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Dietary habits and adherence to dietary recommendations in patients with type 1 and type 2 diabetes compared with the general population in Denmark

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ABSTRACT

Objectives: The aim of the present study was to examine dietary habits and adherence to dietary recommendations in adult patients with type 1 diabetes (T1D) and type 2 diabetes (T2D) compared with the general population in Denmark.
Methods: The study was cross-sectional and included 426 patients with T1D and 348 patients with T2D recruited from an outpatient diabetes clinic in the capital region of Denmark. Dietary habits were assessed by a food frequency questionnaire and compared with dietary data from 2,899 participants without diabetes from the Danish National Survey of Dietary Habits and Physical Activity.
Results: Patients with diabetes had a 20-50% lower intake of added sugar and alcohol, and a 10-20% higher intake of fibre and vegetables compared with the general population ($p<0.001$ for all). Patients with T2D had a 37% lower intake of alcohol compared with T1D ($p<0.001$). Adherence to dietary recommendations (e.g. fibre, saturated fat, vegetables, fruit and fish) were low in all groups but lowest in the general population.
Conclusion: The Danish diet is too high in saturated fat and too low in dietary fibre, vegetable, fruit and fish compared to dietary recommendations in both patients with diabetes and the general population. However, our data demonstrate that patients with diabetes consume a healthier diet compared to the general population: Limiting the intake of added sugar and alcohol, and increasing the intake of vegetables and dietary fibre.

Introduction

Diet is a cornerstone in the management of type 1 diabetes (T1D) and type 2 diabetes (T2D) and dietary guidance aims to maintain and improve healthy eating habits to achieve optimal metabolic control. According to the Diabetes and Nutrition Study Group (DNSG) of the European Association for the Study of Diabetes [1], dietary guidelines for patients with T1D and T2D are very similar to the Nordic Nutrition Recommendations (NNR) [2], including the National Food-based Dietary Guidelines [3] targeted the general population. Dietary guidelines for management of T1D mainly focus on improving glycaemic control through matching of carbohydrate intake with insulin and to a limited degree on healthy eating habits [1,4]. In contrast, guidelines for T2D focus on weight reduction or maintenance through energy restriction and healthy eating habits to improve glycaemic control and reduce cardiovascular disease (CVD) [1,4]. In Denmark, patients with diabetes are offered free-of-charge access to dietary counseling with a

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dietitian. However, it is unknown whether this individualized approach in diabetes is reflected by a higher dietary adherence to the recommendations. The latest national survey of dietary habits in Denmark (2011–2013) concluded that the Danish diet was too high in fat and carbohydrates (added sugar) and too low in dietary fiber compared with the dietary guidelines [5]. Only a few studies have investigated dietary intake and adherence to the recommendations in patients with diabetes [6–11], in general reporting poor adherence for most macronutrients. Dietary studies comparing patients with diabetes with the general population have not previously been reported to our knowledge. Thus, the aim of this study was to investigate dietary habits and adherence to dietary recommendations in patients with T1D and T2D as compared with the general population in Denmark.

Participants and methods

Design and participants

The dietary survey among patients with T1D and T2D was a cross-sectional design based on a web-based questionnaire with information concerning the patients' habitual diet, physical activity, and socioeconomic status. Data were collected from July 2014 to January 2015. A random sample of 3000 adults (>18 yrs. of age) with diabetes (1500 with T1D and 1500 with T2D) followed in the outpatient clinic at Steno Diabetes Center in Copenhagen were assessed for eligibility. Patients with diabetes-related complications that could influence dietary intake (e.g., gastropareses, celiac disease and kidney disease) were included; however, the number was small (5%). Exclusion criteria included presence of mental or life-threatening disorders. A total of 774 patients (426 with T1D, 348 with T2D) participating in the study (Fig. 1). Patients received a written invitation with information regarding the questionnaire, including a personal token and a hyperlink to a website containing the study questionnaire. The online survey tool, Lime Survey (San Francisco, CA, USA), was connected to a server at the National Food Institute (Technical University of Denmark). Clinical data were extracted from the patients' electronic medical record. Patients were informed that completing the web-based questionnaire was regarded as consent to participate in the study according to Danish regulations for biomedical research. The dietary survey was approved by the local ethics committee and the Danish Data Protection Agency. Data from the cross-sectional study were compared with data from the Danish National Survey of Dietary Habits and Physical Activity in 2011 to 2013 (DANSDA) [5] performed by the National Food Institute and based on a random sample of 2899 adults from the general population with no known history of diabetes.

