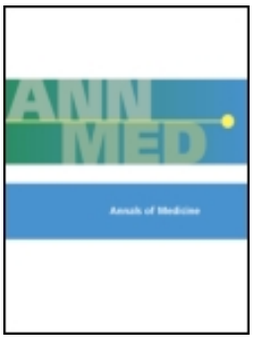

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ORIGINAL ARTICLE

Energy and nutrient intakes and adherence to dietary guidelines among Finnish adults with type 1 diabetes

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Abstract

Background. Patients with type 1 diabetes are instructed to eat a healthy, balanced diet. Implementation of diet is an under-studied phenomenon. We aimed to describe the nutrient intake of a large sample of adult Finnish patients with type 1 diabetes and assess whether they meet the recommendations.

Methods. Cross-sectional data from a total of 817 patients are presented. Data on food intake were collected with a 3-day food record completed twice with a 2–3-month interval. Compliance with dietary guidance was self-reported.

Results. Patients frequently reported a diet low in carbohydrates and fibre but high in fat. Only 28% restricted saturated fatty acid to less than 10% of their daily energy intake. One-fourth of the patients reported higher than recommended sucrose intake. Salt recommendations were frequently exceeded. Of the micronutrients, the recommendations for vitamin A, vitamin D, folate, and iron were most frequently unmet. Although self-reported compliance was associated with a higher frequency of meeting the recommendations for some of the macronutrients, the actual frequencies were modest. In general, those compliant were observed to consume more vitamin and mineral-dense food.

Conclusion. Dietary intake among patients with type 1 diabetes does not, for many nutrients, meet the recommendations.

Key words: *Adherence to dietary guidelines, dietary intake, type 1 diabetes*

Introduction

Type 1 diabetes is a chronic autoimmune disease that requires lifelong insulin treatment for survival. Together with insulin, diet is an essential component of the daily management of the disease. Indeed, one of the major goals of nutritional therapy is to optimize patients' metabolic control in order to reduce the risk of acute and long-term complications (1). Successful treatment necessitates actions to balance food intake, exercise, and insulin administration, and the patient's attending physician, diabetes nurse, and dietician play major parts in the education of the patient to favour healthy, attainable, and sustainable choices.

Currently, patients with diabetes are recommended to eat a healthy, balanced diet that addresses individual needs but also takes into account personal and cultural preferences (1–3). As is the case for the general population (4,5), the diet should provide sufficient amounts of energy, essential nutrients, and fibre. This can be achieved by a generous intake of whole-grain products, fruits, and vegetables as well as the avoidance of excess salt and refined sugar. The consumption of saturated and trans fatty acids should be limited and partially substituted with unsaturated long-chain fatty acids, and when dairy products are used, low-fat products should be preferred. Furthermore, alcohol should

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Key messages

- The dietary intake among patients with type 1 diabetes does not, for many nutrients, meet the recommendations.
- In specific, patients with type 1 diabetes should pay more attention to sufficient intake of carbohydrates and fibre, and avoid excess intake of total fat, saturated fatty acids, and salt.

Abbreviations

BMI	body mass index
E%	percentage of total energy intake
SES	socio-economic status

only be consumed in moderation. A well balanced diet provides all the nutrients the patient needs, and there is no need for nutritional supplements nor herbal preparations. The dietary guidelines for patients with diabetes are fairly consistent with the general guidelines. In Finland, the dietary guidelines for patients with diabetes comply with the American (1) and the European (3) guidelines.

Information regarding patients' food and nutrient intake is needed for effective dietary counselling. Indeed, in clinical practice, patients are provided with guidance, but there are only limited data regarding the actual diet and adherence to dietary recommendations. The most detailed evidence to date regarding nutrient intake among patients with type 1 diabetes was obtained from the EURODIAB Complications Study, conducted more than two decades ago. Amongst other findings, the study indicated that total fat intake frequently exceeded while that of carbohydrates was below the recommendations (6). In a more recent study, adults with type 1 diabetes were observed to exceed the recommendations for fat and saturated fat (7). Furthermore, a small study in Spanish patients with type 1 diabetes revealed that dietary adherence was low except for protein intake (8).

An important and not adequately addressed question regarding dietary counselling is how patients' perceptions about their compliance are related to the actual compliance. Indeed, changing any fallacious dietary habits will hardly take place if patients mistakenly presume they are complying with recommendations.

