences affect the consumption of ultra-processed foods is essential for managing and controlling the disease. Therefore, this study aimed to examine the relationship between the external environment and the consumption of ultra-processed foods in the dietary choices of individuals with type 2 diabetes *mellitus*.

METHODS

Study design and population

This cross-sectional study utilized baseline data from the multicenter clinical trial titled "Effectiveness of a Nutritional Strategy for Glycemic Control in Patients With Type 2 Diabetes *Mellitus* Users of a Public Health System: NUGLIC Study." The trial is registered on ClinicalTrials.gov under the identifier NCT03793855 and was coordinated by HCor, in collaboration with the Institutional Development Program of the Brazilian National Health System (PROADI-SUS), under the Ministry of Health. The study procedures were approved by the hospital's Ethics Committee (CAEE number 32671420.0.0000.5335), and all participants provided informed consent. The study posed minimal

risks to patients and followed both national and international guidelines for research involving human subjects, including the Declaration of Helsinki. Data were collected between 2019 and 2021 from three Brazilian regions. The study included patients of both genders who had a prior diagnosis of type 2 diabetes *mellitus* (T2DM), were aged 30 years or older, had an HbA1c level ≥ 7%, and had not received nutritional guidance for at least six months.

The sample size calculation was performed using the WinPEPI (Programs for Epidemiologists for Windows) version 11.65. Considering a significance level of 5%, power of 90%, a minimum correlation coefficient of 0.2 between the external influences score and the degree of food processing, and a maximum loss percentage of 20%, a minimum total of 311 patients was obtained.

Sociodemographic and clinical characteristics

Information about sociodemographic characteristics including age, marital status, ethnicity, education level, tabaco use, previous comorbidities and use of medications was collected using a questionnaire. Participants categorized based on their marital status (single, married, divorced, widowed, stable union), ethnicity (Caucasian, black, yellow, brown, indigenous), education level (Illiteracy and Incomplete Elementary School, Incomplete Elementary School and Middle School, Incomplete Middle School and High School, Complete High School and Incomplete University Education and University Education), tabaco use (yes or no) [11]. Clinical characteristics were analyzed including previous comorbidities and use of medications.

Patient evaluations followed a standardized protocol administered by trained researchers. All patients underwent anthropometric measurements, dietary assessment, and laboratory examinations.

Anthropometric characteristics

Anthropometric data included weight (kg), height (m), and Waist Circumference (WC) [12, 13]. Waist circumference measurements were taken twice, and the average value was used in the analysis. Weight and height were measured with patients wearing appropriate clothing but no shoes or accessories. These measurements were then used to calculate Body Mass Index (BMI) (kg/m^2) [13]. Waist circumference was measured at the midpoint between the lower border of the rib cage and the iliac crest along the mid-axillary line [14].

Dietary intake assessment

To assess dietary intake, a 24-hour food recall (R24h) was conducted at two different times: during the initial interview and again seven days later via telephone. The Multiple Pass Method (MPM) [15], developed by the United States Department of Agriculture (USDA) in 1999, was used to minimize potential biases in quantifying dietary intake data. The method includes five steps: quick list, commonly forgotten foods list, time and meal definition, detailed cycle, and final review. This approach calculates individuals' food consumption, providing typical distributions of intake by associating the probability and quantity of consumption with statistical modeling. The obtained data were then adjusted for the population under analysis.

Food records were analyzed using Vivanda software, and the NOVA Classification System [5] was applied to categorize foods into four groups based on their degree of processing. Here's a breakdown of each group: Group 1: Unprocessed or minimally processed foods. These undergo minimal industrial processing such as removal of inedible parts, drying, grinding, milling, pasteurization, refrigeration, freezing, or packaging. They do not have added salt, sugar, oils, or fats; Group 2: Culinary ingredients. These are directly obtained from foods in Group 1, such as oils, fats, sugars, and salts; Group 3: Processed foods. These are industrialized products made by adding salt, sugar, and other substances from Group 2 to foods in Group 1. They may undergo preservation methods such as canning or bottling; Group 4: Ultra-processed foods. These foods are extensively processed and typically have a high caloric density due to their high content of fats, salts, and sugars. They are often low in micronutrients and dietary fiber. The intake of each food group was estimated based on the percentage of total energy consumption.