Dietary assessment

Dietary intake of total energy, energy-contributing macronutrients, and foods in patients with diabetes was assessed using a web-based semiquantitative food frequency questionnaire (FFQ), whereas dietary intake in the general population based on DANSDA data was assessed using a precoded food diary. In collaboration with the National Food Institute, we previously performed a study of the relative validity of the FFQ in patients with diabetes against the food diary used in DANSDA [12]. The FFQ covers intake in the previous 3 mo and consists of 270 food items and mixed dishes. Portion sizes were estimated using the same household measures and series of photographs that participants could select according to their habitual dietary intake similar to the food diary in DANSDA [5]. Mean intake of foods and nutrients recorded in the FFQ and the food diaries were calculated using the same General Intake Estimate System (Mmapùrkhmapùj, Denmark) to examine adherence to DNSG recommendations for patients with diabetes and NNR recommendations for the general population. DNSG [1] and NNR [2] use similar targets for recommended intake of carbohydrates (45–60 percentage of energy [E%]), added sugar (<10 E%),

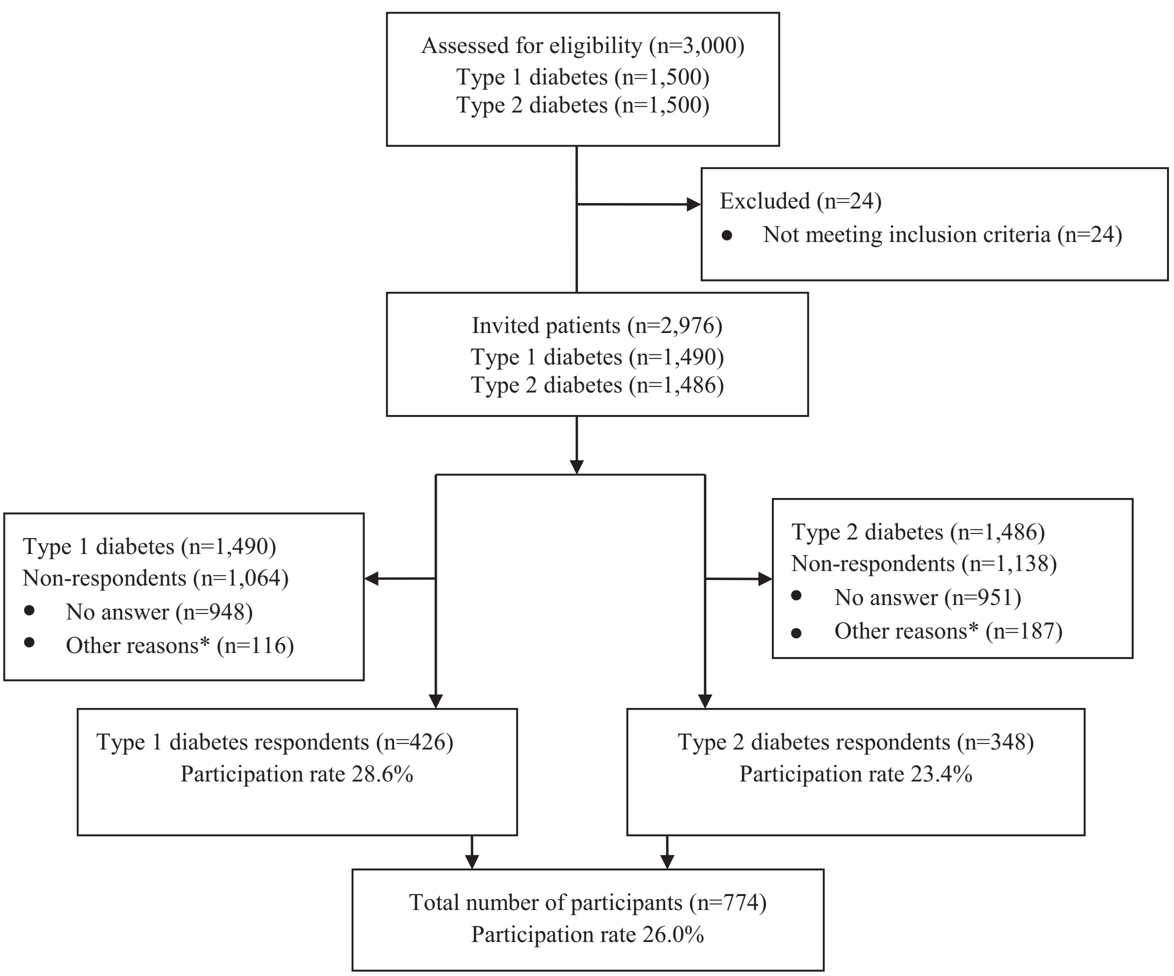

Fig. 1. Flowchart of the diabetes study population. *Other reasons include undelivered mail returned, died, refused to participate, and did not complete the questionnaire.

