CHAPTER 107

Dietary Patterns and cardiovascular biomarkers in Adults with and without type 1 diabetes mellitus

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ABSTRACT
To identify dietary patterns and assess their association with the presence or absence of type 1 diabetes (T1D) and biochemical markers of cardiovascular risk. The study involved patients with T1D and healthy individuals (n=90). Patients with T1D were recruited at the Endocrinology and Diabetes Outpatient Clinic of the Hospital from the Federal University of Ceará (HUWC-UFC) and healthy adult individuals were recruited at the State University of Ceará (UECE) and UFC, in the period from 2016 to 2017. Dietary intake was obtained through 24-hour recalls. Dietary patterns were identified by principal component factor analysis, followed by orthogonal varimax rotation. Poisson regression estimated the prevalence ratios of independent variables about outcomes. Three main patterns were identified: prudent (poultry, fish, tame fruits, whole grains, vegetables, fruits, skimmed milk, and with a negative charge for beef, pork, cereal, legumes, and whole milk), snack (sandwich and fruit smoothie) and western (industrialized drinks, sweets, snacks, and foods rich in fats). The association was observed between the prudent pattern with lower HDL cholesterol levels; the snack pattern with lower fasting blood glucose and higher triglyceride level and the western one with higher fasting blood glucose levels. There was no association between patterns and the presence or absence of T1D. The patterns identified were not associated with the presence or absence of T1D, but have been related to HDL cholesterol, triglycerides, and blood glucose.

Keywords: Western Dietary Pattern, Principal Component Analysis, Type 1 Diabetes Mellitus, Biochemical Markers, Adults.

1 INTRODUCTION

Studies on the analysis of dietary patterns have been carried out since the 1980s to investigate the complexity of food consumption to diseases, especially chronic noncommunicable diseases (NCDs). Among NCDs, we have the diabetes mellitus (DM) with a growing epidemic prevalence around the world, including type 1 diabetes (T1D), a subtype of DM that occurs due to the autoimmune destruction of β cells, leading to insulin deficiency (IDF, 2021).

In recent decades, the prevalence of diabetes mellitus (DM) has shown a greater increase in developing countries compared to developed countries, and this upward trend continues to be observed worldwide. A recent publication by the International Diabetes Federation (IDF) provides an alarming estimate that approximately 537 million individuals across the globe are affected by diabetes. Additionally, the report reveals that roughly 8.75 million people worldwide are currently living with type 1 diabetes (T1D). It is worth noting that among all newly reported cases of T1D, 64% were identified in adults. The life expectancy for individuals with T1D can vary widely, ranging from 19 to 75 years. Tragically, in the year 2022 alone, approximately 35,000 deaths related to T1D occurred in individuals younger than 25 years who had not been previously diagnosed, succumbing within just 12 months of the onset of symptoms (IDF, 2021; IDF, 2022).

The long-term consequences of T1D include chronic complications such as retinopathies, nephropathies, and dyslipidemias (Fuhrman & Ferreri, 2019), and in addition, a high risk for cardiovascular disease than the general population (Dec et al., 2021). Thus, the management and treatment of people with diabetes require a holistic approach to care that involves physical exercise, weight control, monitoring of blood glucose, cholesterol, triacylglycerol, blood pressure, and adequate food consumption (Fuhrman & Ferreri, 2019).

It is widely believed that dietary intake plays a crucial role in improving health outcomes for individuals with type 1 diabetes (T1D) (ADA, 2022). Since 1980, the World Health Organization (WHO) has recommended conducting food consumption studies based on food groups rather than isolated nutrients. However, the analysis of dietary patterns deviates from this approach and allows us to understand the relationship between dietary patterns and the development of diseases (Cena & Calder, 2020). Studying dietary patterns involves examining the quantities, proportions, variety, and combinations of different foods and beverages in a diet, as well as the frequency of their consumption (Schulze et al., 2018). This approach considers the entire diet rather than focusing on specific food groups, enabling an exploration of the synergistic effects of nutrients on health (Sampaio, 2022).

Several studies have indicated that patterns characterized by the consumption of processed foods high in sugars and fats are associated with an increased risk of chronic noncommunicable diseases (CNCDs) (Lutz, 2021). Conversely, healthy dietary patterns that include fruits, vegetables, lean meats, and fish have been shown to reduce the risk of noncommunicable diseases, including diabetes (Walsh et al., 2017). Furthermore, evidence suggests that a healthy dietary pattern is linked to a lower risk of cardiovascular disease (CVD) (Shan et al., 2020).

