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Dietary factors and glycaemic control in patients with diabetes

Wpływ czynników żywieniowych na parametry wyrównania metabolicznego cukrzycy

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Abstract

Introduction and Objective. Although type 1 and type 2 diabetes differ significantly in various aspects, including etiology, treatment and medical guidelines, does the type of disease influence the level of management? The aim of the study is to identify the differences in BMI, food frequency intake, and levels of physical activity between individuals with different types of diabetes, and to assess the link between dietary factors and HbA_{1c} levels.
Materials and Method. The study included 78 patients (mean age 42.8 ± 18.2 years), with T1D (n= 49) or T2D (n= 29). Patients were categorized also into two groups: with higher level of HbA_{1c} (> 6.5%, n = 67) and normal level of HbA_{1c} (< 6.5% n = 11). The KomPAN questionnaire, supplemented with additional diabetes-related questions, were completed by each participant.
Results. T1D was associated with younger age, lower BMI and worse dietary habits, compared to T2D. Higher dietary quality index scores were observed among women with T1D, compared to men, and lower consumption of meat and meat products was reported. Greater levels of physical activity were reported by patients with normal HbA1c. Higher HbA_{1c} level (> 6.5%) was linked to consuming animal fats more than once daily and whole meal products less than once daily.
Conclusions. Food frequency intake and diet quality may be dependent on the type of diabetes and gender. Appropriate HbA_{1c} levels may be connected not only with proper dietary habits, but also with physical activity. The study, however, has significant limitations, including the heterogeneity of the groups; therefore, it is necessary for further research to be conducted on more homogenous populations..

Key words

type 1 diabetes, type 2 diabetes, diet quality, glycated haemaglobin, food frequency intake

Streszczenie

Wprowadzenie i cel pracy. Cukrzyca typu 1 i typu 2 różnią się znacznie pod wieloma względami, w tym etiologią, sposobem leczenia i zaleceniami. Pojawia się pytanie: czy rodzaj choroby wpływa na poziom jej wyrównania? Celem niniejszego badania było zidentyfikowanie zależności pomiędzy wskaźnikiem masy ciała (BMI), częstotliwością spożycia wybranych grup produktów oraz poziomem aktywności fizycznej a rodzajem cukrzycy, a także ocena związku pomiędzy czynnikami żywieniowymi a poziomem hemoglobiny glikowanej (HbA1c).
Materiał i metody. Do badania włączono 78 pacjentów (średni wiek 42,8 ± 18,2 lat), z T1D (N = 49) lub T2D (N = 29). Badanych podzielono na dwie grupy: z podwyższonym (> 6,5%, N = 67) i prawidłowym poziomem HbA1c (6,5%) był związany ze spożywaniem tłuszczów zwierzęcych więcej niż raz dziennie oraz produktów pełnoziarnistych rzadziej niż raz dziennie.
Wyniki. Osoby z T1D charakteryzowały się młodszym wiekiem, niższym BMI oraz gorszymi nawykami żywieniowymi niż osoby z T2D. Wyższe wskaźniki jakości diety odnotowano u kobiet z T1D w porównaniu do mężczyzn, a także zaobserwowano mniejsze spożycie mięsa i jego przetworów. Wyższy poziom aktywności fizycznej zgłaszali pacjenci z prawidłowym poziomem HbA1c, której podwyższony poziom (>6,5%) był związany ze spożywaniem tłuszczów zwierzęcych więcej niż raz dziennie ora produktów pełnoziarnistych rzadziej niż raz dziennie.
Wnioski. Wyniki niniejszego badania sugerują, że częstotliwość spożywania pożywienia zaliczanego do określonych grup żywności i jakość diety mogą być związane z typem cukrzycy, a także z płcią. Jest to zależność wieloczynnikowa, wynikająca także z wiedzy na temat żywienia, nawyków żywieniowych wpojonych we wczesnym dzieciństwie, statusu socjo-ekonomicznego, pochodzenia i innych. Ograniczeniem pracy jest niejednorodność grup, która determinuje przeprowadzenie w przyszłości większej liczby badań na bardziej heterogennych grupach.

Słowa kluczowe

cukrzyca typu 2, hemoglobina glikowana, cukrzyca typu 1, jakość diety, częstotliwość spożywania żywności

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INTRODUCTION

Diabetes mellitus is a group of metabolic diseases characterized with hyperglycaemia caused by a defect in insulin secretion or action. The diagnostic criteria include: random plasma glucose level ≥ 200 mg/dl, fasting plasma glucose (FPG ≥ 126 mg/dl), OGTT ≥ 200 mg, HbA_{1c} ≥ 6.5% [1]. Type1 and type2 diabetes are most commonly diagnosed, but other forms, such as gestational diabetesmonogenic diabetes syndrome, *adult* l*atent autoimmune diabetes*,, drug and chemical-induced diabetes, and diseases of the exocrine pancreas, are also recognized [2]. Type 1 diabetes is caused by an insulin deficiency brought on by β-cell destruction [1]. Compared to type 1 diabetes, type 2 symptoms tend to develop more gradually [3]. Type 2 diabetes occurs due to non-autoimmune progressive loss of β-cell insulin secretion, often accompanying metabolic syndrome and insulin resistance [1, 2]. It can vary from a prevailing insulin resistance with a relative insulin deficiency to an overall secretory defect with insulin resistance [1]. Type 2 diabetes is commonly associated with overweight or increased abdominal fat, regardless of overall weight classification. Unlike in type-1 diabetes, the condition in patients with type 2 diabetes may initially be managed with lifestyle modifications and oral medications, before insulin therapy is required [2].