protein (10–20 E%), saturated fatty acids (SFAs; <10 E%), monounsaturated fatty acids (MUFAs; 10–20 E%), polyunsaturated fatty acids (PUFAs; 5–10 E%), alcohol (women, <10 g/d and men, <20 g/d), vegetables (≥300 g/d), and fish (350 g/wk) [1–3]. DNSG guidelines recommend five daily servings of fruit and vegetables and four weekly servings of legumes [1], interpreted as 250 g fruit and 300 g vegetables (including legume recommendations), because the National Food Institute includes legumes in the calculation of total vegetable intake. DNSG and NNR have different targets for fruit: >250 g/d (DNSG) and ≥300 g/d (NNR), total fat: 25 to 35 E% (DNSG) and 25 to 40 E% (NNR), and dietary fiber: >40 g/d (or 20 g /1000 kcal/d; DNSG) and ≥25 g/d for women and ≥35 g/d for men (NNR) or 3 g/MJ/d (NNR).

Assessment of the prevalence of misreporting of dietary energy intake was performed using the European Food Safety Authority recommendations for dietary surveys [13]. Estimated basal metabolic rate (BMR_{est}) was calculated using equations by Schofield et al. [14] based on sex, age, height, and weight. The ratio of self-reported energy intake (EI_{rep}) to BMR_{est} was used to identify possible under and overreporting using the Goldberg cutoff method according to age-specific physical activity level with three categories (low, moderate, and high) [15,16]. Median EI_{rep}:BMR_{est} was 1.186 (interquartile range [IQR], 0.922–1.461) in T1D and 0.900 (IQR, 0.698–1.710) in T2D with a proportion of potential underreporters of 34% (T1D) vs 42% (T2D), compared with 12% in the general population. Proportion of potential overreporters was low (~1–2%). A high proportion of the underreporters were overweight or obese (~50–90% had a body mass index [BMI] >25 kg/m^2 and ~20–60% had a BMI >30 kg/m^2).

Other variables

Data on socioeconomic status included occupational status (employed, unemployed, pensioner, other) and level of education divided into the following categories:

- long further education (5 y in a university);
- medium further education (2–4 yrs. in a university [college]);
- short further education (1–2 yrs. in a university college);
- vocational education (e.g., skilled worker);
- no further education; and
- unspecified.

Questions and classification of level of education are according to Statistics Denmark (www.dst.dk/en). The Danish version of the International Physical Activity Questionnaire short form (IPAQ-SF) was used to collect data concerning the level of physical activity for the previous 7 d. Data from the IPAQ-SF were converted to *Metabolic Equivalent of Task* (MET) min/wk, and further categorised into low, moderate, or high level of physical activity according to the IPAQ standard definitions (www.ipaq.ki.se). Clinical data including age, sex, type of diabetes, diabetes duration, height and weight, smoking habits, glycated haemoglobin (HbA1c), levels of total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, use of insulin pump, visits with a dietitian, and participation in a weight reduction program were extracted from the patients' electronic medical record.

Background data from the general population

Data from DANSDA was included to compare and adjust the statistical analyses. Data concerning smoking habits, and level of education were collected from personal interviews. BMI was calculated from weight and height, and physical activity was assessed by a 7-d use of pedometer adjusted for biking time and categorized into three physical activity level groups: low <7500 daily steps, moderate 7500 to 9999 daily steps, and high ≥10 00 daily steps.

Statistical analyses

Analyses included standard descriptive statistics. All data were non-normally distributed and therefore presented as medians with IQR. Group differences were tested using Mann–Whitney U test or Kruskal–Wallis one-way analysis of variance as appropriate. Categorical data were compared by using the χ^2 test for differences in proportions. Because of the wide age range (18–75 yrs.), we tested for age effect but did not find any major effects on dietary intake. Despite this, we included age in the multiple linear regression analysis. Percentage differences in dietary energy intake (with 95% confidence interval [CI]) deriving from carbohydrates, added sugar, total fat, SFA, MUFA, PUFA, and protein in patients with T1D and T2D compared with the general population were tested using multiple linear regression analysis adjusted for age, sex, BMI, physical activity level, and education level. Similarly, percentage differences in g/d of dietary fiber, vegetables, fruit, fish, and alcohol were tested using multiple linear regression analysis adjusted for the same variables as first mentioned in addition to total energy intake. Variables were logarithmically transformed for statistical analyses and back transformed to natural units for presentation in the text and forest plot figures. For all statistical tests, a two-sided significance level of $P < 0.05$ was used. All statistical analyses were performed with SPSS version 22.0 (IBM Corp, Armonk, NY, USA).