The characterization of dietary patterns, as well as their effects on the cause or protection of chronic complications in populations with T1D, is of great importance. There are no data available regarding the association between dietary patterns and biochemical markers of CVD in the Brazilian population. Thus, the present study aimed to identify dietary patterns and evaluate their association with the presence or absence of T1D and biochemical markers of cardiovascular risk in Brazilian adults.

2 METHODOLOGY

2.1 STUDY POPULATION AND DATA COLLECTION

This was a cross-sectional study involving patients with T1D recruited from the Endocrinology and Diabetes Outpatient Clinic of the Hospital of the Federal University of Ceará (HUWC-UFC) and healthy adult individuals who were recruited from the State University of Ceará (UECE) and UFC.

Criteria for inclusion of patients with DM1 in the study were: patients of both sexes, with fasting glucose ≥ 126 mg/dL (ADA, 2022); with follow-up time at the outpatient clinic ≥ 6 months; age from 18 to 60 years; clinical and cognitive conditions that allow them to answer interview questions and ability to stand. Patients with renal, heart, or hepatic dysfunction and type 2 diabetes, those with alcoholism and mental disorders (including dementia and Alzheimer's disease). Also, those diagnosed with leprosy, HIV infection, and autoimmune disease, as well as pregnant or lactating women, were excluded from the study.

The study was conducted by the principles of the Declaration of Helsinki, and all participants signed an informed consent form. The UECE and UFC Research Ethics Committee approved this study (protocol nº. 1.357544). The final sample comprised 90 individuals, 45 patients with T1D, and 45 healthy controls.

Data collection was carried out by trained interviewers who used a structured questionnaire to obtain sociodemographic data (age, gender, education, income), family history of diabetes, and lifestyle habits (physical activity, smokers, and drinking). The T1D and control groups were matched by sex, age, and body mass index (BMI).

2.2 ANTHROPOMETRIC AND LIFESTYLE VARIABLES

Alcohol consumption and the status of cigarette smokers were reported by participants. The standards considered for alcohol consumption and cigarette smoke were following the WHO (WHO, 2004) and the Vital and Health Statistics (Schoenborn & Adams, 2010), respectively.

Anthropometric measurements included weight, height, waist, and hip circumference. BMI was used, such as kg/m^2, and the waist-to-hip ratio was established by dividing the waist perimeter by the hip perimeter, according to WHO criteria (WHO, 1995, 2000, 2008).

2.3 BIOCHEMICAL TESTS

Serum samples were collected from all participants after a 12-hour fast for biochemical analysis. All samples were centrifuged at 3000 rpm for 15 minutes at room temperature and the serum was kept frozen at −80°C until analyzed.

Fasting blood sugar, total cholesterol, high-density lipoprotein cholesterol (HDL-C), triglyceride, urea, and creatinine were measured by colorimetric enzymatic method using commercially available kits (Bioclin, Quibasa Quimica Basica Ltda. Wr, Brasil) and an automated biochemical analyzer (Mindray BC-2800, Shenzen Mindray Bio-Medical Electronics, China). Low-density lipoprotein cholesterol (LDL-C) was calculated using the Frederickson-Friedwald equation (Friedewald, Levy, 1972).

2.4 ASSESSMENT OF DIETARY INTAKE

The 24 h food recall method (R24 h) was used to investigate participants' food consumption with the application of two recalls, one on a weekday and the other on a weekend (Arruda et al., 2013). The first was obtained in person, and the second, by phone.

Dietary data were converted from homemade measures to grams or milliliters, and nutritional analysis to quantify the energy and total nutrients were performed using Diet Win Nutritional Analysis software (Reinstem, 1998).

The values obtained for macro and micronutrients were corrected for energy using the residue method and intrapersonal variability (Fisberg, 2004).

2.5 DIETARY PATTERN

Participants reported a total consumption of 137 foods that were aggregated in 17 food groups, considering the similarity of their nutritional composition. Foods consumed by less than 5% of the sample and not included in any group were excluded, according to the criterion adopted by Selem et al. (2014).

