Dietary pattern and type 1 diabetes

Padrão alimentar e diabetes tipo 1

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ABSTRACT

Studies on nutritional epidemiology have shown associations between dietary patterns and diabetes. This study was carried out to identify dietary patterns and assess their association with the presence or absence of type 1 diabetes. In this cross-sectional study with 45 patients with type 1 diabetes and 45 healthy adult subjects, social and lifestyle demographic data were collected using structured questionnaires. Food intake was estimated using a 24-hour recall. Dietary patterns were identified by principal component factor analysis, followed by orthogonal varimax rotation. Poisson regression was used to estimate the prevalence ratios of independent variables about dependent variables. Three main patterns were identified: prudent, snack, and western. Together, they explained 34.49% of the variance. The prudent pattern was one that represents the intake of food groups recommended in a healthy diet. There was no significant association between patterns and the presence or absence of type 1 diabetes.

Keywords: eating; principal component analysis; pattern, western dietary; Diabetes Mellitus, type 1.

RESUMO

Estudos sobre epidemiologia nutricional têm mostrado associações entre padrões alimentares e diabetes. Este estudo foi realizado para identificar padrões alimentares e avaliar sua associação com a presença ou ausência de diabetes tipo 1. Neste estudo transversal com 45 pacientes com diabetes tipo 1 e 45 adultos saudáveis, dados demográficos sociais e de estilo de vida foram coletados por meio de questionários estruturados. O consumo alimentar foi estimado por meio de recordatório de 24 horas. Os padrões alimentares foram identificados por análise fatorial de componentes principais, seguida de rotação ortogonal varimax. A regressão de Poisson foi utilizada para estimar as razões de prevalência das variáveis independentes sobre as variáveis dependentes. Foram identificados três padrões principais: prudente, lanche e ocidental. Juntos, explicaram 34,49% da variância. O padrão prudente foi aquele que representa a ingestão dos grupos alimentares recomendados em uma alimentação saudável. Não houve associação significativa entre padrões e presença ou ausência de diabetes tipo 1.

Palavras-chave: alimentação; análise do componente principal; padrão, dieta ocidental; Diabetes Mellitus tipo 1.

INTRODUCTION

In recent decades, the prevalence of diabetes mellitus (DM) has increased more in developing countries than in developed countries and continues to increase in the worldwide.

A recent publication by the International Diabetes Federation (IDF) reports an estimated 537 million adults with DM worldwide. Brazil ranks sixth among the 10 countries with the highest number of adults with DM, with 15.7 million in the 20-79 age group (IDF, 2021).

Among the categories of DM, type 1 diabetes (T1D) results from the autoimmune destruction of β cells, usually leading to absolute insulin deficiency (ADA, 2022), and can affect people at any age, but usually develops in children and young adults (IDF, 2021).

Long-term T1D complications include microvascular complications and macrovascular diseases. Despite important advances in the treatment of T1D, these complications still represent the main cause of morbidity and mortality in patients with T1D (PIONA *et al.*, 2021).

Prevention is the most effective way to reduce morbidity and mortality in DM (MARTINEZ, 2021). Lifestyle modifications such as healthy eating, regular exercise, and cessation of smoking are control measures that can influence the glycemic control of patients with T1D. Thus, adequate DM control makes it possible to reach the maximum potential for development in terms of quality of life and reduction of DM-related comorbidities (SALES-PERES et al., 2016; JOSEPH, 2016).

In recent years, the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD) have recommended the adoption of a healthy dietary pattern for individuals with DM in their dietary guidelines (DAVIES et al., 2018). The study of dietary patterns represents the amounts, proportions, variety, or combination of different foods and beverages in diets, as well as the frequency with which they are habitually consumed (SCHULZE et al., 2018). Rather than focusing on a particular food group, this type of analysis takes into account the complete diet and, therefore, may explain the synergistic effects of nutrients on health (WALSH *et al.*, 2017). In this sense, some studies show that dietary patterns that prioritize fruits, vegetables, whole grains, fish, low consumption of red meat, processed meat, and sweet drinks are related to a reduced risk of chronic non-communicable diseases (NCDs), including DM (SCHULZE et al., 2018).

Currently, the literature is still scarce on the investigation of dietary patterns and associations with T1D, particularly in the Brazilian population. Therefore, the present study aimed to characterize dietary patterns and assess their association with the presence or absence of T1D in Brazilian adults.