Results

Overall participation rate was 26% (T1D 29% and T2D 23%; Fig. 1). The study participants were generally healthier than non-responders (Table 1). As shown in Table 2, patients with T2D were older and heavier than those with T1D and the general population.

Table 1
Characteristics of participants and non-responders

Characteristics	T1D (n = 1490)			T2D (n = 1486)		
	Participants (n = 426)	Non-respondents (n = 1064)	*P*-value*	Participants (n = 348)	Non-respondents (n = 1138)	*P*-value*
Sex (F/M), % (n)	49/51 (209/217)	44/57 (463/601)	0.052	29/71 (101/247)	40/60 (455/683)	<0.001
Age, y	53 (41–64)	48 (34–61)	<0.001	66 (58–71)	68 (58–75)	0.001
BMI, kg/m^2	24.9 (22.6–27.6)	25.1 (22.7–28.2)	0.164	29.2 (26.5–33.3)	30 (26.7–34.4)	0.040
Height, m	1.74 (1.67–1.80)	1.74 (1.67–1.82)	0.430	1.74 (1.68–1.81)	1.72 (1.63–1.79)	<0.001
Weight, kg	75.5 (66.8–84.6)	78 (66.3–88.2)	0.105	90.5 (78.5–102.8)	88.9 (76.8–102.3)	0.365
Insulin pump, % (n)	29 (122)	21 (222)	0.001	0 (0)	0 (0)	-
Duration of diabetes, y	26 (14–39)	20 (12–33)	<0.001	15 (9–21)	16 (9–22)	0.312
Smokers, % (n)	14 (58)	24 (250)	<0.001	11 (39)	18 (207)	0.002
HbA1c, mmol/mol	58 (52–65)	62 (55-–71)	<0.001	57 (51–66)	59 (51–70)	0.036
TC, mmol/L	4.50 (4.00–5.10)	4.60 (4.00–5.20)	0.044	4.0 (3.50-–4.70)	4.1 (3.50–4.80)	0.456
HDL-C, mmol/L	1.55 (1.31–1.94)	1.45 (1.19–1.80)	0.000	1.07 (0.89–1.30)	1.06 (0.88–1.30)	0.482
LDL-C, mmol/L	2.50 (2.00–2.90)	2.50 (2.08–3.10)	0.037	2.00 (1.50–2.40)	2.00 (1.50–2.60)	0.311
Systolic blood pressure, mm Hg	128 (120–136)	127 (118-–136)	0.077	130 (122–139)	130 (119–139)	0.118
Diastolic blood pressure, mm Hg	76 (70–82)	76 (70–82)	0.995	77 (70–82)	76 (69–82)	0.024
Dietitian visits within previous year, % (n),						
None	71 (304)	76 (804)	0.093	68 (238)	71 (813)	0.274
1–2	22 (93)	18 (193)	0.102	19 (65)	17 (191)	0.413
≥3	7 (29)	6 (67)	0.717	13 (45)	12 (134)	0.562
Weight reduction initiated with dietitian within the previous year, % (n)	32 (39)	27 (71)	0.348	58 (64)	62 (203)	0.426

BMI, body mass index; HbA1c, glycated hemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol, T1D, type 1 diabetes; T2D, type 2 diabetes; TC, total cholesterol.
Data are medians (IQR: 25th–75th percentile) or proportion (numbers).
*Mann–Whitney U test or χ^2 test for differences between participants and non-responders with T1D and T2D.

Table 2
Background characteristics

Characteristics	Patients with T1D (n = 426)	Patients with T2D (n = 348)	General population (n = 2899)
Sex (F/M), % (n)	49/51 (209/217)	29/71 (101/247)	52/48 (1507/1392)
Age, y	53 (41–64)	66 (58–71)	48 (35–60)
BMI, kg/m^2	25 (22.7–27.6)	29.2 (26.5–33.3)	25.6 (23.1–28.6)
Smokers, %	13.6	11.2	20.8
Physical activity level			
Low, % (n)	18.3 (77)	39.4 (136)	32.9 (895)
Moderate, % (n)	42.9 (180)	36.5 (126)	25.2 (684)
High, % (n)	38.8 (163)	24.1 (83)	41.9 (1141)
Education level			
No further education, % (n)	13.1 (56)	11.2 (39)	22.5 (652)
Vocational education*, % (n)	20 (85)	26.4 (92)	38 (1101)
Short further education (1–2 y), % (n)	12.3 (52)	7.2 (25)	7.4 (213)
Medium further education (2–4 y), % (n)	26.7 (114)	26.2 (91)	20.3 (589)
Long further education (5 y), % (n)	23.9 (102)	15.2 (53)	11.8 (342)
Unspecified education, % (n)	4.0 (17)	13.8 (48)	0 (0)

BMI, body mass index;T1D, type 1 diabetes; T2D, type 2 diabetes.
Data are medians (IQR: 25th–75th percentile) or proportion (numbers).
*Skilled worker, office worker, crafts education.