In recent years, the effects of childhood excess body weight on the pathogenesis of type 1 diabetes has also been emphasized [4]. Healthy diet and exercise play supportive roles in type 1 diabetes, but insulin management remains crucial. On the other hand, in type 2 diabetes, diet modifications and increased physical activity are the first line of defence. Weight management significantly improves insulin sensitivity [5]. The American Diabetes Association (ADA) advises that there is no single ideal diet for all individuals with diabetes. Instead, it highlights scientifically validated meal patterns, such as the Mediterranean, vegetarian, low-fat, and low-carbohydrate diets, which help manage blood glucose, cholesterol, and blood pressure [6]. These recommendations coincide with the Polish Diabetes Association (PDA) guidelines for patients. According to the PDA, the optimal macronutrient proportions for this group of patients should be determined individually, considering age, physical activity, presence of diabetes- related complications, comorbid conditions, and the preferences of the person with diabetes [7].

The recommendations from the European Association for the Study of Diabetes (EASD) also focus on a range of dietary patterns appropriate for diabetes control. These include consuming minimally processed plant-based foods, such as whole grains, vegetables, fruits, legumes, nuts, and seeds. EASD recommendations also underline the need to reduce the consumption of sweetened beverages, sodium, refined grains, and processed red meat. Weight management strategies and the moderate use of non-nutritional sweeteners are also endorsed by the guidelines [8]. Inadequate diabetes management, particularly unhealthy dietary habits may contribute to the development of macrovascular complications, such as cardiovascular diseases and microvascular complications, including diabetic nephropathy, retinopathy, and neuropathy. These conditions are associated with increased mortality, vision impairment, renal failure and general deterioration in the quality of life [2, 9]. In type 1 diabetes, poor glycaemic control may result in the development of diabetic ketoacidosis (DKA), a life-threatening condition, whereas in type 2 diabetes, hyperosmolar hyperglycaemic state (HHS) may be induced [2].

Despite the health hazards and life-threatening consequences of poor nutrition in diabetes, low adherence to dietary recommendations is observed. Geng et al. concluded that only 20.7% of a large cohort, consisting of over 15,000 patients with diabetes, adhered to the majority of the recommendations to reduce the risk of microvascular complications. These recommendations included maintaining proper body weight, following a healthy diet, engaging in regular physical activity, not smoking, and limiting alcohol consumption [10]. Jaworski et al. observed that patients' low adherence to nutritional recommendations and lack of regular blood glucose testing was associated with a low level of disease acceptance [11].

OBJECTIVE

The aim of the study is to determine the differences, in BMI, food frequency intake, and level of physical activity in patients with different types of diabetes. A detailed analysis of patients' dietary habits was conducted, with focus on the impact of the frequency of consumption of selected food groups on HbA_{1c} levels.

MATERIALS AND METHOD

Study participants. Participants were recruited at the Department of Internal Medicine and Diabetology, Franciszek Raszeja Hospital, Poznań University of Medical Sciences, between December 2023 – March 2024. The eligibility criteria for participants included the following:

- diagnosis of type-1 diabetes (T1D) or type-2 diabetes (T2D);
- data regarding glycated haemaglobin (Hb1Ac) levels (%) over the past six months;
- aged over 18 years;
- no clinical diagnosis of eating disorders;
- no clinical diagnosis of food allergy or digestive ailments: irritable bowel syndrome, ulcerative colitis, Crohn's disease, or celiac disease;
- not currently pregnant, and not breastfeeding;

The study initially involved 107 patients: 53 with T1D and 54 with T2D. One participant was excluded from the study due to a diagnosis of LADAT (Lymphadenopathy). Twenty-eight respondents who were unaware of their recent HbA_{1c} results were also excluded, as this measurement was deemed essential for the analysis. The study therefore finally included 78 patients with T1D (n = 49) and T2D (n = 29). The characteristics of participants are shown in Table 1.

Evaluation of nutritional habits. The Kompan questionnaire, created by the Behavioural Conditions of Nutrition Team of the Committee of Human Nutrition Science, Polish Academy of Sciences, was used to evaluate the nutritional habits of the participants. Kowalkowska et al. have previously described how data from the Kompan Questionnaire is interpreted [12]. In order to comprehensively evaluate dietary quality, three dietary indices were calculated.

Table 1. Characteristics of study participants

Parameters	All (n = 78)	T1D (n = 49)	T2D (n = 29)	*p* - value
Anthropometric parameters, mean ± SD				
Age [years]	42.8 ± 18.2	32.4 ± 10.9	61.0 ± 11.1	<0.001
Women 40.3%	45.0 ± 20.2	32.2 ± 14.1	62.6 ± 11.7	<0.001
Men 59.7%	41.3 ± 16.8	32.5 ± 11.4	59.5 ± 10.1	<0.001
Body weight [kg]	85.3 ± 22.0	79.7 ± 16.4	93.7 ± 27.2	0.005
Women	75.4 ± 15.0	71.6 ± 15.2	79.1 ± 13.9	NS
Men	92.0 ± 23.6	84.4 ± 15.4	107.8 ± 29.6	<0.001
BMI [kg/m²]	28.4 ± 6.5	26.0 ± 5.0	32.2 ± 6.9	<0.001
Women	27.7 ± 5.8	25.5 ± 5.8	30.1 ± 4.9	0.01
Men	28.8 ± 7.0	26.2 ± 4.6	34.1 ± 8.1	<0.001
Methods of treatment, n (%)				
Functional intensive	35 (45.5)	25 (51.0)	10 (35.7)	
insulin therapy	12 (15.6)	7 (14.3)	5 (17.9)	
Women	23 (29.9)	18 (36.7)	5 (17.9)	
Men				
	22 (28.5)	22 (44.9)	-	
Insulin Pump	11 (14.3)	11 (22.5)	-	
Women	11 (14.3)	11 (22.5)	-	
Men				
	18 (23.4)	2 (4.1)	16 (57.1%)	
Oral medicine and insulin	8 (10.4)	-	8 (28.6%)	
Women	9 (11.3)	2 (4.1)	8 (28.6%)	
Men				
Other comorbidities, n (%)				
Thyroid dysfunction	13 (16.9)	6 (12.2)	7 (25.0)	
Women	9 (11.7)	4 (8.2)	5 (17.9)	
Men	4 (5.2)	2 (4.1)	2 (7.1)	
Hypertension	32 (41.6)	10 (20.4)	22 (78.6)	
Women	11 (14.3)	2 (4.1)	9 (32.1)	
Men	21 (27.3)	8 (16.3%)	13 (46.4)	
Atherosclerosis	10 (13.0)	1 (2.0)	9 (32.1)	
Women	3 (3.9)	-	3 (10.7)	
Men	7 (9.1)	1 (2.0)	6 (21.4)	