MATERIALS AND METHODS

This cross-sectional study was conducted with a sample size of 90 adult individuals (45 patients with T1D and 45 individuals without T1D). The subjects in the groups were chosen through convenient sampling. The patients with T1D were recruited from the Endocrinology and Diabetes Outpatient Clinic of the Hospital of the Federal University of Ceará (HUWC-UFC) and the individuals without T1D were recruited from the State University of Ceará (UECE) and UFC.

Participants were contacted by phone, by letter, and in person. Criteria for inclusion of patients with T1D in the study were: be diagnosed with T1D with follow-up time in the Outpatient Clinic ≥ 6 months; ages 18 to 60 years; clinical and cognitive conditions enabling them to respond to interview questions; the ability to remain in the standing position and signed informed consent.

Patients with renal, cardiac, hepatic dysfunction, type 2 diabetes, leprosy, HIV infection, autoimmune disease, alcoholism, and mental disorders, as well as pregnant and lactating women were excluded. The group without T1D was defined with the same criteria, except that they did not have a family history of diabetes and abnormal blood glucose.

The researcher briefly explained his research plan, the ethics of the study, and the confidentiality of personal information before the written informed consent form. Demographic questionnaires (age, gender, education, income, ethics), 24h food recall method (R24h), family history of diabetes, and lifestyle habits (physical activity, smoking, and drinking) were collected in this research. The groups were matched by sex and age. The standards considered for alcohol consumption and cigarette smoking were by the WHO (WHO, 2004) and the Vital and Health Statistics (SCHOENBORN & ADAMS,

2010), respectively. Participants themselves reported alcohol consumption and cigarette smoking status.

The 24 h food recall method (R24 h) was used to investigate participants' food consumption with the application of two recalls on nonconsecutive days, one on a weekday and the other on a weekend. The first R24 h was obtained in person, and the second, by phone (louzada, 2015). Food data from each sample obtained from the 24-hour food recall were converted from household measurements to grams or milliliters and after that, inserted in the Microsoft Excel program. Due to a large number of food items and considering previous studies, food items with similar nutritional characteristics were categorized into the same group.

Principal component factor analysis (PCA) and an orthogonal varimax rotation were applied to identify dietary patterns and to ensure that factors remained uncorrelated and facilitate data interpretation. The adequacy of the data to factor analysis was confirmed by the Kaiser-Meyer-Olkin (KMO) coefficient (> 0.5) and Bartlett's sphericity test (p <0.001). Components with eigenvalues greater than 1.0, Cattel plot (scree plot) and conceptual meaning of the identified patterns were criteria used to define the number of retained factors. Each major component was interpreted based on foods with factor loads ≥ 0.3 or ≤ - 0.3, where negative charges indicate an inverse association of the food item and positive charges indicate a direct association. The names of identified patterns were named according to the composition of their food items and in accordance the nomenclature with established in the literature (newby, 2004).

For statistical analysis of the data, the Shapiro-Wilk test was used to determine the distribution of the numerical variables and the normality. The data are expressed as characteristic (%). Independent Student's t-test and Fisher's exact chi-square test were used to testing differences between the sociodemographic profile and lifestyle of individuals with and without T1D. Poisson regression with robust analysis of variance was used to investigate associations between dietary patterns and the presence or absence of diabetes. The first analysis (model 1) was the raw model. The second analysis (model 2) was adjusted for sex, age, income, education, and case and control group. The third analysis (model 3) was adjusted to the criteria of model 2 and in addition to lifestyle (physical activity). The

estimates were calculated by points and 95% confidence intervals. Statistical analyses were performed in Stata, version 13.0, adopting a significance level of 5%.

The study has been approved by the UECE and UFC Research Ethics Committee (protocol nº. 1,357,544) and carried out by the Code of Ethics of the World Medical Association (declaration of helsinki) for experiments that involved humans.

RESULTS AND DISCUSSION

The T1D group had a mean age of 31.02 ± 9.29 yeThe T1D group had a mean age of 31.02 ± 9.29 years, ranging between 19 and 63 years, with a predominance of income ≤ 3 minimum wages (73.33%), and more than half of the patients (55.56%) had elementary and high school. The group without T1D had a mean age of 30.13 ± 9.70 years, ranging between 19 and 56 years, more than half had an income ≥ 3 minimum wages (64.44%), and university education (80 %). Most individuals with T1D had less schooling (primary and secondary only) and lower income than the group without T1D (p<0.001) (Table 1).

Analyzing the lifestyle, cigarette smoking was infrequent among patients with T1D (6.67%) and without T1D (4.44%). In the same way, the current consumption of alcohol was reported by only 2.22% of individuals without T1D. The T1D group was more physically active (p<0.05) (Table 1).