Compared with the general population, patients with diabetes were better educated, with fewer smokers (Table 2) and more users of dietary supplementation (see Table 1 in [17]). The median daily energy intake was lower in patients with diabetes (Table 3), and even after adjustments for age, sex, BMI, physical activity and education level remained lower in T1D (−9.9%; 95% CI, −11.2 to −8.6; $P < 0.001$) and T2D (−12.3%; 95% CI, −13.8 to −10.8; $P < 0.001$) compared with the general population (data not shown). The proportion of patients with diabetes and of the general population achieving the recommended intakes was high for MUFAs, PUFAs, and protein (80–100%; Fig. 2) but low for dietary fiber, SFAs, fruit, and fish (<25%; Fig. 2). All groups had higher than recommended intake of SFA (~13 E% in patients with diabetes vs 15 E% in the general population), whereas the median intake of total fat was identical in all groups (~37–38 E%; Table 3). Using the DNSG recommendation for total fat intake (<35 E%), the adherence in patients with diabetes was low compared with the general population (NNR recommendation <40 E%; Fig. 2). Median intake of carbohydrates was ~45 E% and in the lower end of the recommended 45 to 60 E% (Fig. 2). More patients with diabetes than in the general population were close to fulfilling the recommendations for reducing the intake of added sugar (97% vs 67%; Fig. 2). Although low (Fig. 2), the median intakes of dietary fiber adjusted for total energy was higher in patients with diabetes than in the general population (29–31 versus 23 g/10 MJ; Table 3). Patients with diabetes had the highest adherence to intake of vegetables (T1D 44% and T2D 36% vs 15% of the general population Fig. 2), and when adjusted for total energy, median intake of vegetables was above the recommended lower limit of 300 g/d in T1D (346 g/10 MJ), compared with 290 g/10 MJ in T2D and 189 g/10 MJ in the general population (Table 3). After adjustment for age, sex, BMI, energy intake, physical activity, and education a 20% higher intake of vegetables was seen in patients with diabetes compared with the general population ($P < 0.001$' Fig. 3). Participants with diabetes demonstrated a 30% lower intake of added sugar and 20% to 50% lower intake of alcohol than the general population ($P <$ 0.001 for all; Fig. 3). Patients with T2D had a 37% lower intake of alcohol as compared with patients with T1D ($P < 0.001$).

Table 3
Intake of energy, nutrients and healthy foods

Dietary intake	DNSG targets*	NNR targets†	T1D (n = 426)	T2D (n = 348)	General population (n = 2899)
Energy, MJ/d			7.9 (6.2–9.6)	7.4 (5.9–9.4)	9.4 (7.7–11.4)
Carbohydrates, E%	45–60	45–60	45.2 (41.3–49.3)	46.1 (41.2–50)	45.9 (42.2–49.7)
Added sugar, E%	<10	<10	3.3 (1.9–5)	3.2 (1.9–5.1)	7.8 (5.1–11.3)
Fiber, g/d,					
Men	>40	>35	22.8 (16.8–31.8)	21.5 (15.9–28.9)	21.5 (17.1–26.5)
Women	>40	>25			
Fiber, g/10 MJ			30.6 (24.7–37)	29.0 (23.5–35.9)	22.7 (18.8–27.5)
Fat, E%	25–35	25–40	37.6 (34.1–41.8)	36.6 (32.9–40.1)	37.8 (34.2–41.4)
SFA, E%	<10	<10	13.1 (11.4–14.9)	13.4 (11.4–5.2)	14.9 (13.1–16.9)
MUFA, E%	10–20	10–20	14.7 (12.8–17)	13.9 (12–15.9)	13.9 (12.4–15.6)
PUFA, E%	≤10	5–10	6.8 (5.8–8)	6.5 (5.5–7.4)	5.7 (5.2–6.4)
Proteins, E%	10–20	10–20	16.9 (15.7–18.7)	17.3 (15.8–19.2)	16.0 (14.4–17.9)
Alcohol, g/d,					
Men	<20	<20	9.3 (2.7–19)	6.1 (2.1–16.3)	14.7 (3. –29.7)
Women	<10	<10	5.5 (1.7–12.9)	1.6 (0.1–5.3)	7.2 (1–17.4)
Vegetables, g/d	≥300	≥300	268 (169–413)	218 (139–368)	178 (122–254)
Vegetables, g/10 MJ			346 (225–540)	290 (196–447)	189 (126–270)
Fruit, g/d	≥250	≥300	102 (52–207)	103 (58–202)	161 (80–265)
Fruit, g/10 MJ			135 (72–232)	141 (74–255)	172 (84–287)
Fish, g/d	≥350	≥350	196 (105-308)	210 (119–315)	196 (70–371)