1) Pro-Healthy Diet Index 10 (pHDI-10) – calculated by summing-up the frequencies of consumption (times per day) of fruit, vegetables, whole meal bread, milk (including flavoured milk), fermented milk beverages (e.g. yogurt and kefir), curd cheese (including homogenized varieties), fish products and dishes, legume-based dishes, thick milled buckwheat cereal products, oatmeal, whole grain pasta, other coarse grains, and dishes prepared from white meat (defined here as chicken, turkey, rabbit, and others).
2) Non-Healthy Diet Index 14 (nHDI-14) – calculated by summing-up the frequencies of consumption (times per day) of confectionery products, fried dishes, alcoholic drinks, sweetened carbonated beverages, meat, powdered and ready-to-eat soups, fast food and energy drinks, light bread, and 'white' cereal products (white rice, plain pasta, semolina, couscous), butter, lard, yellow cheese, and red meat dishes (veal, mutton, lamb, beef, pork and venison).
3) The Diet Quality Index (DQI) – a tool used to assess overall dietary quality in relation to health guidelines. Various dietary components are evaluated by the DQI, including intake of fruits and vegetables, whole grains, protein sources, fat quality, added sugars, and sodium. Each component is typically assigned a score, which is subsequently combined to generate an overall index score, with higher values indicating greater adherence to dietary recommendations.

For the purposes of statistical analysis, 66 food items from the Kompan Questionnaire were divided into 13 food groups: 1) whitemeal products, 2) whole meal products, 3) dairy products and eggs, 4) meat and meat products, 5) fish and sea foods, 6) fruits, 7) fast foods and snacks, 8) animal fats, 9) sweets, 10) vegetables and legumes, 11) sweetened beverages, 12) energy drinks, and 13) alcoholic beverages. The frequency of consumption was estimated as times per month. Patients also provided answers about amount of meals and daily physical activity.

In addition to the Kompan questionnaire, participants were also asked about their diabetes: type of diabetes diagnosed, duration of illness, age at diagnosis, comorbidities, and method of treatment. Anthropometric indices (height and weight) and the most recent HbA_{1c} (%) results were also provided by all patients. BMI was calculated as body weight divided by body height squared (kg/m²). To avoid any misunderstanding of the instructions, questions, or the meaning of some questionnaire items, the questionnaire was completed by the participants in the presence of an investigator.

Statistical analysis. Statistical analysis was conducted using Statistica software version 13.0 PL (StatSoft, Tulsa (OK), USA). Values are presented as means and standard deviations (SDs), or as proportions. The normality of variable distribution was determined using the Shapiro-Wilk test. Means were compared between subgroups with different type of diabetes, different disease duration, different genders, and patients with different levels of HbA_{1c} (%) (< 6.5%), using Student's *t*-test for continuous variables. Logistic regression analysis was used to estimate the odds ratios (OR) and the 95% confidence intervals (95% CI) of the estimated BMI, as well as food frequency intake in relation to the risk of $HbA_{1c} > 6.5\%$. P values less than 0.05 were considered statistically significant.

RESULTS

Significant differences were observed between anthropometric parameters in the patients with T1D and T2D and between men and women. Patients with T1D were found to be younger, in both genders ($p < 0.001$), to have lower body weight ($p = 0.005$), and to exhibit lower BMI values (< 0.001). Significant differences in body weight were not seen in women. There were also different illness durations for each type of diabetes, although only for males ($p < 0.05$).

The differences in the quality of the diet, food frequency intake, and physical activity in patients (both men and women) with different types of diabetes are shown in Table 2.

Among the patients with T1D, the consumption of fast foods and snacks ($p = 0.012$), sweetened beverages ($p = 0.037$), and energy drinks ($p = 0.026$) was found to be higher, whereas fruit intake ($p = 0.006$) was lower compared to T2D patients. The same parameters were compared for men and women with different types of diabetes. The DQI was found to be statistically higher in women with T1D compared to men with T1D ($p = 0.004$). The intake of meat and meat products was found to be lower in women with T2D ($p = 0.004$) than men with the same disease. Differences in meat and meat product intakes were also seen in the comparison between diet quality and food frequency intake in all women and men (independently of diabetes type) ($p = 0.001$). Differences

Table 2. Differences in anthropometrical parameters, diet quality, food frequency intake, and physical activity in study participants (men and women) with different types of diabetes