Our aim was to examine the energy and nutrient intake of adult Finnish patients with type 1 diabetes and to study whether the intakes reflect the current dietary recommendations. Furthermore, we assessed whether self-reported compliance was associated with measured compliance with dietary recommendations.

Patients and methods

Cross-sectional data from the patients participating in the Finnish Diabetic Nephropathy Study are presented. Since the study started in 1997, data from more than 4,800 patients with type 1 diabetes, irrespective of their nephropathy status, have been collected. The collection of the data on food intake started in October 2007. The present analyses include the data from the patients providing food diaries by December 2009. Type 1 diabetes was defined as onset of diabetes before the age of 35 years, and permanent insulin treatment initiated within 1 year of diagnosis. The study protocol was approved by the Ethics Committee of Helsinki University Central Hospital, and a written informed consent was obtained prior to participation.

The patients filled in a diet questionnaire that aimed to capture their habitual dietary intake. With regard to the types of food-stuffs consumed, the questionnaire conformed to the ones previously used in nutritional studies among the general population in Finland. Thus, questions such as the type of milk products, spreads, and breads consumed, and the consumption frequency of fish, vegetables, and soft drinks were included. The questionnaire was modified to include type 1 diabetes-specific items, such as questions regarding self-reported compliance with dietary guidance. The patients reported whether they followed the given guidance always, most of the time, sometimes, seldom, or never. Those following the guidance always or most of the time were considered compliant, and the remaining patients non-compliant.

Patients who returned the diet questionnaire were subsequently allocated a 3-day record (two weekdays and a weekend day). In this record, data on food consumption, physical activity, insulin preparation, insulin dose, and blood glucose concentrations were reported. The 3-day recording was repeated with a 2–3-month interval. Up to two reminders were sent to the non-responders.

Provided with detailed instructions on how to fill in the record, the patients recorded the type, the amount, and the point of time of all foods and drinks consumed. Patients estimated portion sizes using household measures and information on food labels. The continuation of habitual practices during the recording days was emphasized. Patients were also advised to report the type, the amount, and the time of the administration of the prandial insulin. Moreover, patients were asked to measure and report their blood glucose concentrations using their personal

blood glucose monitoring equipment. Finally, information on the type, intensity, duration, and the timing of physical activity was reported on the same sheet. At arrival, the records were checked for completeness and in case of ambiguous recording patients were contacted for clarification. Data from the diet questionnaires (e.g. fat-free milk) were also used to double-check vague entries in the records (e.g. milk), as applicable.

In this paper, data on nutritional intake are reported. The mean energy and nutrient contents of the recorded days were calculated using the Diet32 software (version 1.4.6.2, AIVO, Turku, Finland) that is based on the Finnish National Food Composition Database (Fineli) (9). Joules are presented as the unit of energy intake (1 kJ = 4.19 kcal). The intakes were compared with the dietary recommendations for patients with diabetes established by the Finnish Diabetes Association (2). As these guidelines did not include vitamins and minerals, their intakes were compared with the recommendations by the National Nutrition Council (5) that are based on the Nordic Nutrition recommendations 2004 (4).

Descriptive data were collected during the study visits. Height and weight of the patients were measured in light clothing. Following a 10-minute rest, blood pressure was measured twice with 2 minutes' interval in the sitting position. The mean of these two measurements was used in the analyses. HbA_{1c}, serum triglyceride, and cholesterol concentrations were determined as previously described (10). Data on smoking and social class (grouped as unskilled/skilled blue-collar, upper/lower white-collar, farmers, and others) were collected using a self-administered questionnaire. Unskilled blue-collar workers were classified as having a low socio-economic status.

Statistical analyses

Descriptive statistics were reported as percentages for categorical data, mean ± standard deviation (SD) for normally distributed data, and median (interquartile range (IQR)) for non-normally distributed data. Although not normally distributed, dietary data were presented as mean ± SD. The paired comparisons were done with independent samples *t* test for normally distributed variables and Mann-Whitney *U* test for non-normally distributed variables. The comparisons between self-reported compliance and the frequencies of meeting the dietary recommendations were done using chi-square test. *P* values below 0.05 were considered significant. All data were analysed using SPSS 17.0 for Windows (SPSS, Chicago, IL, USA).