Mindful Eating Questionnaire (MEQ)

To assess dietary mindfulness, the study utilized questions from the original Mindful Eating Questionnaire (MEQ) [16], which consists of 28 items rated on a Likert scale: 1 (never/rarely), 2 (sometimes), 3 (often), and 4 (usually/always). Each item is scored between 1 and 4, with higher scores indicating greater levels of mindful eating. The MEQ encompasses five domains: Disinhibition, Awareness, External Cues, Emotional Response, and Distraction. The MEQ was developed as a tool for researchers to examine individuals' conscious eating abilities, acquired through various practices and interventions, and to assess mindfulness related to food intake. In this study, particular attention was given to the External Cues domain, where higher scores indicate a greater influence of environmental factors on individuals' dietary patterns.

Statistical analysis

The statistical analysis was conducted using IBM®SPSS® Program version 21.0. Associations between the degree of food processing and numerical or ordinal variables were assessed using Spearman's correlation coefficient. Median comparisons were conducted using the Mann-Whitney test. For controlling confounding factors, a Multivariate Linear Regression model was applied. Except for the external domain, variables with a p-value <0.10 were included in the multivariate model. Model fit quality was evaluated using residual plots along with the Variance Inflation Factor (VIF) to assess multicollinearity effects.

RESULTS

The sample consisted of 325 individuals, with an average age of 60.85±9.28 years. Of the participants, 60% were female, 58.8% were married, and 49.2% were Caucasian. The highest levels of education were illiteracy and incomplete elementary school, representing 27.7% of the sample. Regarding comorbidities, in addition to T2DM, 82.5% had hypertension, and 63.1% had dyslipidemia. The most commonly used medications were biguanides and insulin, taken by 86.5% and 43.6% of the participants, respectively (Table 1).

In Table 1, the anthropometric data is presented, the average weight value was 79,8±14,1 Kg, the average BMI value was 30,3 ± 4,6 kg/m^2, and the average WC value was 103,1±11,7 cm.

Table 1 – Sociodemographic, anthropometric, clinical, and therapeutic characteristics of individuals with type 2 diabetes *mellitus*. Brazil, 2021. (n=325).

Variables	M±SD
Age (years)	60.85±9.28
Weight (kg)	79.8±14.1
Body Mass Index (kg/m²)	30.3±4.6
Waist circumference (cm)	103.1±11.7
Variables	n (%)
Gender	
Male	130 (40)
Female	195 (60)
Marital Status	
Single	54 (16.6)
Married	191 (58.8)
Divorced	25 (7.7)
Widowed	41 (12.6)
Stable Union	14 (4.3)
Ethnicity	
Caucasian	160 (49.2)
Black	74 (22.8)
Yellow	5 (1.5)
Brown	84 (25.8)
Indigenous	2 (0.6)
Education Level	
Illiteracy and Incomplete Elementary School	90 (27.7)
Incomplete Elementary School and Middle School	69 (21.2)
Incomplete Middle School and High School	55 (16.9)
Complete High School and Incomplete University Education	87 (26.8)
University Education	24 (7.4)
Previous Comorbidities	
Hypertension	268 (82.5)
Dyslipidemia	205 (63.1)
Acute Myocardial Infarction	64 (19.7)
Angina	19 (5.8)
Cerebrovascular Accident	18 (5.5)
Heart Failure	15 (4.6)
Retinopathy	45 (13.8)
Tabacco Use	15 (4.6)
Use of Medications	
Sulfonylurea	119 (36.6)
Metiglinides	5 (1.5)
Biguanides	281 (86.5)
Alfa-glucodaise Inhibitor	2 (0.6)
Glitazones	6 (1.8)
Gliptins	18 (5.5)
GLP-1 Analogues or Incretin Mimetics	2 (0.6)
SGLT2 Inhibitors	32 (9.8)
Insulin	141 (43.4)

Regarding the NOVA Classification System, the highest percentage was from the unprocessed or minimally processed foods group at 64.4% (53.4–73.5), while the lowest percentage was from the processed culinary ingredients group at 1.8% (Table 2).

Following the NOVA Classification System, a higher percentage of unprocessed or minimally processed foods was associated with lower values in the external domain (r=-0.167; $p<0.01$), as shown in Table 3. Conversely, a higher percentage of processed foods was associated with higher external domain values (r=0.136; $p<0.05$). (Table 3). However, these correlations were considered weak.