To identify dietary patterns, we used principal component factor analysis (ACP), and an orthogonal varimax rotation. The adequacy of the data to factor analysis was confirmed by the Kaiser-Meyer-Olkin (KMO) coefficient (> 0.5) and Bartlett's sphericity test ($p < 0.001$). The number of factors retained was defined based on the following criteria: components with eigenvalues greater than 1.0, Cattel graph (scree plot), and conceptual meaning of the identified patterns. Each major component was interpreted based on foods with factor loads ≥ 0.3 or ≤ - 0.3. The names of identified patterns were named according to the composition of their food items and by the nomenclature already established in the literature (Newby & Tucker, 2004).

2.6 STATISTICAL ANALYSIS

For statistical analysis of the data, a descriptive analysis of the variables under study was initially performed. Continuous variables are presented as the means (standard deviation), and categorical variables are presented as simple frequencies and percentages. The normality of the numerical variables was assessed using the Shapiro-Wilk test. Poisson regression with robust variance estimation was used in the bivariate and multivariate analyses to estimate the prevalence ratios (PR) of the independent variables (presence or absence of diabetes and characteristics of dietary intake of individuals with and without diabetes) about outcomes, classifying the dependent variables (food consumption patterns) as dichotomous: low intake (1st, 2nd and 3rd quartiles) and high intake (4th quartile).

We used the analysis of variance for continuous variables and the chi-square test for categorical variables to determine the differences between the characteristics of individuals in the lower quartile (Q1) and individuals in the upper quartile (Q4) of consumption and biochemical tests in each pattern.

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%.

3 RESULTS

3.1 SOCIODEMOGRAPHIC, ANTHROPOMETRIC, AND LIFESTYLE CHARACTERISTICS

The DM1 group had a mean age of 31.02 ± 9.29 years, with a predominance of income ≤ 3 minimum wages (73.33%), non-smokers (93.33%), and more than half of the patients (55.56%) had elementary and high school. The control group had a mean age of 30.13 ± 9.70 years, more than half had an income ≥ 3 minimum wages (64.44%), with a predominance of non-smoking individuals (95.56%) and university education (80 %). Participants in each group were matched and there was no significant difference in terms of age, sex, or BMI.

The fasting blood glucose was significantly different between T1D patients and healthy controls. Patients with T1D had a fasting blood glucose of 157.11 ± 57.72 mg/dL and individuals in the control group had 90.04 ± 6.02 mg/dL. Most individuals with T1D had completed elementary school and had a lower income than the control group ($p<0.001$). Based on BMI, appeared without excess weight in 64.44% of subjects, with no difference between groups. On the other hand, the DM1 group had a higher waist-hip ratio (p<0.05) but was more physically active than the control group (p<0.05) (Table 1).

Table 1 - Sociodemographic, anthropometric, and lifestyle characteristics of individuals with and without type 1 diabetes mellitus.

Variables	With T1D (n = 45)		Without T1D (n = 45)		*p**
	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		
Smokers					0,645£
N	3		2		
%	6,67		4,44		
Glucose (mg/dL)	157,11	57,72	90,04	6,02	<0,001**
BMI (kg/m²)	24,22	3,05	25,00	4,15	0,356‡
Without excess weight					0,375
N	29		24		
%	64,44		53,33		
Overweight					
N	16		21		
%	35,56		46,67		
WC (cm)	84,48	8,04	84,37	11,91	0,962+
Without risk*					
N	27		21		0,647£
%	60,00		46,67		
With increased and substantially increased risk*					
N	18		24		
%	40,00		53,33		
WHR	0,87	0,05	0,83	0,08	0,022+
Without risk					
N	25		35		0,040£
%	55,56		77,78		
Substantially increased risk					
N	20		10		
%	44,44		22,22		

Source: Direct search.

Subtitle: WC - Waist Circumference; CVD - Cardiovascular Diseases; WHR - Waist-to-Hip Ratio; * Risk of metabolic complications associated with obesity. P value considered significant below 0.05. ** Mann-Whitney test. £ - independent Student's t-test. ‡ - Fisher's exact chi-square test. + - Pearson's chi-square test.

3.2 DIETARY PATTERN

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 prudent standard was characterized by foods such as poultry, fish, tame fruits, whole grains, vegetables, fruits, and skimmed milk, and with a negative charge for beef, pork, cereal, legumes, and whole milk. The snack pattern included foods such as sandwiches and fruit smoothies. The Western standard was composed of industrialized drinks, sweets, snacks, and foods rich in fats, with a negative charge for soups and broths (Table 02).