Results

A total of 63% of the patients returned the diet questionnaire, and 67% of them filled in the diet record (42% of all the patients). Those providing diet records were more frequently women, were less frequently smokers, and had more frequently higher socio-economic status. Furthermore, they were older, had lower diastolic blood pressure, lower HbA_{1c}, total cholesterol, HDL and triglyceride concentrations. Data from a total of 817 patients (39% men) are included in these analyses (Table I). Of these patients, 673 (82%) provided a food record from 6 days. Compared to these patients, the ones that provided food records from 3–5 days did not differ with respect to energy and fibre intake or the percentage of energy derived from protein, carbohydrates, sugars, fats, or saturated, monounsaturated, and polyunsaturated fatty acids. The percentage of energy obtained from alcohol was slightly higher among patients with 6 days' food record. Patients with 3–6 days' food record were analysed together. The median (IQR) time gap between the dietary and the basic characteristics data collection was 2.5 (0.8–8.4) years.

Energy, macronutrients, and alcohol

Men and women reported energy intakes between 4.2 and 16.5 MJ/day (1,003–3,939 kcal/d) and 2.6 and 13.1 MJ/d (626–3,137 kcal/d), respectively (Table II). On average, carbohydrates provided 45.1 ± 6.6 percentage of total energy intake (E%) with 51% of the patients reaching the recommended levels. The mean sucrose-derived energy

Table I. Description of the study population.

	Men n = 322 (39%)	Women n = 495 (61%)
Age (years)	51 (40–60)	47 (37–54)
Diabetes duration (years)	33 (21–44)	32 (21–40)
Low socio-economic status[a] (%)	46	45
Current smoking (%)	15	13
Body mass index (kg/m^2)	25 (24–27)	25 (23–27)
Blood pressure (mmHg)		
Systolic	140 (129–153)	130 (119–142)
Diastolic	79 (72–87)	76 (70–82)
HbA_{1c} (%)	7.9 (7.2–8.7)	8.1 (7.3–8.8)
Triglycerides (mmol/L)	0.99 (0.69–1.32)	0.80 (0.60–1.10)
Total cholesterol (mmol/L)	4.4 (3.9–5.1)	4.6 (4.1–5.2)
HDL cholesterol (mmol/L)	1.6 (1.3–1.9)	1.8 (1.5–2.2)

Data shown as median (interquartile range) for continuous non-normally distributed variables and frequency (%) for categorical variables.

[a]Blue-collar workers.

was below the recommended upper level, but almost one-quarter of the patients exceeded the recommendations for sucrose intake.

The protein intake was on average 77.3 ± 21.6 g/day. A total of 90% of the patients met the dietary guidelines for protein intake.

Fats provided, on average, 33.8 ± 6.2 E%, and 52% of the patients reported a diet with the recommended level of fat intake. The mean intake for saturated fatty acids exceeded the recommendations, and only 28% restricted saturated fatty acid to less than 10% of their daily energy intake. The majority of patients adhered to dietary guidelines for intakes of monounsaturated and polyunsaturated fatty acids. However, intake of these fatty acids was still below recommendations in 30% and 36% of patients.

Reported mean alcohol consumption was 2.9 g/day and ranged between 0 and 119 g/day. On average, alcohol provided 1 E%, and 82% of the patients met the recommended level of < 5 E%.

Fibre and salt

The average fibre intake was lower than recommended. Those reaching the recommended intake for fibre (4%) ingested, on average, 46.1 ± 7.0 g fibre daily. The mean salt intake exceeded the recommendations both in men and women, and only 27% of patients reported a diet with the recommended salt intake. Compared to men, women more frequently met the salt recommendations (14% versus 36%; $P < 0.001$).

Micronutrients

The micronutrient intakes per MJ are presented in Table III. Of the vitamins, the recommendations for vitamin D and folate were most frequently unmet. Moreover, only two-thirds met the recommendations for vitamin A. While 82% of the patients adhered to the guidelines for calcium intake, only half of the patients reported a diet with the recommended level of iron intake.

Self-reported compliance with dietary guidance and achievement of dietary recommendations

A total of 65% of women and 56% of men reported that they comply with the dietary guidance most of the time or always (compliant) ($P = 0.022$). Compared to those who reported complying with the dietary guidance sometimes, seldom, or never (non-compliant), those compliant had longer diabetes duration and lower BMI.