Table 1 – Baseline characteristics of individuals with and without type 1 diabetes.

Variables	With Type 1 Diabetes		Without Type 1 Diabetes		$p^\star$
	n = 45		n = 45		
	Average	Dp	Average	Dp	
Age (years)	31,02	9,29	30,13	9,70	0,527£
Education					<0,001‡
Elementary School					0,033£
N	9		2		
%	20		4,44		
High school					0,048£
N	16		7		
%	35,56		15,56		
University education					<0,001£
N	20		36		
%	44,44		80		
Income					<0,001‡
≤ 3 minimum wages					
N	33		16		
%	73,33		35,56		
≥ 3 minimum wages					
N	12		29		
%	26,67		64,44		
Physical activity (practice)					0,011£
N	30		18		
%	66,67		40,00		
Smoking					0,645£
N	3		2		
%	6,67		4,44		
Alcoholism					0,315£
N	0		1		
%	0		2,22		

Subtitle: p < 0.05 in bold font. £ - independent Student's t test. ‡ - Fisher's exact chi-square test.

Participants reported a total consumption of 137 foods that were aggregated in 17 food groups, considering the similarity of their nutritional composition (Table 2). Foods consumed by less than 5% of the sample and not included in any group were excluded, such as peanuts, cashews, Para nuts, and oilseeds according to the criterion adopted by Selem *et al.* [24].

Table 2. Food grouping used in the dietary pattern analysis.

Food group	Food items
Poultry, fish, and seafood	Poultry, shrimp, fish, and sushi.
Alcoholic beverages	Beer and wine.
Industrialized beverage	Cajuina, soda, artificial juice, industrialized juice, ketchup, sausages, canned food, coconut milk, tomato sauce, pâté, canned fish, and corn chips.
Infusion	Coffee and tea.
Beef and pork	Beef, sun-dried meat, pork, meat escondidinho, egg, feijoada and offal.
Cereal	Rice, baião, sweet potato, English potato, sweet biscuit, salted biscuit, cake without filling, couscous, milk flour, farofa, granola, pasta, cassava, pasta, corn, paçoca, bread, popcorn, mush, tapioca, and toast.
Whole grain	Brown rice, oatmeal, cereal bar, whole wheat crackers, whole wheat bread, and wholemeal toast.
Diet e light	Light chocolate milk, sweetener, diet biscuit, light yogurt, light yogurt, lactose-free milk, light margarine, zero soda, light soda, shake and light toast.
Sweets	Chocolate milk, sugar, stuffed biscuit, cake with stuffing, candy, honey, and ice cream.
Vegetables and fruits	Pineapple, avocado, acai, banana, persimmon, guava, kiwi, orange, apple, papaya, mango, watermelon, melon, strawberry, pear, tangerine, grape, raisins, pumpkin, Swiss chard, watercress, lettuce, eggplant, beetroot, broccoli, onion, chives, carrots, parsley, coriander, cabbage, pumpkin, gherkin, cucumber, peppers, cabbage, tomato, coconut water, and natural juice.
Saltys and fats	Olive oil, mayonnaise, butter, margarine, cream, french fries, and pizza.
Legumes	Beans, chickpeas, lentils, and soybeans.
Skimmed milk	Skimmed milk and fermented milk.
Whole milk	Whole yogurt, chocolate milk, whole milk, cheese, and curd.
Oilseeds	Peanuts, cashews, Para nuts, and oilseeds.
Sandwich	Sandwiches.
Soups and broths	Soups and broths.
Fruit vitamin	Fruit smoothie.

A KMO equal to 0.0502 and the Bartlett test <0.001 indicated the adequacy of the study sample size and the items tested in the factor analysis, respectively. Three dietary patterns were identified, namely: prudent, snack, and western, which explained 34.49% of the total intake variance. The variance explained by the three factors retained from the dietary patterns identified in the present study was similar to the values of other studies carried out with patients with diabetes and healthy adults, ranging from 22 to 35% (SHU, 2017; MARTÍNEZ, 2020).

Dietary patterns, which reflect the complexity of intake based on the combination of foods from various groups, have attracted great attention in assessing the relationship between diet and health, and few studies have examined dietary patterns in individuals with T1D.