Table 2 - Factor loads for the three dietary patterns identified among patients with and without type 1 diabetes mellitus.

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

Source: Direct search.

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

3.3 ASSOCIATION OF DIETARY PATTERNS WITH DIABETES AND FOOD CONSUMPTION

It was found that there was no significant association between dietary patterns with or without T1D (Table 3). Individuals with higher adherence (Q_4) to the prudent standard showed higher protein consumption (p = 0.009) when compared to the less adherent individuals (Q_1). For the snack pattern, the highest adherence (Q_4) implied a higher consumption of carbohydrates (p<0.001), lipids (p<0.001), saturated fats (p<0.001), monounsaturated (p = 0.003), and lower consumption of fibers (p<0.001).

There was no difference in nutrient intake among individuals with lower adherence (Q_1) and greater adherence (Q_4) to the Western standard (Table 4).

3.4 ASSOCIATION OF DIETARY PATTERNS WITH BIOCHEMICAL MARKERS

As indicated in Table 5, a lower HDL level (p=0.044) was observed in individuals with greater adherence (Q4) to the prudent pattern. Individuals with a lower level of fasting blood glucose (p = 0.002) and a higher level of triglycerides (p=0.001) showed greater adherence (Q4) to the snack pattern. In the Western pattern, individuals with greater adherence (Q4) had a higher level of fasting blood glucose (p=0.016).

Table 3 - Association between dietary patterns and the presence or absence of type 1 diabetes mellitus.

	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	p=0,627	p=0,147	p=0,174	p=0,062	p=0,129	p=0,070	p=0,335	p= 0,954	p= 0,240
With T1D	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference	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)

Source: Direct search.

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 and BMI classification).

Table 4 – Dietary characteristics of individuals with and without type 1 diabetes mellitus according to the quartile categories of the dietary patterns.

	Prudent Pattern	Snack Pattern	Western Pattern						
	Q1 (SD)	Q4 (SD)	p	Q1 (SD)	Q4 (SD)	p	Q1 (SD)	Q4 (SD)	p
Food Intake									
Energy (kcal)	1961,12 (538,91)	3111,08 (565,96)	0,300	1402,15 (395,70)	2221,76 (532,01)	0,176	1724,63 (558,66)	2086,16 (708,66)	0,372
Protein (g)	85,71 (21,44)	100,48 (26,66)	0,009	85,89 (7,83)	92,29 (26,30)	0,645	89,81 (18,94)	90,62 (21,59)	0,656
Carbohydrate (g)	225,40 (2,84)	223,99 (26,96)	0,767	207,09 (15,21)	235, 93 (27,36)	<0,001	222,86 (24,76)	223,02 (28,05)	0,704
Fibers (g)	17,56 (4,67)	17,56 (4,06)	0,678	19,11 (5,44)	15,67 (3,39)	<0,001	19,02 (6,24)	16,96 (3,40)	0,166
Lipids (g)	63,92 (12,46)	62,17 (8,46)	0,941	55,07 (7,86)	67,75 (9,08)	<0,001	62,45 (9,40)	60,31 (8,29)	0,231
Cholesterol (mg)	279,85 (48,50)	290,60 (51,68)	0,568	270,45 (54,06)	283,20 (55,06)	0,311	268,43 (49,06)	277,83 (52,42)	0,110
Saturated (g)	21,01 (4,22)	21,12 (3,69)	0,816	17,78 (2,76)	22,17 (3,26)	<0,001	20,66 (3,39)	20,83 (3,47)	0,891
Monounsaturated (g)	16,05 (2,47)	16,00 (2,30)	0,923	14,45 (2,08)	15,98 (2,31)	0,003	15,27 (2,10)	15,51 (2,00)	0,198
Polyunsaturated (g)	12,49 (1,85)	11,62 (1,62)	0,200	11,21 (0,84)	12,22 (2,20)	0,131	11,38 (1,49)	11,92 (1,37)	0,358

Source: Direct search.

Subtitle: values presented in mean / Standard Deviation (SD) for continuous variables. † ANOVA for continuous variables and chi-square test for categorical variables.

Table 5 – Biochemical characteristics of individuals with and without type 1 diabetes mellitus according to the quartile categories of the dietary patterns.