Table 2 – Dietary intake of patients with type 2 diabetes *mellitus* according to the NOVA food classification. Brazil, 2021. (n=325).

Variables	Variations on the scale	Median (P25–P75)
Unprocessed and minimally processed foods	0–100	64.4 (53.4–73.5)
Processed culinary ingredients	0–100	1.8 (0–5.3)
Processed foods	0–100	12.5 (5.7–22.0)
Ultra-processed foods	0–100	16.4 (8.9–25.5)

Table 3 – Association of diet quality data among individuals with type 2 diabetes *mellitus* using the NOVA classification system, with external domains analyzed via Pearson or Spearman correlation coefficients. Brazil, 2021.

Variables	External
Unprocessed and minimally processed foods	-0.167**
Processed culinary ingredientes	0.005
Processed foods	0.136*
Ultra-processed foods	0.081

Note: *p<0.05; **p<0.01.

Additionally, there was a weak but statistically significant positive correlation between the external domain and BMI values (r=0.124; p<0.01), weight values (r=0.119; p<0.01), and WC values (r=0.151; p<0.01). Therefore, the higher the external domain scores, the higher the values of weight, BMI, and WC (Table 4).

Table 4 – Association of external domain with anthropometric data of individuals with type 2 diabetes *mellitus* using Pearson or Spearman correlation coefficients. Brazil, 2021.

Variables	Body Mass Index	Waist Circumference	Weight
External Domain	0.124*	0.119*	0.151**

Note: *p<0.05; **p<0.01.

In Table 5, even after adjustment by the multivariate model, the external domain remained inversely associated with the consumption of fresh or minimally processed foods, meaning that for each additional point in this domain, there was a 3.08% reduction in the consumption of these types of foods. Additionally, it showed a positive association with processed food consumption, indicating that for each additional point in the external domain, there was an average increase of 1.96% in processed food consumption. Regarding processed food consumption, the number of medications remained independently associated, meaning that for each additional medication used, there was an average increase of 1.63% in processed food consumption. Lastly, for each additional level of education, there was an average increase of 1.03% in the consumption of ultra-processed foods.

Table 5 – Multiple Linear Regression Analysis to assess factors independently associated with the degree of food processing.

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Degree of food processing	Variables	b (95% CI)	p
Unprocessed and minimally processed foods	External domain	-3.08 (-5.16 a -0.99)	0.004
	Age	0.08 (-0.10 a 0.26)	0.374
	Hypertension	4.71 (-0.47 a 9.89)	0.075
	Number of comorbidities	-0.26 (-1.99 a 1.49)	0.774
Processed culinary ingredients	External domain	-0.07 (-0.63 a 0.49)	0.816

Table 5 – Multiple Linear Regression Analysis to assess factors independently associated with the degree of food processing.

Degree of food processing	Variables	b (95% CI)	*p*
Processed culinary ingredients	Time since diabetes diagnosis	-0.04 (-0.09 a 0.01)	0.120
	Number of medications	-0.29 (-0.83 a 0.24)	0.282
	Hypertension	-0.58 (-1.72 a 0.57)	0.321
Processed foods	External domain	1.96 (0.20 a 3.72)	0.029
	Number of medications	1.63 (0.06 a 3.21)	0.042
Ultra-processed foods	External domain	1.35 (-0.41 a 3.11)	0.131
	Education level	1.03 (0.01 a 2.05)	0.049
	Glucose	0.00 (-0.00 a 0.00)	0.249
	Hypertension	-3.45 (-7.01 a 0.11)	0.057

Note: b: Slope Coefficient; CI: Confidence Interval.

DISCUSSION

The study observed an inverse correlation between the consumption of unprocessed or minimally processed foods and the External domain of the MEQ. This suggests that a higher intake of unprocessed foods is associated with reduced environmental influences on the eating patterns of individuals with T2DM. In other words, when individuals consume more unprocessed foods, they are less likely to be influenced by external cues in their eating behavior. Conversely, within the same population, it was found that higher external influences on eating patterns were associated with higher values of weight, BMI, and WC as well as a greater percentage of intake from processed foods. This indicates that individuals who are more influenced by their environment in terms of eating tend to have higher body weight measurements and consume more processed foods.