Parameters	T1D			T2D			p – value	
	All (n = 49)	Women (n = 18)	Men (n = 31)	All (n = 29)	Women (n = 14)	Men (n = 15)	T1D (all) vs. T2D (all)	Women (all) vs. Men (all)
Duration of the illness [years]	13.20 ± 10.65	12.22 ± 8.30	13.77 ± 11.9	14.14 ± 7.96	14.07 ± 9.08	14.20 ± 7.09	NS	NS
pHDI-10	27.76 ± 11.60	31.06 ± 13.08	25.87 ±10.67	26.97 ± 8.55	26.36 ± 8.31	27.53 ± 9.02	NS	NS
nHDI-14	15.43 ± 7.93	13.72 ± 7.86	16.42 ± 7.13	13.86 ± 6.61	12.07 ± 5.84	15.53 ± 7.04	NS	NS
DQI	12.35 ± 13.27	17.33 ± 12.35*	9.45 ±12.86*	13.10 ±10.18	14.28 ± 0.99	12.00 ± 9.62	NS	0.04
Amount of meals [per day]	3.68 ± 0.92	3.67 ± 0.97	3.69 ± 0.88	3.50 ± 0.76	3.71 ± 0.91	3.40 ± 0.63	NS	NS
White meal products [times/day]	0.81 ± 0.58	0.70 ± 0.56	0.87 ± 0.57	0.76 ± 0.80	0.77 ± 0.82	0.74 ± 0.81	NS	NS
Whole meal products [times/day]	1.38 ± 0.81	1.50 ± 0.90	1.31 ± 0.79	1.11 ± 0.99	1.09 ± 1.09	1.13 ± 0.93	NS	NS
Dairy products and eggs [times/day]	2.09 ± 1.48	2.50 ± 2.02	1.86 ± 1.15	2.12 ± 1.16	2.04 ± 0.85	2.19 ± 1.42	NS	NS
Meat and meat products [times/day]	1.33 ± 0.76	1.07 ± 0.71	1.48 ± 0.73	1.43 ± 0.76	1.02 ± 0.29*	1.80 ± 0.87*	NS	0.001
Fish and sea foods [times/day]	0.17 ± 0.18	0.11 ±0.11	0.20 ± 0.21	0.15 ± 0.13	0.16 ± 0.15	0.18 ± 0.11	NS	NS
Fruits [times/day]	0.77 ± 0.53	0.93 ± 0.49	0.68 ± 0.54	1.13 ± 0.55	1.07 ± 0.55	1.10 ± 0.57	0.006	NS
Fast foods and snacks [times/day]	0.40 ± 0.29	0.37 ±0.31	0.41 ± 0.28	0.24 ± 0.19	0.18 ± 0.17	0.30 ± 0.19	0.012	NS
Animal fats [times/day]	0.87 ± 0.73	0.85 ± 0.64	0.88 ± 0.79	1.17 ± 0.84	1.12 ± 0.74	1.21 ± 0.95	NS	NS
Sweets [times/day]	0.44 ± 0.41	0.42 ± 0.34	0.45 ± 0.46	0.32 ± 0.45	0.44 ± 0.56	0.21 ± 0.28	NS	NS
Vegetables and legumes [times/day]	1.31 ± 0.88	1.50 ± 0.73	1.23 ± 0.96	1.00 ± 0.50	0.91 ± 0.29	1.08 ± 0.63	NS	NS
Sweetened beverages [times/day]	0.21 ± 0.43	0.15 ± 0.46	0.24 ± 0.41	0.04 ± 0.10	0.05 ± 0.13	0.0 ± 0.04	0.037	NS
Energy drinks [times/day]	0.15 ± 0.35	0.10 ± 0.19	0.18 ± 0.41	0.00 ± 0.03	0.00 ± 0.00	0.01 ± 0.04	0.026	NS
Alcoholic beverages [times/day]	0.16 ± 0.30	0.09 ± 0.12	0.19 ± 0.37	0.06 ± 0.13	0.02 ± 0.03	0.09 ± 0.17	NS	NS
Physical activity [times/week]	0.22 ± 0.28	0.14 ± 0.22	0.23 ± 0.30	0.23 ± 0.41	0.15 ± 0.47	0.18 ± 0.34	NS	NS

mean ± SD; *- significant differences; pHDI-10 - Pro-Healthy-Diet-Index-10; nHDI-14 - Non-Healthy-Diet-Index-14; DQI – diet quality index

were also noted for DQI, with women having significantly higher value (p = 0.04).

The parameters of the normal and high HbA_{1c} (%) groups are compared in Table 3, where significant differences in animal fats intake are shown (p = 0.003), with consumption being higher in participants exhibiting elevated HbA_{1c} (%) levels. Higher physical activity (p=0.040) was observed in those with normal HbA_{1c} (%). Lower nHDI-14 values (p = 0.009) were also observed in this group. When the differences were analyzed separately for men and women, it was noted that intakes of whole meal products (p = 0.039), meat and meat products (p = 0.05), and animal fats (p = 0.010), as well as nHDI-14 levels (p = 0.011), were higher in men with elevated HbA_{1c} (%) compared to those with normal HbA_{1c} (%). Higher physical activity levels (p=0.01) was also observed in men with normal HbA_{1c} (%).

The effects of BMI, diet quality indexes, food frequency intake of selected food groups and physical activity on the risk of HbA_{1c} > 6.5% among patients with diabetes is shown in Table 4. Patients with HbA_{1c} levels exceeding6.5% were found to be 87% more likely to consume animal fats more than once daily, and the likelihood was 4.70 times greater when whole meal products were consumed less than once a day. Low physical activity (less than twice a week) was also associated with an 84% higher probability of HbA_{1c} > 6.5%.

DISCUSSION

The aim of this study was to analyze the differences in BMI, food frequency intake, and physical activity level for patients with different type of diabetes. The associations between dietary factors and HbA_{1c} levels were also evaluated.

Patients with T1D were found to be significantly younger, have lower body weight and BMI compared to patients with T2D. It is worth emphasising that the mean BMI value in the T1D group (25.5 ± 5.8 kg/m^2) also indicated overweight. The relationship between body weight gain in adults and the risk of T2D is widely known [13, 14]. Kaneto et al. observed that long-term weight or BMI gain beginning at the age of 20, and continuing through adulthood – even when remaining within the normal weight range, and independently of the final weight status attained – is a significant predictor of T2D [15]. The increasing incidence of T1D in children in many countries can also be seen in this context. Although overweight status is not particularly common in individuals with T1D, numerous studies have demonstrated that accelerated growth constitutes a risk factor for the development of the disease. A causal role of greater body weight in the risk of developing T1D was confirmed by Richardson et al. [16]. Childhood obesity was also confirmed by Censin et al. to contribute to the development of type 1 diabetes later in life [17]. The ongoing trend of increasing height and BMI among children and adolescents in industrialized countries has also been suggested as a contributing factor to the risk of developing T1D [18].