	Prudent Pattern	Snack Pattern	Western Pattern						
	Q1 (SD)	Q4 (SD)	p	Q1 (SD)	Q4 (SD)	p	Q1 (SD)	Q4 (SD)	p
Fasting glucose (mmol/L)	129,26 (53,09)	127,81 (54,09)	0,761	158,76 (62,93)	108,35 (32,47)	0,002	116,78 (45,19)	128,99 (49,10)	0,016
Serum Cholesterol	189,49 (37,04)	180,16 (31,20)	0,721	186,61 (45,74)	186,88 (33,79)	0,979	175,80 (34,21)	182,84 (28,37)	0,148
Triglycerides (mmol/L)	111,10 (53,03)	117,14 (62,95)	0,590	72,47 (30,55)	135,89 (64,07)	0,001	103,51 (56,24)	122,25 (65,50)	0,775
HDL Cholesterol (mmol/L)	74,22 (22,30)	66,5 (22,30)	0,044	75 (22,51)	78,45 (23,74)	0,336	71,48 (27,04)	71,05 (23,70)	0,467
LDL Cholesterol (mmol/L)	93,40 (35,63)	91,38 (29,17)	0,741	95,63 (34,78)	85,05 (43,39)	0,432	85,58 (33,74)	88,46 (26,73)	0,451
Serum Creatinine	0,99 (0,20)	0,91 (0,24)	0,145	0,93 (0,21)	0,90 (0,22)	0,487	0,87 (0,22)	0,90 (0,21)	0,492
Urea	33,02 (11,95)	29,27 (9,75)	0,156	31,56 (10,17)	26,92 (8,46)	0,471	28,53 (8,81)	29,60 (10,06)	0,257

Source: Direct search.

Subtitle: High-Density Lipoprotein Cholesterol (HDL); Low-Density Lipoprotein Cholesterol (LDL); values presented in mean / Standard Deviation (SD) for continuous variables. † ANOVA for continuous variables and chi-square test for categorical variables. p-value considered significant below 0.05.

4 DISCUSSION

T1D is a challenging disease and has become a major public health problem. Poor glycemic control developed by diabetes causes a series of complications, which can interfere in three different aspects, physical, psychological, and social, with the ability to impact productivity, social life, family relationships, and leisure (Maciel et al., 2018). One of the approaches used to control blood glucose is dietary planning (Oliveira, 2019) with likely indications of changes in eating habits, which may be particularly difficult to achieve and sustain.

Nutritional therapy for individuals with diabetes represents a fundamental pillar for the treatment of the disease. Among the related objectives, we highlight the maintenance of glycemic levels within acceptable standards; achieving a good lipid profile; providing a caloric amount with the adequate distribution of macronutrients and micronutrients, necessary to achieve and maintain adequate weight; prevention and treatment of complications associated with diabetes; maintain the patient's health and quality of life (Lemos, 2019). Adequate dietary treatment, with the consumption of legumes, rich in fiber, allows additional improvements in glycemic control, insulin resistance, and lipid profile, with lower risks of diseases associated with DM (Macedo, 2020).

We identified three main dietary patterns among patients with T1D and healthy adult controls: the prudent pattern that was inversely related to HDL. The snack pattern was associated with the reduction in fasting blood glucose, as well as the increase in triglycerides and the western pattern showed an association with a higher level of fasting blood glucose. Nevertheless, neither association was observed between the dietary patterns with the presence of T1D. The variance explained by the three factors retained from eating patterns was similar to findings by Martínez et al., (2020) that found 32.49% of the variance in patients with type 2 diabetes.

The pattern is prudent and 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). Die**ts** that follow a prudent/healthy eating pattern are associated with low morbidity and mortality, better glycemic control, and a lipid profile (Yazdi et al., 2020). A prudent, healthy, and balanced dietary pattern, consisting of a frequent intake of vegetables, fruits, fish, and whole grains, and a low intake of fried, canned, processed foods, tubers, and refined carbohydrates, were found to be negatively associated with the development of diabetes (Neuhouser, 2019). Studies carried out with patients with diabetes showed a higher risk of the disease in the Western dietary pattern compared to prudent eating patterns (Pestoni et al., 2021; Ushula et al., 2022).