In the present study, the characterization of dietary patterns showed that the prudent pattern showed higher consumption of poultry, fish, tame fruits, whole grains, vegetables, fruits, skimmed milk, and with a negative charge for beef, pork, cereal, legumes, and whole milk. The snack pattern had a high intake of sandwiches and fruit smoothies. The western pattern was marked by greater consumption of industrialized drinks, sweets, snacks, and foods rich in fats, with a negative charge for soups and broths. The prudent pattern explained the most proportion of variance (13.21%) (Table 3).

Table 3 - Factor loadings of dietary patterns identified among patients with and without type 1 diabetes.

Food groups	Prudent	Snack	Western
Poultry, fish, and seafood	0.509		
Whole grain	0.647		
Vegetables and fruits	0.494		
Skimmed milk	0.304		
Beef and pork	-0,578		
Cereal	-0,597		
Legumes	-0.361		
Whole milk	-0.328		
Sandwich		0.881	
Fruit vitamin		0.422	
Industrialized beverage			0.683
Sweets			0.652
Salts and fats			0.647
Soups and broths			-0.395
Explained variance %	13,21	11,11	10,17
Eigenvalue	2,25	1,89	1,73

Subtitle: Foods with factor loads ≥ 0.3 or ≤ - 0.3; total variance 34.49%.

Our findings are, in part, in agreement with the study carried out by Sajjadpour (2021) in patients with T1D, which also identified three dietary patterns, with the presence of some food groups similar to the present study (vegetables and fruits, grains, legumes, sweets, and savory), however with a different definition in the identification of dietary patterns. The three dietary patterns identified in Iranian women with T1D were: the "grains, pulses and nuts" pattern, consisting of grains, pulses, sweets and desserts, olives/pickles, and milk; the "fruits and vegetables" pattern consisting of legumes, fruits, vegetables, red meats and oils, and the "high-calorie foods, snacks, sweets and desserts"

pattern consisting of high-energy foods, snacks, sweets and desserts (sajjadpour, 2021).

The pattern of food consumption named prudent explained the highest percentage of variance. Its composition was characterized by foods recommended in the treatment of T1D, as well as in the prevention of NCDs (birds, fish, seafood, whole grains, vegetables, fruits, and skimmed milk). Alaradi *et al.* (2020) also identified in individuals with T2D, a pattern prudent definition and composition (high intake of salad and raw vegetables, fresh fruits and canned or dried fruits and dates, cooked vegetables, yogurt, and fish) corroborating with our finding. They also highlighted that participants with high consumption of the prudent dietary pattern were more likely to be highly educated, use supplements, and frequently consumption of fruits and vegetables.

A prudent, healthy, and balanced eating pattern (high consumption of fruits, vegetables, fish, whole grains, low intake of fried, canned, processed foods, tubers, and refined carbohydrates), and also the Mediterranean diet can help with glycemic control and have been shown to be negatively associated with the development of diabetes (shadman, 2016; neuhouser, 2019). While high intakes of saturated fats, salt, and an energy-dense typical of the Western diet are associated with poor glycemic control with a higher risk of complications in patients with diabetes (pan, 2019; sadiva, 2019).

The snack pattern was characterized by easy-to--prepare meals and usually consumed by individuals who spend more time away from homes, such as sandwiches and fruit smoothies. So far, we have not found any dietary pattern called "snack" in adult individuals with T1D in literature. But recently, a study carried out to assess the relationship between dietary patterns and kidney disease in patients with T2D also identified a dietary pattern defined as a "snack", consisting of dairy products, whole-grain bread, vegetables, and low-calorie products (rodrigues, 2022). Although it is a different characterization from our findings, both have a higher proportion of processed and ultra--processed foods.

According to the Pesquisa de Orçamentos Familiares (pof, 2017-2018) held in Brazil, a significant increase was observed in the frequency of sandwich consumption, which varied from 8.3% to 13.8%, in all regions of the country and all classes of income.

Individuals who reported the consumption of sandwiches, in addition to other foods such as juices, pizza, sweets, and drinks with added sugar, also known as processed and ultra-processed foods, had a higher consumption of energy, saturated fat, trans fat, and a lower intake of fibers (pof, 2017-2018; louzada *et al.*, 2019).

In this sense, it is in agreement with studies that indicate that the consumption of processed and ultra-processed foods, as well as the unhealthy snack dietary pattern, are harmful to human health in general and are associated with the development of NCDs, such as diabetes (martins, 2018; srour et al., 2019; almoraie, 2021).

In addition to the evident risk of adherence to the "snack" dietary pattern, it is noteworthy that the inclusion of snacks for patients using insulin should be individualized based on the interval between meals, metabolic control, treatment, and risk of hypoglycemia, in addition to being balanced with the potential risk of weight gain (hassanein, 2021).