Upon analyzing food frequency intake among patients, no significant differences were observed between men and women with T1D regarding the consumption of specific food groups. However, it is noteworthy that women exhibited higher DQI values compared to men. Differences in meat and meat products intake was observed in individuals with T2D, where the consumption was higher in men with T2D. Other studies have demonstrated that women tend to exhibit a stronger preference for vegetables and whole grains compared to men. Additional gender-related distinctions

Table 3. Differences in anthropometrical parameters, diet quality and food frequency intake in study participants (women and men) with different level of HbA1c (%)

Parameters	All (n = 78)		Women (n = 32)		Men (n = 46)	
	Normal HbA1c (%) (n = 11)	High HbA1c (%) (n = 67)	Normal HbA1c (%) (n = 4)	High HbA1c (%) (n = 28)	Normal HbA1c (%) (n = 7)	High HbA1c (%) (n = 39)
Age (years]	42.72 ± 15.34	43.09 ± 18.70	29.25 ± 13.79	47.86 ±19.90	50.43 ± 10.34	39.67 ± 17.25
Body weight [kg]	84.00 ± 17.00	85.19 ± 22.87	71.25 ± 14.24	75.45 ±15.20	91.28 ± 14.48	92.18 ± 24.98
BMI [kg/m²]	26.92 ± 5.41	28.49 ± 6.68	24.52 ± 2.96	27.96 ± 6.05	28.29 ± 6.19	28.86 ± 7.15
Duration of illness [years]	12.00 ± 8.09	13.81 ± 9.96	7.00 ± 7.79	13.89 ± 8.41	14.86 ± 7.24	13.85 ± 11.05
pHDI-10	25.73 ±10.00	27.76 ± 10.77	33.25 ± 8.73	28.39 ± 11.66	21.43 ± 8.32	27.31 ±10.21
nHDI-14	9.73 ± 4.36*	15.69 ± 7.18*	9.25 ± 0.96	13.54 ± 7.33	10.00 ± 5.57*	17.23 ± 6.75*
DQI	16.00 ± 12.80	12.07 ± 11.93	24.00 ± 9.20	14.86 ± 11.70	11.43 ± 12.79	10.08 ±11.84
Amount of meals [per day]	3.27 ± 0.65	3.66 ± 0.88	3.25 ± 0.50	3.75 ± 0.97	3.29 ± 0.76	3.59 ± 0.82
Whitemeal products [times/day]	0.72 ± 0.80	0.80 ± 0.64	0.35 ± 0.26	0.79 ± 0.70	0.93 ± 0.95	0.82 ± 0.60
Wholemeal products [times/day]	1.03 ± 0.97	1.32 ± 0.88	1.66 ± 0.88	1.27 ± 1.01	0.67 ± 0.88*	1.36 ± 0.78*
Dairy products and eggs [times/day]	1.79 ± 1.09	2.15 ± 1.45	2.39 ± 1.48	2.29 ± 1.65	1.45 ± 0.71	2.06 ± 1.30
Meat and meat products [times/day]	1.00 ± 0.34	1.43 ± 0.78	0.91 ± 0.44	1.07 ± 0.57	1.05 ± 0.29*	1.68 ± 0.81*
Fish and sea foods [times/day]	0.18 ± 0.16	0.16 ± 0.17	0.21 ± 0.20	0.12 ± 0.12	0.17 ± 0.15	0.18 ± 0.19
Fruits [times/day]	0.93 ± 0.63	0.90 ± 0.56	1.04 ± 0.76	0.99 ± 0.49	0.88 ± 0.60	0.83 ± 0.60
Fast foods and snacks [times/day]	0.35 ± 0.30	0.34 ± 0.26	0.42 ± 0.43	0.27 ± 0.25	0.31 ± 0.23	0.38 ± 0.26
Animal fats [times/day]	0.33 ± 0.41*	1.08 ± 0.78*	0.50 ± 0.41	1.03 ± 0.70	0.24 ± 0.41*	1.12 ± 0.84*
Sweets [times/day]	0.22 ± 0.32	0.43 ± 0.44	0.09 ± 0.07	0.48 ± 0.45	0.30 ± 0.38	0.39 ± 0.43
Vegetables and legumes [times/day]	1.29 ± 0.68	1.20 ± 0.79	1.71 ± 0.72	1.18 ± 0.61	1.05 ± 0.57	1.21 ± 0.91
Sweetened beverages [times/day]	0.09 ± 0.15	0.15 ± 0.38	0.05 ± 0.07	0.11 ± 0.38	0.11 ± 0.18	0.18 ± 0.37
Energy drinks [times/day]	0.04 ± 0.07	0.11 ± 0.30	0.04 ± 0.07	0.06 ± 0.16	0.04 ± 0.06	0.14 ± 0.37
Alcoholic beverages [times/day]	0.11 ± 0.14	0.12 ± 0.27	0.08 ± 0.04	0.06 ± 0.10	0.13 ± 0.17	0.17 ± 0.34
Physical activity [times/week]	0.42 ± 0.41*	0.20 ± 0.30*	0.17 ± 0.30	0.14 ± 0.01	0.57 ± 0.31*	0.22 ± 0.45*

mean ± SD; *- significant differences; pHDI-10 - Pro-Healthy-Diet-Index-10; nHDI-14 - Non-Healthy-Diet-Index-14; DQI – diet quality index Normal HbA1c (%) – HbA1c (%) < 6.5%; High HbA1c (%) – HbA1c (%) > 6.5%

Table 4. Odds ratios (OR with 95% confidence intervals) of the risk of HbA1c > 6.5% by BMI (kg/m²), diet quality indexes and the food frequency intake of selected food groups among patients with diabetes