DNSG, Diabetes and Nutrition Study Group; E%, percentage of energy; MUFA, monounsaturated fatty acid; NNR, Nordic Nutrition Recommendations including Food-based Dietary Guidelines; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid;T1D, type 1 diabetes; T2D, type 2 diabetes.
Data are medians (IQR: 25th–75th percentile).
*The European dietary recommendations in diabetes according to DNSG.
†NNR for the general population in the Nordic countries including the Food-based Dietary Guidelines.

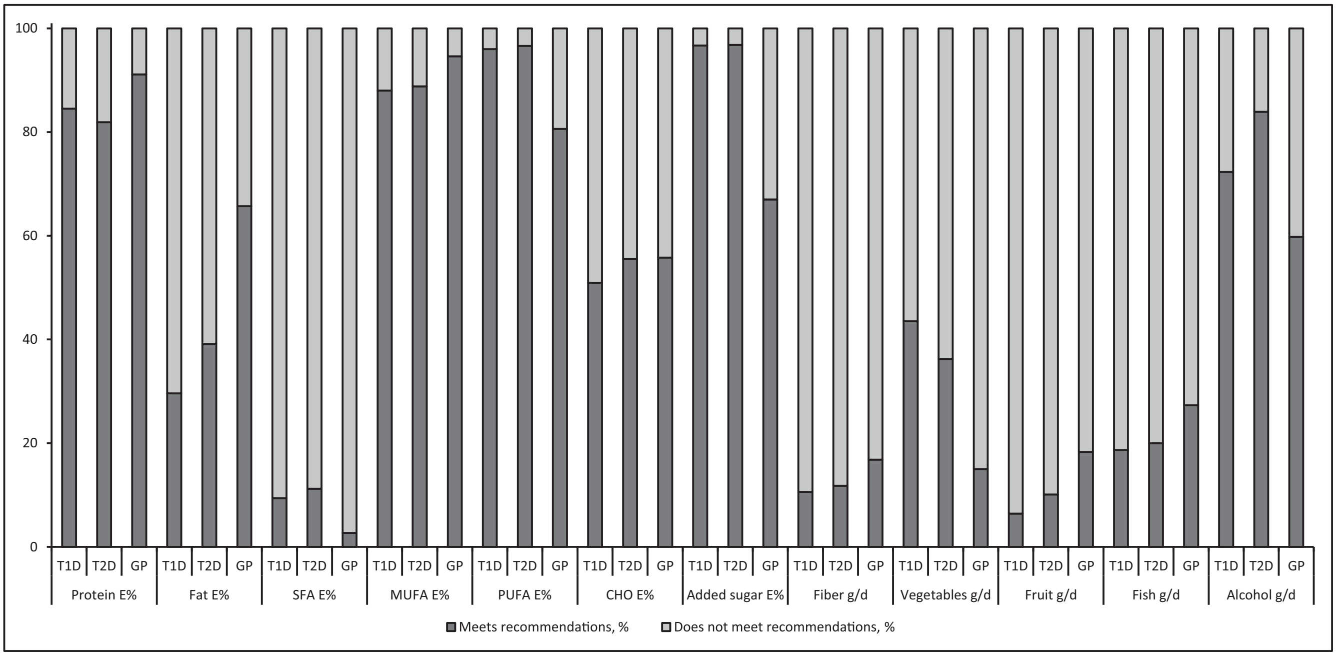

Fig. 2. Percentages of patients with type 1 and type 2 diabetes and of the general population meeting the dietary recommendations. NNR recommendations for the general population: 10–20 E% protein, 25–40 E% fat, <10 E% SFA, 10–20 E% MUFA, 5–10 E% PUFA, 45–60 E% CHO, <10 E% added sugar, ≥25 g/d dietary fiber for women and ≥35 g/d fiber for men, ≥300 g/d vegetables, ≥300 g/d fruit, ≥350 g/wk fish, <10 g/d alcohol for women and <20 g/d alcohol for men. DNSG recommendations in diabetes: 10–20 E% protein, 25–35 E% fat, <10 E% SFA, 10–20 E% MUFA, ≤10 E% PUFA, 45–60 E% CHO, <10 E% added sugar, ≥40 g/d dietary fiber, ≥300 g/d vegetables, ≥250 g/d fruit, ≥ 350 g/wk fish, <10 g/d alcohol for women and <20 g/d alcohol for men. CHO, carbohydrate; DNSG, Diabetes and Nutrition Study Group; E%, percentage of energy; GP, general population; MUFA, monounsaturated fatty acid; NNR, Nordic Nutrition Recommendations including Food-based Dietary Guidelines; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid; T1D, type 1 diabetes; T2D, type 2 diabetes.