These findings underscore the importance of dietary choices and environmental influences in managing weight and dietary quality among individuals with T2DM. Adopting a diet rich in unprocessed foods may contribute to more mindful eating behaviors and potentially better health outcomes in this population.

External influences on eating behaviors often operate through various media channels, leading to automatic eating responses characterized by triggers, inductions, and excessive consumption of low-nutritional-quality foods. This habitual pattern can be disrupted through mindful eating practices, which involve paying attention while eating and aiming for dietary awareness [17]. Automatic eating behaviors encompass emotional, impulsive, and habitual eating tendencies [18]. In contrast, mindful eating has been shown to positively impact dietary patterns by promoting increased consumption of fruits and vegetables, thereby enhancing overall food quality [19]. It also tends to decrease the consumption of high-energy-density foods and reduce the frequency or intensity of compulsive eating episodes [20]. These benefits highlight the potential of mindful eating as a strategy to improve dietary habits and mitigate the negative effects of external influences on eating behaviors [19].

Individuals with chronic diseases, including diabetes, may be particularly vulnerable to external eating stimuli [20]. For instance, they tend to exhibit increased food consumption following visual cues, such as watching culinary television shows [21]. These external stimuli can prompt automatic eating responses, characterized by impulsive and habitual eating behaviors. Therefore, promoting mindful eating practices can serve as an effective intervention to mitigate weight gain and facilitate weight loss in individuals with chronic diseases. Mindful eating involves cultivating awareness and attention during meals, which can interrupt automatic eating patterns [20]. By fostering mindful eating behaviors, individuals may gain greater control over their food choices, reduce impulsive

eating episodes triggered by external stimuli, and potentially improve their overall dietary quality and health outcomes.

Ultra-processed foods are characterized by their extensive use of artificial additives, such as food dyes, stabilizers, flavor enhancers, aromas, and artificial sweeteners, among others [22]. These additives contribute to the practicality, convenience, and wide variety of foods in this category, making them increasingly popular across different age groups. Despite their convenience, the rising consumption of ultra-processed foods has coincided with a significant increase in chronic diseases such as type 2 diabetes *mellitus*, hypertension, and obesity. Studies have shown that high intake of ultra-processed foods in adults is associated with various adverse cardiovascular outcomes, particularly dyslipidemia and elevated blood pressure [23]. Obesity, in particular, has been closely linked to the consumption of ultra-processed foods, as highlighted in numerous studies [24,25].

These findings underscore the health risks associated with frequent consumption of ultra-processed foods and highlight the importance of promoting diets rich in minimally processed and whole foods to mitigate the burden of chronic diseases in populations [26]. Despite the well-documented negative health outcomes associated with the consumption of industrialized foods, their prevalence remains significant. It is crucial to note that the excessive intake of food additives can disrupt hormonal regulation, impairing natural satiety mechanisms [24,25].

In Brazil, ongoing public policies, guidelines, and initiatives address the impact of ultra-processed food consumption on public health. These efforts also recognize the influence of media and food packaging in promoting and shaping consumer choices towards these types of foods. The overarching goal of these initiatives is to discourage the consumption of ultra-processed foods and promote the consumption of unprocessed or minimally processed foods, as advocated in the Dietary Guidelines for the Brazilian Population. By focusing on promoting healthier dietary choices and reducing the intake of ultra-processed foods, these policies aim to improve public health outcomes and mitigate the burden of chronic diseases associated with poor dietary habits.

As a cross-sectional study, this research has inherent limitations, primarily due to the collection of exposure and outcome data at the same time. This setup makes it challenging to establish temporal relationships between events and to determine with certainty whether the observed correlations are causal.

In this study, a weak relationship was found between the consumption of unprocessed or minimally processed foods and the External domain of the MEQ. This underscores how significantly the environment can influence the dietary choices of individuals with T2DM. Furthermore, the findings indicate that higher external influences are associated with increased weight, BMI, and WC among participants.

There is a scarcity of studies exploring the relationship between mindful eating and food quality, particularly in individuals with T2DM. More research is needed to better understand how these factors interrelate and influence dietary behaviors and health outcomes in this population. Addressing these research gaps could provide valuable insights for developing effective interventions aimed at promoting healthier eating habits and improving outcomes for individuals managing chronic diseases like T2DM.

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