Parameters	Crude OR (CI 95%); p value
BMI [kg/m²] overweight or obesity	1.70 (0.32; 8.97); NS
pHDI-10 [≤ upper quartile]	8.43 (0.59; 119.71); NS
nHDI-14[≥ upper quartile]	-
DQI [≤ upper quartile]	0.22 (0.02; 1.92); NS
Whitemeal products [≥ once a day]	0.39 (0.08; 1.92); NS
Wholemeal products [≤ once a day]	4.70 (1.07; 20.74); 0.04
Dairy products and eggs [≤ once a day]	0.72 (0.06; 8.38); NS
Meat and meat products [≥ twice a week]	-
Fish and sea foods [≤ twice a week]	0.31 (0.05; 2.14); NS
Fruits [≥ twice a day]	0.29 (0.03; 3.42); NS
Fast foods and snacks [≥ once a week]	0.83 (0.18; 3.88); NS
Animal fats [≥ once a day]	0.13 (0.02; 0.79); 0.02
Sweets [≥ twice a week]	0.28 (0.05; 1.67); NS
Vegetables and legumes [≤ twice a day]	1.93 (0.37; 10.20); NS
Sweetened beverages [≥ twice a week]	3.52 (0.48; 26.01); NS
Energy drinks [≥ once a week]	6.40 (0.86; 47.70); NS
Alcoholic beverages [≥ once a week]	0.64 (0.03; 12.01); NS
Physical activity [≤ two times a week]	0.16 (0.03; 0.79); p = 0.02

pHDI-10 – Pro-Healthy-Diet-Index-10; nHDI-14 – Non-Healthy-Diet-Index-14; DQI – diet quality index

in dietary habits have been observed in areas such as meal frequency, snacking behaviour, and hunger patterns. Women were more likely to eat more frequently and experienced enhanced morning hunger, whereas men are less inclined to snack. Moreover, these differences extend to various eating contexts, including eating speed, dining out, and eating alone, with men generally tending to eat more rapidly and to dine out more frequently [19].

Differences in food frequency intake in general between patients with T1D and T2D were also observed in this study. Significantly lower fruit consumption was reported, along with higher intake of fast foods and snacks, as well as increased consumption of sweetened beverages and energy drinks by individuals with T1D. The differences between dietary habits in patients with T1D and T2D may depend on different forms of treatment. Patients with T1D are always treated with insulin, whereas patients with T2D are usually treated by diet therapy, some with oral medicine and insulin only when needed. For these reasons, the risk of hypoglycaemia is much higher in patients with T1D. This condition requires the consumption of easily digestible carbohydrates in order to restore blood glucose levels to the reference range. This could account for the more frequent consumption of sweetened beverages and fruits by patients with this type of diabetes. On the other hand, it should be emphasized that frequent consumption of sweetened beverages could be associated with poor metabolic control of T1D. The detrimental impact of a high glycaemic index diet on the atherogenic risk profile represents a significant finding in patients with T1D, given that atherosclerotic cardiovascular diseases constitute a leading cause of increased mortality within this population [20]. It was also observed, that fast foods and snacks tend to be consumed more frequently by patients with T1D than by participants with T2D, as these types of products are typically preferred by younger individuals. This study supports previous findings indicating that adherence to a healthy diet among young patients with T1D was insufficient [21, 22]. Previous data suggests that older patients posses a greater understanding of the consequences of the illness, as well as higher levels of acceptance regarding their disease and self-care regimen [23]. Crucial in this context is also the westernization of dietary habits in young generation [24]. Individuals with T2D are found to be less likely to drink energy beverages, which may be attributed to the frequent presence of comorbidities, such as hypertension, which prevent the consumption of these types of products [25]. It worth emphasizing that patients with T1D should also avoid energy beverages. The consumption of energy drink may impose a significant carbohydrate load on individuals with diabetes, necessitating adjustments in insulin dosage. Energy drinks also contain a number of other supplementary substances, e.g. taurine, glucuronolactone, guarana, ginseng and gingko bilboa, the exact physiologic consequences of which for patients with diabetes remain unclear. Ingestion of energy drinks was associated by Olateju et al. [26] with marked hyperglycaemia and acute pressor response in patients with type 1 diabetes. Overall, all patients with diabetes should avoid consuming energy drinks due to their clear correlation with metabolic syndrome. According to data from 3 prospective cohort studies involving 19,431 participants, a 20% greater risk of developing metabolic syndrome was observed among individuals with the highest level of energy drink intake compared to those with the lowest intake [27]. The caffeine in the drinks may lead to elevated blood pressure, which is a critical factor to be considered for those at risk of diabetes-related complications [26].

The results of HbA_{1c} measurements indicate that 85.9% of patients had elevated values, while only 14.1% had levels within the proper range. HbA_{1c} is considered a marker that reflects the average blood glucose level over the preceding 3 months, with approximately 50% of this value influenced by glucose levels during the most recent month [28]. The American Diabetes Association's current guidelines for HbA_{1c} levels in adults recommend a range of 6.5% – 7% [29], while the Polish Diabetes Association recommends values below 6.5% [28]. Elevated HbA_{1c} levels are linked to heightened mortality risk and an increased prevalence of diabetes-related complications, including cardiovascular disorders and microvascular conditions. Research shows that maintaining HbA_{1c} levels within the recommended limits is crucial to reduce these risks [30, 31].

In other studies, adherence to a balanced diet incorporating low-glycaemic-index foods has been associated with improved HbA_{1c} regulation. Younger patients with a higher frequency of processed or ready-to-eat foods consumption are anticipated to encounter greater difficulty in maintaining optimal HbA_{1c} levels [32, 33]. In the current study, higher consumption of animal fats was reported by patients with higher level of HbA_{1c}. Moreover, evidence suggests that both the intake of specific food items and the overall dietary composition may impact HbA_{1c} levels, potentially serving as determinants of dietary quality as assessed by the nHDI-14 index. As reported by Grahovac et al., greater adherence to the recommendations of the Mediterranean diet was observed among patients with HbA_{1c} levels of <7%, compared to those with levels of HbA_{1c} > 7%, suggesting a potential beneficial effect of this dietary pattern on glycaemic control. Adherence to these recommendations was also positively correlated with disease duration, and negatively correlated with body mass index [34]. A study by Benson et al. demonstrated that both the Mediterranean and DASH (Dietary Approaches to Stop Hypertension) diets were consistently associated with lower HbA_{1c} levels than other dietary patterns [35]. These findings highlight the significance of structured dietary interventions, particularly those emphasizing plant-based foods, healthy fats, and whole grains in enhancing glycaemic control in individuals with diabetes.