Discussion

Results from the present study demonstrated that overall dietary adherence to recommendations, for example, to limit intake of added sugar and alcohol and increase intake of vegetables and dietary fiber, was significantly higher in patients with T1D and T2D than in the general population, even after adjusting for possible confounders (sex, age, physical activity, and education). Only two smaller studies (n <200 participants) have previously investigated patients with T1D and T2D [8,9] and found low adherence to all dietary recommendations except for protein intake. Although dietary recommendations are evidence based, the current strength of evidence does not support one ideal distribution of macronutrients in a diet that applies to all patients with T1D or T2D [4]. For carbohydrates, the ideal dietary intake to achieve good glycemic control in T1D or to obtain and maintain a weight loss in T2D is still under debate [18].

There is consensus to reduce intake of SFA and increase intake of dietary fiber, particularly from whole grain cereals, associated with lower CVD-specific and all-cause mortality in patients with diabetes, whereas only modest effects on glycaemic control have been found with intakes >50 g/d of fiber [4,19]. In the present study, <10% of the patients with diabetes fulfilled the DNSG recommendations of 40 g/d of fiber. Perhaps the recommended dietary fiber intake is unrealistic for the majority, which may be why the North American dietary guidelines recommend that patients with diabetes should consume at least the amount of dietary fiber and whole grain as recommended for the general population, corresponding to the NNR [2,4]. When adjusted for total energy intake, intake of dietary fiber and vegetables was found to be significantly higher in patients with diabetes. Since consumption of fiber-rich vegetables, fruits, legumes, and whole grain cereals are part of the dietary recommendations in most patients with diabetes, this higher intake may reflect a greater awareness on eating a high-fiber diet. Less than 10% of patients with diabetes and of the general population met the recommendations for intake of SFA, reflecting a general problem of abundance of SFA in the Western diet. The present findings are in accordance with those from several observational studies in which intake of total fat and saturated fat exceeded recommendations; whereas the opposite is true for intake of fiber in patients with diabetes [6,7,10,11].

The strengths of the present study were the large sample size, the standardized and validated method for dietary data collection, and the examination of possible differences in dietary habits between patients with diabetes and the general population. Another strength was the online survey for data collection because it presented a minimal burden and maximal flexibility for the respondents and potentially reduced underreporting of alcohol consumption, for example, which for many are sensitive topics in interviewer-administered surveys. A weakness is the low rate of participation (26%) and the possible biases this may have resulted in since patients with healthier eating habits tend to be more prone to participate in comparable nutritional studies. Low participation rates have been reported for comparable surveys in contrast to surveys that involve a more personalized recruitment and data collection [20,21]. However, overall participation rates have declined in epidemiologic studies in Denmark over the past 50 y: from ~85% (late 1970s) to ~45% (2006) [22]. Quantifying differences in dietary intake based on dietary data from two different dietary assessment methods is another study limitation, and another bias when interpreting these results is the effect of possible non-response bias because respondents with diabetes had a higher education level than respondents from the general population. Only 12% in the general population had a long further education compared with 15% to 24% of the individuals with diabetes. Reflecting this, population-based studies of diabetes and obesity face selective and markedly lower participation among the lowest social classes, the