Analyzing the dietary characteristics of individuals who had greater adherence to the defined dietary patterns, it was found that the prudent pattern had higher consumption of proteins and the snack pattern increased consumption of carbohydrates, lipids, saturated fats, monounsaturated and less consumption of fibers. In general, adequate protein consumption has had a protective effect as it has a low glycemic response by reducing the glycemic index of foods and a greater thermal effect for using more energy in your digestion, thus increasing the basal metabolic rate (Thomas, Kapoor, Nitin, 2016).

In the snack pattern, the presence of foods defined as processed and ultra-processed, such as snacks, industrialized drinks, and sweets have a higher energy density and a high content of refined carbohydrates, saturated fats, sodium, and lower fiber content (Louzada et al., 2021). It is consistent with growing evidence that indicates that the consumption of processed and ultra-processed foods is harmful to human health in general and is associated with the development of NCDs, such as diabetes and cardiovascular disease (Srour et al., 2019).

There are few studies with T1D, that have investigated the relationship between dietary patterns and biochemical markers of cardiovascular risk, particularly in adults. Our findings showed that the prudent pattern was inversely related to HDL level. Previous studies indicate that a diet based on fresh and minimally processed foods, rich in whole grains, vegetables, fruits, and fish, has been associated with high levels of HDL (Nasreddine et al., 2018). However, in the present research, we did not find the same results between the prudent standard and HDL levels.

Although this pattern presents a variety of healthy foods. Is possible that the low practice or physical inactivity of the participants may explain, in part, this result. An increase in HDL levels, as a result of physical activity, can be explained by the breakdown of triglyceride-rich lipoproteins and increases the average lifespan of HDL. However, for such a result, greater intensity and frequency of physical activity are needed (Pitanga et al., 2021), which we did not find in our findings, as most participants reported doing physical activity at a frequency of one to three times a week.

The reduction in fasting blood glucose was associated with the snack pattern, as well as the increase in triglycerides. The reduction in the consumption of main meals, such as breakfast, lunch, and dinner, is an important change that has been taking place in current eating behavior. The consumption of snacks is commonly used as a replacement for one of these meals, being generally a food with a high content of carbohydrates and fat, which promotes changes in triglyceride levels (Cao et al., 2022).

Lopes et al., (2022) suggest that the energy intake of snacks can help to reduce the total daily energy intake, probably, this has contributed to the reduction of blood glucose, even if in an unhealthy way, since an increase in the level of triglycerides was also observed. On the other hand, the Western pattern had associated with a higher level of fasting blood glucose, strengthening the studies that show a higher risk of diabetes in the Western dietary pattern (Pestoni et al., 2021; Ushula et al., 2022) and this also indicate that strategies to stimulate healthy eating habits among adults need to be developed.

Although the study did not show an association of the dietary patterns identified with the presence or absence of T1D, the evidence supports consumption of the prudent standard as important in combating NCDs, and it discourages consumption of the Western standard (Shan et al., 2020; Walsh et al., 2017). The higher level of education in healthy individuals and monitoring by the multidisciplinary health team of patients with T1D may explain, in part, the lack of association between dietary patterns and the presence or absence of T1D, considering that both groups had similar profiles of food consumption. Brazilian studies reinforce that the greater consumption of more nutritious foods is higher among individuals with higher education (Freire et al., 2018), and that the work of the multidisciplinary team allows for better adoption of healthy eating habits (Cradock et al., 2021), which corroborates the findings of the present study.

To our knowledge, the present study is the first to report on dietary patterns and biomarkers of cardiovascular risk in adults with T1D in Brazil. Our study stands out for evaluating eating habits and their relation with cardiovascular risk markers. The strength of this study was the use of R24h, a method that is quick to apply and requires no processes, such as validation and calibration. The method was used for more than one day of ingestion and on nonconsecutive 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 & Schulze, 2005).

A limitation of this study includes the cross-sectional design since the presence of risk factors and outcomes are measured simultaneously. However, cross-sectional studies are alternatives for adopting actions that promote healthy eating habits in populations. Another limiting point is that glycated hemoglobin and blood pressure were not analyzed. In addition, we recognize the small sample of individuals with T1D in the population studied. There may be 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.

5 CONCLUSION

In conclusion, three main dietary patterns were identified among patients with T1D and healthy adults: prudent, snack, and western patterns that were related with biochemical markers of cardiovascular risk. In addition, the prudent pattern was the one that exhibited food groups recommended in a healthier diet. However, no association was observed between the dietary patterns with the presence of T1D. Prospective studies are warranted to better understand the effects of dietary patterns in adult people with T1D.

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