Compliant patients achieved the recommendations for carbohydrate, fat, saturated fatty acids,

Table II. Mean daily energy, macronutrient, alcohol, fibre, and salt intakes of Finnish adults with type 1 diabetes and compliance with the recommendations.

Nutrient (recommended intake[a])	Men[b] $n = 322$ (39%)	Women[b] $n = 495$ (61%)	All[b] $n = 817$	Intake below recommendation[c]	Recommendation achieved[c]	Intake above recommendation[c]
Energy, MJ	8.8 ± 2.1	7.2 ± 1.7	7.8 ± 2.1	NA	NA	NA
Carbohydrate, E%[d] (45–60 E%)	44.5 ± 6.8	45.5 ± 6.5	45.1 ± 6.6	48 (39.7 ± 4.5)	51 (49.8 ± 3.5)	1 (61.7 ± 2.3)
Sucrose, E% (< 10 E%)	6.7 ± 3.3	8.2 ± 3.6	7.6 ± 3.5	NA	77 (6.1 ± 2.2)	23 (12.5 ± 2.7)
Fibre, g (≥ 40 g)	24.5 ± 9.0	22.5 ± 7.6	23.3 ± 8.2	96 (22.4 ± 6.9)	4 (46.1 ± 7.0)	NA
Fibre, g/4.2 MJ (≥ 20 g/4.2 MJ)	11.9 ± 3.9	13.4 ± 4.3	12.9 ± 4.2	94 (12.2 ± 3.4)	6 (22.6 ± 2.4)	NA
Protein, E% (10–20 E%)	16.7 ± 3.0	16.8 ± 2.7	16.7 ± 2.8	0	90 (16.1 ± 2.1)	10 (22.1 ± 2.7)
Fat, E% (25–35 E%)	34.0 ± 6.3	33.7 ± 6.1	33.8 ± 6.2	7 (22.3 ± 2.5)	52 (30.9 ± 2.6)	41 (39.6 ± 4.0)
Saturated fatty acids, E% (< 10 E%)	12.0 ± 3.1	11.8 ± 3.2	11.8 ± 3.1	NA	28 (8.3 ± 1.4)	72 (13.2 ± 2.4)
Monounsaturated fatty acids, E% (10–20 E%)	11.4 ± 2.6	11.3 ± 2.6	11.4 ± 2.6	30 (8.5 ± 1.2)	70 (12.5 ± 1.8)	<1 (22.2 ± 2.8)
Polyunsaturated fatty acids, E% (5–10 E%)	5.6 ± 1.5	5.7 ± 1.5	5.7 ± 1.5	36 (4.2 ± 0.6)	63 (6.3 ± 1.1)	1 (11.0 ± 0.8)
Cholesterol, mg	265 ± 106	206 ± 75	229 ± 93	NA	NA	NA
Cholesterol, mg/MJ	26.6 ± 4.1	27.2 ± 3.9	27.0 ± 4.0	NA	NA	NA
Alcohol, E% (< 5 E%)	1.3 (0–23)	0.9 (0–23)	1.0 (0–23)	NA	82 (1.1 ± 1.4)	18 (9.2 ± 4.3)
Alcohol, g	3.9 (0–119)	2.0 (0–56)	2.9 (0–119)	NA	NA	NA
NaCl, g (< 6 g)	8.3 ± 2.1	6.6 ± 1.6	7.2 ± 2.0	NA	27 (5.0 ± 0.8)	73 (8.1 ± 1.6)

[a]Recommendations established by the Finnish Diabetes Association.
[b]Mean ± SD or median (range).
[c]The values are percentage of subjects in the category and their intake (mean ± SD).
[d]Percentage of total energy intake.
NA = not applicable.

Table III. Mean micronutrient densities of the diets among Finnish adults with type 1 diabetes.