The third pattern identified was called western because it is rich in industrialized drinks, sweets, snacks, and fats. We identify that its composition is similar to other patterns reported in the literature with the same name (fung, 2004; qi, 2009; beigrezaei, 2019). Many of the common components in a Western diet pattern are linked to pro-inflammatory mechanisms (ahluwalia, 2012; medina-remón, 2017) with a high risk of developing cardiovascular diseases, cancer, respiratory diseases, infections, and diabetes (casas, 2016). Studies carried out with patients with diabetes have shown a higher risk of disease complications in the western dietary pattern compared to prudent dietary patterns (doostvandi *et al.*, 2016; rodríguez-monforte *et al.*, 2017).

Although the present study did not show an association of dietary patterns identified with the presence or absence of T1D (Table 4), this research supports the consumption of the prudent pattern to improve glycemic control and reduce the incidence of diabetes complications of patients with T1D and discourage the consumption of western patterns.

This study showed the absence of the association found in our findings can be explained, in part, by the higher level of education of healthy individuals and by the multidisciplinary treatment performed for patients with T1D, given that both groups had similar food consumption profiles. Corroborating this

Table 4 - Association between dietary patterns and individuals with and without type 1 diabetes.

| | Prudent Pattern | | | Snack Pattern | | | Western Pattern | | |
	M_1	M_2	M_3	M_1	M_2	M_3	M_1	M_2	M_3
GROUP With T1D	p=0,627 Reference	p=0,147 Reference	p=0,174 Reference	p=0,062 Reference	p=0,129 Reference	p=0,070 Reference	p=0,335 Reference	p= 0,954 Reference	p= 0,240 Reference
Without T1D	1,2 (0,57 – 2,50)	1,68 (0,83 – 3,41)	1,61 (0,81 – 3,19)	2,14 (0,96 – 4,77)	1,95 (0,82 – 4,62)	2,16 (0,94 – 4,96)	0,69 (0,33 – 1,46)	0,98 (0,45 – 2,12)	0,65 (0,32 – 1,33)

Subtitle: * p value obtained by Poisson regression. M_1: gross model; M_2: adjusted for sociodemographic variables (gender, age, income, education and case and control group); M_3: M_2 and lifestyle (physical activity).

finding, Brazilian studies reinforce that consumption of more nutritious foods is higher among individuals with a higher level of education (FREIRE, 2018) and that the treatment performed by the multidisciplinary team allows a better adoption of healthy eating habits (FEDERAL DISTRICT, 2015; VANNUCHIL, 2016). Additionally, Moura et al. (2018), when developing a nutritional education program for individuals with diabetes, found a significant improvement in food quality, with an improvement in the profile of food intake and a decrease in the monthly consumption of oil and sugar.

The present study has some strengths and limitations. Due to the cross-sectional study design, a causal relationship could not be established between the variables and study outcomes. However, cross-sectional studies are alternatives for adopting actions that promote healthy eating habits in populations.

It is possible that there is an association between dietary patterns and T1D, but it was not found in the present study. T1D patients were under regular monitoring with an outpatient follow-up time of ≥ 6 months, including nutritional counseling, which can lead to changes in eating habits. Also, we recognize the small sample in the population studied.

One of the strengths of this study was the use of R24h. The R24h method is fast to apply, low cost and does not require the literacy of respondents and does not require processes such as validation and calibration. However, it has a limitation because it depends on the interviewee's memory, because of the difficulty in estimating the size of portions, and because it does not allow the measurement of habitual intake at an individual level. Thus, in the present study, the method was used for more than one day of ingestion and on non-consecutive days to analyze the individual's usual diet. Another advantage was the

identification of dietary patterns by principal component analysis (PCA), which identifies foods that are often eaten together, and specific food items are aggregated according to the degree to which they are correlated with each other in main factors or components that must account for the maximum of the total variance (MICHELS, 2005). In addition, this is the first Brazilian study that sought to characterize the dietary pattern of individuals with T1D.

CONCLUSION

Thus, this study identified, through the application of PCA, three main dietary patterns in an adult population with and without T1D: prudent, snack, and western. The prudent pattern was one that represents the intake of food groups recommended in a healthy diet. While snacks and western are unfavorable dietary patterns for individuals with T1D. No association was demonstrated between dietary pattern and the presence or absence of T1D. Considering that little is known about dietary patterns and populations with T1D, we recommend that new approaches be undertaken to investigate the relation between adherence to dietary patterns and T1D.

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