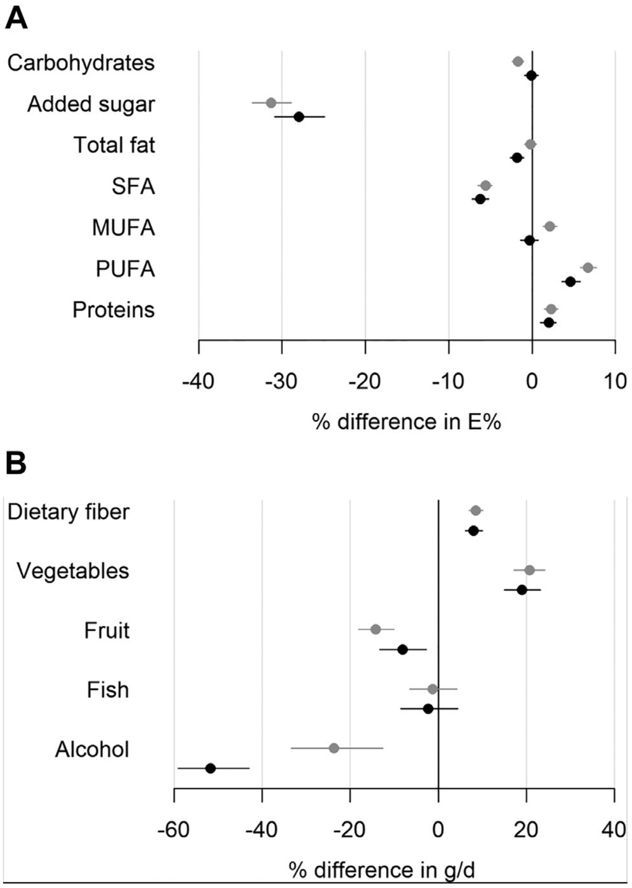

Fig. 3. (A) shows the percent differences in energy intake (with 95% CI) for patients with T1D (gray lines) and T2D (black lines) compared with the general population, adjusted for age, sex, BMI, physical activity, and level of education and (B) shows the percent difference in g/d (with 95% CI) for patients with T1D (gray lines) and T2D (black lines) compared with the general population, adjusted for age, sex, BMI, physical activity, level of education, and energy intake. BMI, body mass index; CI, confidence interval; E%, percentage of total energy; SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid.

most obese, the most inactive, ethnic minorities, and those with unfavorable risk profiles [23–26]. However, we tried to reduce the risk of selection bias and increase the participation rate by offering participants with difficulties in completing the online survey the opportunity to be interviewed by the study recruiter via telephone or face to face.

In the present analysis, after adjusting for several potential confounders including level of education, physical activity, and BMI, we still found significant differences in dietary intake of >20% between patients with diabetes and the general population, thus suggesting an independent difference.

All data in the dietary survey of patients with diabetes are self-reported except for the clinical data, making the assessment of dietary intake and physical activity subject to errors. The FFQ is a retrospective method for assessment of dietary intake where biases caused by errors in memory and perception of portion sizes of food are main issues, thus to reduce the risk of memory bias, the present FFQ was only based on the previous 3 mo, an HbA1c period. The FFQ used in the present study also included photos with the option of choosing habitual portion sizes instead of using predefined standard portion sizes as done in most FFQs, and we have previously performed a validation of our FFQ against the food diary used in DANSDA and found good alignment between the two dietary assessments methods [12]. The present FFQ and the food diary used in DANSDA are based on the same principles using the same software system at the National Food Institute. However, some of the observed differences in intake of healthy foods and macronutrients may be explained by the different assessment methods for dietary data collection and differences in underreporting in our dietary study among patients with diabetes compared with participants in DANSDA. Consequently, we only presented and discussed differences in dietary intake >10%, in the multiple regression analysis. Patients with diabetes had a 10% to 12% lower energy intake than the general population and underreporting of energy intake is a well-known problem in self-reported dietary assessment studies. Underreporting has been found in other nutritional epidemiologic studies including patients with T2D [7,27] and a Danish population [28] and is associated with both the past and current high BMI [28,29]. The fact that most patients with diabetes acknowledge the importance of healthy eating, foods less accepted, especially in diabetes (e.g., added sugar), may have been underreported to a greater degree in the present diabetes populations. Underreporting may also be due to dieting attempts resulting in a negative energy balance. We found that ≤21% of the potential underreporters in the present study were in a calorie-restricted program assessed by a dietitian during the study period. Previous studies have reported that dieting is an important contributor to systematic bias [15]; however, we did not exclude low-energy reporters in the present analyses as others have done [11]. Data suggest that calculated BMR may be overestimated by the Schofield equations only in the most obese (BMI >35 kg/m^2) and that even when adjusting for BMR, this may not transfer the group into the category of acceptable/plausible reporters [15]. The higher proportion of underreporters in the present diabetes population compared with that found in DANSDA, where physical activity was measured by pedometer, may also have been due to overreporting of physical activity level in the study. A systematic review found that physical activity is generally overestimated using International Physical Activity Questionnaire short form compared with objective measurements [30].

Conclusion

Results from the present study demonstrated that Danish patients with T1D and T2D consumed significantly less added sugar and alcohol and significantly more vegetables and dietary fiber than the general population in Denmark. These findings support the hypothesis that dietary guidance by dietitians may lead to greater adherence to dietary recommendations in patients with diabetes. Still, the diet of Danish patients with diabetes contains too much saturated fat and too little dietary fiber, vegetables, fruit, and fish compared to the dietary recommendations as the diet of the general Danish adult population. Dietary education in patients with diabetes needs a greater focus on strategies to improve the overall quality of the diet and thereby meet the current dietary recommendations for the management of diabetes and overall metabolic control.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2018.10.021.

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