Nutrient (recommendation/MJ[a])	Men $n = 322$ (39%)	Women $n = 495$ (61%)	All $n = 817$	%[b]
Vitamins				
Vitamin A (80 mg RE)	120 ± 163	128 ± 99	125 ± 128	67
Vitamin D (1 μg)	0.90 ± 0.56	0.91 ± 0.58	0.90 ± 0.57	32
Vitamin E (0.9 mg TE)	1.17 ± 0.27	1.33 ± 0.31	1.26 ± 0.30	92
Thiamine (0.12 mg)	0.20 ± 0.05	0.20 ± 0.05	0.20 ± 0.05	98
Riboflavin (0.14 mg)	0.24 ± 0.06	0.26 ± 0.06	0.25 ± 0.06	99
Vitamin B6 (0.13 mg)	0.27 ± 0.07	0.27 ± 0.08	0.27 ± 0.08	100
Folate (45 μg)	37.9 ± 12.4	40.7 ± 11.9	39.6 ± 12.2	23
Vitamin C (8 mg)	14.8 ± 6.6	20.4 ± 10.4	18.2 ± 9.5	91
Minerals				
Calcium (100 mg)	128 ± 41	146 ± 42	139 ± 43	82
Phosphorus (80 mg)	201 ± 35	208 ± 39	205 ± 38	100
Potassium (350 mg)	505 ± 93	560 ± 127	538 ± 118	97
Magnesium (35 mg)	49 ± 8	52 ± 10	51 ± 10	97
Iron (1.6 mg)	1.6 ± 0.4	1.7 ± 0.4	1.7 ± 0.4	51
Zinc (1.1 mg)	1.6 ± 0.3	16 ± 0.3	1.6 ± 0.3	97
Iodine (17 μg)	28 ± 6	28 ± 6	28 ± 6	98
Selenium (4 μg)	8.5 ± 1.7	8.5 ± 1.7	8.5 ± 1.7	100

Data shown as mean ± SD.
[a]Recommendations established by the National Nutrition Council.
[b]Percentage of patients reaching the recommended intake.
RE = retinol equivalent; TE = tocopherol equivalent.

and alcohol intake more frequently than those non-compliant (Table IV). In general, however, the frequencies of achieving the recommendations for macronutrient intakes among compliant patients were modest, with the highest frequencies observed for protein, alcohol, and sucrose (88%, 85%, and 77%, respectively). Moreover, those non-compliant more frequently achieved the recommendations for protein and monounsaturated fatty acids.

Both compliant and non-compliant patients reported diets with lower than recommended levels of vitamin D and folate (Table V). The nutrient densities of thiamine, folate, vitamin C, potassium, iron, zinc, and iodine were higher among those compliant.

Discussion

Our results showed that the dietary intake among Finnish patients with type 1 diabetes does not, for many nutrients, meet the recommendations. Only half of the patients achieved the recommendations for carbohydrate and fat intake. More than 70% of patients exceeded the recommendations for saturated fat and salt intake. Fibre intake was below recommendations in almost all of the patients, and one-fourth exceeded the recommendations for sucrose intake. Moreover, a large proportion of patients reported diets with low vitamin D, folate, and iron densities.

In Finland, all patients with type 1 diabetes are given dietary guidance at some stage after the diagnosis. Information regarding nutrition can, however, also be found from other sources such as the Internet and other patients with diabetes. In these cases, obtaining valid information is on one's own initiative. We were therefore interested to study whether patients' self-reported compliance with dietary guidance reflects the achievement of the actual recommendations. In general, self-reported compliance was associated with the consumption of more vitamin and mineral-dense food, suggesting that self-reported compliance is associated with more prudent food choices. Although self-reported compliance was also associated with a higher frequency of meeting the recommendations for some of the macronutrients, including carbohydrate, fat, and saturated fatty acids, the actual frequencies were only modest. The gap between self-reported compliance and measured implementation of dietary recommendations implies the need for more well planned nutrition counselling.

In their daily practice, patients with type 1 diabetes need to adjust their prandial insulin dose with carbohydrate intake (11). Estimation of the carbohydrate amount in a meal is not always easy, and patients therefore frequently struggle both with postprandial hypo- and hyperglycaemia. Consistent with Toeller et al. (6), nearly half of the patients in the current study did not meet the recommendations for carbohydrate intake measured as percentage of total

Table IV. Self-reported compliance with dietary guidance and the frequencies of achieving dietary recommendations.