It must be emphasized that maintaining HbA_{1c} levels cannot be achieved solely through adherence to dietary requirements: regular physical activity is also required, as confirmed by the current study. Walking is considered a convenient, low-impact form of physical activity, and has been reported as the most commonly performed activity among individuals with diabetes. An accumulation of 10,000 steps per day has been demonstrated to effectively improve glucose tolerance and reduce blood pressure in overweight, inactive women at risk of T2D [36]. Messina et al. demonstrated that exercise combined with insulin therapy is also an effective way to maintain blood glucose levels within range in both obese and non-obese patients with diabetes [37]. It was shown by Charles et al. that patients with diabetes engaging in moderate to high levels of physical activity exhibited a 44% – 80% lower risk of all-cause mortality, compared to those with low physical activity [38].

Limitations of the study. The study has significant limitations. Due to the heterogeneity and unequal sample sizes of the groups of patients with T1D and T2D, it was not possible to draw definitive conclusions regarding the impact of diabetes type on dietary behaviours and HbA_{1c} levels. Future research should focus on conducting surveys within a more homogenous cohort, including individuals of similar age, which can influence patients' dietary choices. Future research, together with medical and dietary recommendations, should prioritize raising awareness about the nutritional value of the daily diet and its impact on diabetes management. Promising directions for future research should include an examination of emotional, social, and economic factors influencing dietary decisions among patients with diabetes. Additionally, multivariate correlation or regression analyses should be conducted, considering patients' lifestyle, age and BMI in relation to the frequency of selected food groups.

CONCLUSION

The findings of the study indicate that food frequency intake and diet quality may be influenced by the type of diabetes. Overall, women tend to exhibit healthier dietary habits compared to men. Physical activity combined with a healthy diet – characterized by the inclusion of whole grain products and limitation of animal fats – has been shown to reduce HbA_{1c} levels.