Recommendation[a]	Compliant[b], n = 494 (61%)			Non-compliant[c], n = 311 (39%)			P[d]
	Intake below recommendation	Recommendation achieved	Intake above recommendation	Intake below recommendation	Recommendation achieved	Intake above recommendation	
Carbohydrate intake 45–60 E%[e]	44 (40.1 ± 3.9)	55 (50.2 ± 3.7)	1 (62.6 ± 2.8)	54 (39.3 ± 5.1)	45 (49.2 ± 3.1)	1 (60.5 ± 0.2)	0.004
Sucrose intake < 10 E%	NA	77 (6.1 ± 2.2)	23 (12.4 ± 2.7)	NA	78 (6.2 ± 2.2)	23 (12.8 ± 2.6)	0.864
Fibre intake ≥ 40 g	96 (23.0 ± 7.0)	4 (47.5 ± 8.4)	NA	96 (21.6 ± 6.8)	4 (43.7 ± 2.5)	NA	1.000
Fibre intake ≥ 20 g/4.2 MJ	94 (11.4 ± 3.4)	6 (21.9 ± 1.9)	NA	95 (11.4 ± 3.4)	5 (21.9 ± 1.9)	NA	0.358
Protein intake 10–20 E%	0	88 (16.3 ± 2.1)	12 (22.1 ± 2.9)	0	94 (15.9 ± 2.1)	6 (22.0 ± 2.1)	0.008
Fat intake 25–35 E%	8 (22.0 ± 2.8)	57 (30.7 ± 2.6)	35 (39.2 ± 3.5)	6 (23.1 ± 1.6)	45 (31.2 ± 2.5)	49 (40.1 ± 4.6)	0.002
SAFA intake < 10 E%	NA	35 (8.3 ± 1.4)	65 (12.9 ± 2.2)	NA	17 (8.2 ± 1.5)	83 (13.6 ± 2.7)	<0.001
MUFA intake 10–20 E%	34 (8.5 ± 1.3)	66 (12.3 ± 1.7)	<1 (21.1 ± 0.0)	23 (8.6 ± 1.0)	76 (12.7 ± 1.9)	1 (22.6 ± 3.9)	0.003
PUFA intake 5–10 E%	34 (4.2 ± 0.6)	65 (6.4 ± 1.1)	1 (11.0 ± 0.7)	38 (4.2 ± 0.6)	60 (6.3 ± 1.1)	2 (11.0 ± 0.9)	0.178
Alcohol intake < 5 E%	NA	85 (1.1 ± 1.4)	15 (8.8 ± 4.2)	NA	78 (1.1 ± 1.4)	22 (9.8 ± 4.4)	0.023

Data are presented as percentage of subjects in the category and their intake (mean ± SD).
[a]Recommendations established by the Finnish Diabetes Association.
[b]Complying with dietary guidance always or most of the time.
[c]Complying with dietary guidance sometimes, seldom, or never.
[d]Statistical comparison (chi-square) between the proportions of patients achieving the recommendations in compliant versus non-compliant subgroups.
[e]Percentage of total energy intake.
SAFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; NA = not applicable.

energy. Whether this reflects patients' fear of hyperglycaemia and subsequent long-term complications is not known. What can be speculated, however, is that striving for normoglycaemic values could result in avoidance of carbohydrates. Interestingly, at the same time, one-fourth of the patients exceeded the recommendations for sugar intake. Sugar-containing snacks may have been used to correct hypoglycaemia that resulted from consumption of meals with carbohydrate content lower than anticipated.

A generous intake of fibre-containing foods, such as legumes, whole-grain products, and fruits and vegetables, is recommended to provide not only fibre but also vitamins and minerals (1,2). Fibre intake is, however, frequently lower than recommended (6), a phenomenon also seen in this study. Patients with type 1 diabetes, specifically, could benefit from a diet rich in fibre, as it slows down the gastric emptying and therefore reduces postprandial glycaemic response (12). Indeed, a high-fibre diet (50 g/day) compared to low-fibre diet (15 g/d) reduced mean daily blood glucose concentration and the number of hypoglycaemic events (13). Moreover, those compliant with the high-fibre regimen also showed significant reduction in HbA_{1c}. In daily practice long-term compliance with such high fibre intakes can, however, be questionable.

Consistent with previous findings (8) the majority of patients in the present study achieved the recommendations for protein intake measured as the proportion of total energy. While protein restriction may be beneficial in delaying the progress of renal disease, there is currently no evidence to justify the use of protein restriction in patients without established renal disease (14). Moreover, even among those with established renal disease, restricting protein intake to only 0.8–1.0 g/kg reference body weight is considered sufficient (2). Due to the median gap of 2.5 years in the collection of dietary and basic characteristic data, we did not have up-to-date data on the patients' weight at the time of the reported dietary intake. Therefore we chose not to study the protein intake per body weight in this population. However, a sub-analysis among those with the gap ≤ 1 year (n = 218) showed that 18% of the patients reported protein intake lower than 0.8 g per body weight. While this could reflect potential under-reporting, it could also show a tendency for some patients to favour low-protein diets. Whether this occurs in order to reduce the risk of renal disease is, however, not known. The reasons for the lower than recommended protein intake among such patients needs to be evaluated, and sufficient intake of good quality protein should be ensured.

According to the current dietary recommendations, the total intake of fat should be kept in moderation (2). However, a fairly large proportion of the patients exceeded the recommendations for fat intake,

Table V. Mean micronutrient densities of the diets in groups of self-reported dietary compliance.

Nutrient (recommendation/MJ[a])	Compliant[b] n = 494 (61%)	%[c]	Non-compliant[d] n = 311 (39%)	%[c]	P[e]
Vitamins					
Vitamin A (80 mg RE)	129 ± 132	69	120 ± 123	63	0.065
Vitamin D (1 mg)	0.92 ± 0.53	33	0.86 ± 0.58	30	0.438
Vitamin E (0.9 mg TE)	1.28 ± 0.29	93	1.24 ± 0.32	89	0.064
Thiamine (0.12 mg)	0.20 ± 0.05	99	0.19 ± 0.05	97	0.041
Riboflavin (0.14 mg)	0.26 ± 0.06	99	0.25 ± 0.06	99	1.000
Vitamin B6 (0.13 mg)	0.28 ± 0.08	100	0.26 ± 0.07	99	0.563
Folate (45 μg)	41.0 ± 12.2	26	37.3 ± 11.9	18	0.008
Vitamin C (8 mg)	19.1 ± 9.7	94	16.7 ± 9.0	86	0.001
Minerals					
Calcium (100 mg)	139 ± 44	81	138 ± 40	84	0.297
Phosphorus (80 mg)	209 ± 39	100	199 ± 34	100	1.000
Potassium (350 mg)	554 ± 118	98	510 ± 114	94	0.002
Magnesium (35 mg)	52 ± 10	98	49 ± 9	96	0.289
Iron (1.6 mg)	1.7 ± 0.4	58	1.6 ± 0.4	39	<0.001
Zinc (1.1 mg)	1.6 ± 0.3	98	1.5 ± 0.3	95	0.011
Iodine (17 mg)	29 ± 6	99	27 ± 6	97	0.041
Selenium (4 μg)	8.6 ± 1.7	100	8.3 ± 1.6	100	1.000

Data shown as mean ± SD.
[a]Recommendations established by the National Nutrition Council.
[b]Complying with dietary guidance always or most of the time.
[c]Percentage of patients reaching the recommended intake.
[d]Complying with dietary guidance sometimes, seldom, or never
[e]Statistical comparison (chi-square) between the proportions of patients achieving the recommendations in compliant versus non-compliant subgroups.
RE = retinol equivalent; TE = tocopherol equivalent.

as previously seen in other populations with type 1 diabetes (6,7). While a higher fat intake, due to its high energy density, may predispose to obesity, a lower intake can compromise the intake of essential fatty acids (15). Indeed, dietary unsaturated fatty acids have shown a number of beneficial health effects such as reduction of cardiovascular risk due to anti-arrhythmic, anti-inflammatory, anti-thrombotic, and lipid-lowering actions (16). Moreover, there is evidence that substitution of saturated fats with unsaturated fats improves insulin sensitivity (17). In the current study, mean saturated fatty acid intake exceeded the recommendations, and only 28% restricted its intake to less than 10% of their daily energy intake. Moreover, the mean cholesterol intake exceeded the level recommended by the American Diabetes Association (18). These could be of potential significance as patients with type 1 diabetes have increased risk of vascular diseases, the risk of which may be further augmented by a high intake of saturated fatty acids.

While the dietary intakes of vitamins such as vitamin B6, thiamine, and riboflavin were, on average, sufficient, the intakes were frequently below those recommended for a number of other vitamins. Among these was vitamin D, the intake of which is often low also among the general population (19). Although vitamin D is also synthesized in the skin, the exposure to sunlight does not suffice to meet the requirements during a large part of the year in Finland. Therefore food such as fish, milk products, eggs, and enriched fats is an important source of vitamin D. Folate is another vitamin whose intake, especially among women, does not always meet the recommendations (20,21). Sufficient folate intake is of great importance especially among women of reproductive age. It should be noted that while our aim was to evaluate the sufficiency of the dietary intake among patients with type 1 diabetes, the potential use of dietary supplements, not taken into account in the current analyses, does increase the actual intake of some vitamins and minerals.