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REFERENCES

1. Petersmann A, Müller-Wieland D, Müller UA, et al. Definition, Classification and Diagnosis of Diabetes Mellitus. Exp Clin Endocrinol Diabetes. 2019;127:1–7. doi:10.1055/a-1018-9078
2. ElSayed NA, Aleppo G, Aroda VR, et al. 2. Classification and Diagnosis of Diabetes: Standards of Care in Diabetes—2023. Diabetes Care. 2023;46:19–40. doi:10.2337/dc23-S002
3. Roep BO, Thomaidou S, van Tienhoven R, et al. Type 1 diabetes mellitus as a disease of the β-cell (do not blame the immune system?). Nat Rev Endocrinol. 2021;17(3):150–61. doi:10.1038/s41574-020-00443-4
4. Marcus C, Danielsson P, Hagman E. Pediatric obesity—Long-term consequences and effect of weight loss. J Intern Med. 2022;292(6):870–91. doi:10.1111/joim.13547
5. Redondo MJ, Hagopian WA, Oram R, et al. The clinical consequences of heterogeneity within and between different diabetes types. Diabetologia. 2020;63(10):2040–8. doi:10.1007/s00125-020-05211-7
6. Evert AB, Dennison M, Gardner CD, et al. Nutrition Therapy for Adults With Diabetes or Prediabetes: A Consensus Report. Diabetes Care. 2019;42(5):731–54. doi:10.2337/dci19-0014
7. Araszkiewicz A, Borys S, Broncel M, et al. 2025 Guidelines on the management of patients with diabetes – a position of Diabetes Poland. Curr Topics Diabet. 2025;5:1–158. doi.org/10.5114/ctd/203685
8. The Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes (EASD), Aas AM, Axelsen M, Churuangsuk C, et al. Evidence-based European recommendations for the dietary management of diabetes. Diabetologia. 2023;66(6):965–85. doi:10.1007/s00125-023-05894-8
9. Cole JB, Florez JC. Genetics of diabetes mellitus and diabetes complications. Nat Rev Nephrol. 2020;16(7):377–90. doi:10.1038/s41581-020-0278-5
10. Geng T, Zhu K, Lu Q, et al. Healthy lifestyle behaviors, mediating biomarkers, and risk of microvascular complications among individuals with type 2 diabetes: A cohort study. PLoS Med. 2023;20:e1004135. doi:10.1371/journal.pmed.1004135
11. Jaworski M, Panczyk M, Cedro M, et al. Adherence to dietary recommendations in diabetes mellitus: disease acceptance as a potential mediator. Patient Prefer Adher. 2018;12:163–74. doi:10.2147/PPA.S147233
12. Kowalkowska J, Wadolowska L, Czarnocinska J, et al. Reproducibility of a Questionnaire for Dietary Habits, Lifestyle and Nutrition Knowledge Assessment (KomPAN) in Polish Adolescents and Adults. Nutrients 2018;10:1845. doi:10.3390/nu10121845
13. Kodama S, Horikawa C, Fujihara K, et al. Quantitative relationship between body weight gain in adulthood and incident type 2 diabetes: a meta- analysis. Obes Rev. 2014;15(3):202–14. doi:10.1111/obr.12129
14. Nagaya T, Yoshida H, Takahashi H, et al. Increases in body mass index, even within non-obese levels, raise the risk for Type 2 diabetes mellitus: a follow-up study in a Japanese population. Diabet Med. 2005;22(8):1107–11. doi:10.1111/j.1464-5491.2005.01602.x
15. Kaneto C, Toyokawa S, Miyoshi Y, et al. Long-term weight change in adulthood and incident diabetes mellitus: MY Health Up Study. Diabetes Res Clin Pract. 2013;102(2):138–46. doi:10.1016/j.diabres.2013.08.011.
16. Richardson Tg, Crouch DJM, Power GM, et al. Childhood body size directly increases type 1 diabetes risk based on a lifecourse Mendelian randomization approach. Nat Commun. 2022;13;2337. doi.org/10.1038/s41467-022-29932-y
17. Censin JC, Nowak Ch, Cooper N, et al. Childhood adiposity and risk of type 1 diabetes: Amendelian randomization study. PLoS Med. 2017;14(8):e1002362; doi.org/10.1371/journal.pmed.1002362
18. Hyppönen E, Virtanen SM, Kenward MG, et al. Childhood Diabetes in Finland Study Group. Obesity, increased linear growth, and risk of type 1 diabetes in children. Diabetes Care. 2000;23:1755–60. doi:10.2337/diacare.23.12.1755
19. Feraco A, Armani A, Amoah I, et al. Assessing gender differences in food preferences and physical activity: a population-based survey. Front Nutr. 2024;20:1348456. doi:10.3389/fnut.2024.1348456
20. Piłaciński S, Zozulińska-Ziółkiewicz DA. Influence of lifestyle on the course of type 1 diabetes mellitus. Arch Med Sci. 2014;24;10(1):124–34. doi:10.5114/aoms.2014.40739
21. AlBurno H, Mercken L, de Vries H, et al. Determinants of healthful eating and physical activity among adolescents and young adults with type 1 diabetes in Qatar: A qualitative study. PLoS One. 2022;6;17(7):e0270984. doi:10.1371/journal.pone.0270984
22. Micha R, Mozaffarian D. Trans fatty acids: effects on metabolic syndrome, heart disease and diabetes. Nat Rev Endocrinol. 2009;5(6):335–44. doi:10.1038/nrendo.2009.79
23. Wolpert HA, Anderson BJ. Young adults with diabetes: need for a new treatment paradigm. Diabetes Care. 2001;24(9):1513–4. doi:10.2337/diacare.24.9.1513.
24. Morinaka T, Wozniewicz M, Jeszka J, et al. Westernization of dietary patterns among young Japanese and Polish females – a comparison study. Ann Agric Environ Med. 2013;20(1):122–30. doi:10.1038/nrendo.2009.79
25. Bleich SN, Wang YC. Consumption of Sugar-Sweetened Beverages Among Adults With Type 2 Diabetes. Diabetes Care. 2011;34:551–5. doi:10.2337/dc10-1687
26. Olateju T, Begley J, Green DJ, et al. Physiological and Glycemic Responses Following Acute Ingestion of a Popular Functional Drink in Patients with Type 1 Diabetes. Can J Diabetes. 2015;39:78–82. doi:10.1016/j.jcjd.2014.07.220
27. Malik VS, Popkin BM, Bray GA, et al. Sugar-Sweetened Beverages and Risk of Metabolic Syndrome and Type 2 Diabetes. Diabetes Care. 2010;33:2477–83. doi:10.2337/dc10-1079
28. Araszkiewicz A, Bandurska-Stankiewicz E, Borys S, et al. 2023 Guidelines on the management of patients with diabetes – a position of Diabetes Poland. Curr Topics Diabet. 2023;3:1–133. doi:10.5114/ctd/160061
29. Katsarou A, Gudbjörnsdottir S, Rawshani A, et al. Type 1 diabetes mellitus. Nat Rev Dis Primers. 2017;3:17016. doi:10.1038/nrdp.2017.16
30. Critchley JA, Carey IM, Harris T et al. Variability in Glycated Haemaglobin and Risk of Poor Outcomes Among People With Type 2 Diabetes in a Large Primary Care Cohort Study. Diabetes Care. 2019;42:2237–46. doi:10.2337/dc19-0848
31. Bergenstal RM. Glycemic Variability and Diabetes Complications: Does It Matter? Simply Put, There Are Better Glycemic Markers!. Diabetes Care. 2015;38:1615–21. doi:10.2337/dc15-0099
32. Sugimoto T, Sakurai T, Uchida K, et al. Impact of Type 2 Diabetes and Glycated Haemaglobin Levels Within the Recommended Target Range on Mortality in Older Adults With Cognitive Impairment Receiving Care at a Memory Clinic: NCGG-STORIES. Diabetes Care. 2024;47:864–72. doi:10.2337/dc23-2324
33. Olesen KKW, Thrane PG, Hansen MK, et al. The impact of glycated haemaglobin A1c on cardiovascular risk in diabetes patients with and without coronary artery disease. Eur Heart J. 2023;44:ehad655.2546. doi:10.1056/NEJMoa0908359
34. Grahovac M, Kumric M, Vilovic M, et al. Adherence to Mediterranean diet and advanced glycation endproducts in patients with diabetes. World J Diabetes. 2021;12(11):1942–56. doi:10.4239/wjd.v12.i11.1942
35. Benson G, Hayes J. An Update on the Mediterranean, Vegetarian, and DASH Eating Patterns in People With Type 2 Diabetes. Diabetes Spectr. 2020;33:125–32. doi:10.2337/ds19-0073
36. Swartz AM, Strath SJ, Bassett DR, et al. Increasing daily walking improves glucose tolerance in overweight women. Prev Med. 2003;37(4):356–62. doi:10.1016/s0091-7435(03)00144-0
37. Messina G, Alioto A, Parisi MC, et al. Experimental study on physical exercise in diabetes: pathophysiology and therapeutic effects. Eur J Transl Myol. 2023;33(4):11560. doi:10.4081/ejtm.2023.11560
38. Charles D, Sabouret P, Moll A, et al. The relationship between mortality and daily number of steps in type 2 diabetes. Panminerva Med. 2023;65(3):335–42. doi:10.23736/S0031-0808.22.04732-2