Food records are frequently used to study food and nutrient intake in a variety of populations (6,22,23). Considerable variability in the food intake exists, however. This is due not only to individuals' differences in dietary habits but also to within-individual differences in foods consumed from one day to another. Thus, the number of days required to measure accurately the usual intake can be questioned. In a research setting, the number of days recorded is often a trade-off between feasibility and accuracy. There are, however, some data to suggest that, at the group level, 3 days of recording should provide a good estimate for habitual energy intake, while 4, 6, and 5 days are required for protein, fat and carbohydrates, respectively (24). However, to

measure accurately vitamin A intake, for example, requires a much longer period. Thus our results will need to be evaluated in the light of this limitation.

Although 6-day food records should be sufficient to capture the habitual food intake at the population level, the potential for under-reporting has still to be considered. The phenomenon of under-reporting of energy intake is widely acknowledged (25,26) and has potentially occurred in the present study as well. Although we decided not to exclude any patients based on their reported energy intake, we did evaluate the quality and credibility of the food records on their arrival and excluded any unsound records ($n = 2$). The remaining records were considered reliable even with very low (or high) energy intakes. Indeed, as the records covered only a short time period it is not unexpected to find unusually low or high energy intakes. Should these unusual, albeit common, periods be excluded, the true group mean could be distorted. Moreover, under-reporting has been found to be rather evenly distributed over different types of foods and drinks (27,28). While such potential unsystematic under-reporting unlikely distorts the group comparisons, the absolute values of nutrient intakes may not be totally accurate. Indeed, to reduce the effect of potential under-reporting of energy intake, we calculated nutrient densities instead.

With the aim to study the nutritional intake of patients with type 1 diabetes compared to the given guidelines we did not regard a control group of non-diabetic patients essential. Based on the results from the national FINDIET 2007 survey (21), however, the intake observed in our study is fairly well consistent with that of the Finnish population. Indeed, despite the differences in the methods used to study the dietary intake, both the FINDIET 2007 and our study indicated saturated fatty acids, vitamin D, and folate as some of the challenges in the diet. Major differences, on the other hand, seem to be associated with a lower carbohydrate and sucrose intake and a higher fibre intake among patients with type 1 diabetes.

With the record, we did not only collect data on food intake but also requested data on physical activity, insulin administration, and blood glucose levels. Whether this has influenced reporting of dietary data is not known. Importantly, those more interested in diet and health issues (i.e. women, non-smokers, the ones with higher socio-economic status) were more frequently represented in this study reducing the generalizability of our results. It is also probable that the ones participating in the study are the ones most likely to be compliant with dietary guidance. However, beyond these limitations, our results may be generalized to other populations with Western dietary pattern.

In conclusion, patients with type 1 diabetes frequently fail to meet the dietary recommendations for carbohydrates, fibre, fat, saturated fatty acids, and salt. While self-reported compliance with dietary recommendations was associated with higher frequency of meeting the recommendations for carbohydrates, fat, saturated fatty acids, and alcohol, the observed frequencies were only modest. Based on these results we stress the need to increase the intake of fibre while reducing the sugar intake. Re-evaluation of insulin dosing should potentially accompany these modifications. Our results also suggest that patients, in general, should aim at reducing the intake of saturated fatty acids, a modification that would simultaneously reduce the intake of total fat. Furthermore, based on the low dietary intakes, patients with type 1 diabetes should consider taking vitamin D supplementation during periods when sunlight is not sufficient to ensure endogenous vitamin D production. Moreover, women of reproductive age should pay more attention to their folate and iron intakes, as they frequently were below recommendations. In practice, it may be difficult simultaneously to meet all recommendations, e.g. large amounts of whole-grain products in the diet help to achieve the targets for fibre, but may lead to an excess in salt intake. However, most of the dietary shortcomings found in the current study would be overcome simply by increasing the amount of whole-grain products, fruits, vegetables, legumes, and fish in the diet.

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Supplementary material available online

Appendix