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Original Article

Is Dietary Macronutrient Distribution Related to Serum Lipid Profiles in Children and Adolescents with Type 1 Diabetes?

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ABSTRACT

Aim: The aim of this study was to evaluate the dietary macronutrient distribution affects on serum lipid profiles in type 1 diabetes mellitus (T1D).

Materials and Methods: This cross-sectional study included 82 children and adolescents between the ages of 2 and 18 years with a diabetes age of ≥1 year. Dietary intake was evaluated by 3-day food diaries, including three consecutive days (two weekdays and one weekend day).

Results: The mean age of the 82 patients with diabetes was 11.6±4.3 years (range: 2-18 years) (45.1% female), the median diabetes duration was 3.4 (2.9) years, the mean HbA1c level was 7.0±1.4%, and mean body mass index standard deviation score was 0.2±1.1. The median distribution of energy from carbohydrates, protein and fat in the total energy intake was 50.0% (6.2), 17.4% (2.7) and 32.5% (5.1), respectively. Dietary fiber intake was inadequate in 64 (77.9%) participants, while for 77 participants (93.9%), saturated fatty acid intake was above the recommended intake. For children and adolescents with T1D, mean serum cholesterol, triglycerides, low-density lipoprotein, and high-density lipoprotein levels were 162.9±33.4 mg/dL, 86.2±49 mg/dL, 87.9±29.2 mg/dL, and 60.7±17.9 mg/dL, respectively.

Conclusion: To maintain healthy eating, consuming foods high in saturated fat should be limited, and children and adolescents with T1D should be supported by their family and healthcare professionals in the consumption of diets high in fiber.

Keywords: Type 1 diabetes, dietary macronutrients intake, children, adolescents

Introduction

Nutritional management is one of the essential components of type 1 diabetes mellitus (T1D) management, diabetes care and education. It aims to ensure the continuation of normal growth and development, to develop lifelong healthy eating habits, to provide optimal glycemic control, to prevent/delay complications which may develop due to diabetes, to reduce cardiovascular disease (CVD) risk factors, and to maintain psycho-social well-being. Current dietary recommendations for children and adolescents with T1D reflect guidelines for healthy eating developed for the general population. Implementation of an individualized meal plan with prandial insulin adjustments improves glycemic outcomes (1,2). However, previous studies have reported that children and adolescents with T1D eat more atherosclerosis-prone diets than healthy control subjects and greater dietary quality is associated with more optimal glycemic control (3-7). This study aimed to evaluate how dietary macronutrient distribution affects the serum lipid profiles.

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Materials and Methods

Study Design and Participants

This cross-sectional study included 82 children and adolescents with T1D between the ages of 2 and 18 years, with a diabetes age ≥1 year, followed up in Ege University between April and December, 2022, and whose serum lipid profiles were routinely evaluated at a diabetes outpatient clinic. T1D patients with co-morbidities (celiac disease, cystic fibrosis, etc.) affecting food consumption and nutrient intake were excluded from this study.

Anthropometric Evaluation and Metabolic Control

Height was measured to the nearest millimeter using a Seca 264® stadiometer. Weight was measured unclothed using an electronic scale to the nearest 100 grams (Desis Model KW®). Body mass index (BMI) was calculated by the formula; weight (kg)/height (m^2). Standard deviation scores (SDS) for weight, height, and BMI were calculated according to age and gender using reference values for Turkish children and adolescents (8,9). HbA1c <7% was defined as good glycemic control (10).

Food Diary

For each people with diabetes (PwD), dietary intake was evaluated by 3-day food diaries, consisting of three consecutive days (two weekdays and one weekend day). All food and beverages consumed (including dressings) were recorded by weighing for 3 days. The food diaries were checked by a diabetes dietician, verified for consistency and accuracy, and supplementary information was requested if needed. The analysis included dietary records of snacks and meals (732 meals, 381 snacks). Total energy intake (kcal), carbohydrate (energy %), protein (energy %), fat (energy %), saturated fatty acids (SFAs) (energy %), dietary cholesterol (mg), and dietary fiber (g/1.000 kcal) intakes were calculated using the Ebispro for Windows, Turkish Version (BeBiS 8.2) (Stuttgart, Germany).

Statistical Analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences version 25.0 (SPSS Inc., Chicago, IL, USA). The level of significance was defined as p<0.05. Categorical variables were represented as counts and percentage values. Normal distribution was tested for quantitative variables. Continuous variables with normal or skewed distributions are presented as mean (± SD) or median (interquartile range). Group differences were investigated using the independent t-test for normally distributed data and the Mann-Whitney U test for skewed data. Spearman's correlation coefficients were used to explore relationships between SFA and dietary fiber intake with serum cholesterol, triglycerides (TG), low-density lipoprotein (LDL) and high-density lipoprotein (HDL) levels. Correlation values of 0.10-0.29 were interpreted as small, 0.30-0.49 as medium, and 0.50-1.0 as large (11).

Ethical Consideration

This study was approved by the Ege University Faculty of Medicine Clinical Research Ethics Committee (approval number: 22-4T/13, date: 07.04.2022). The aim of this study was explained to each participant, and written informed consent was obtained. This study's procedures followed the Declaration of Helsinki.

Results

The mean age of the 82 PwD was 11.6±4.3 years (range: 2-18 years) (45.1% female), the median diabetes duration was 3.4 (2.9) years, the mean HbA1c was 7.0±1.4%, and the mean BMI-SDS was 0.2±1.1 (Table I). Thirty-six percent of the participants were on insulin infusion pump therapy (IIPT), 63.4% were on multiple daily insulin injections (MDI) (≥4 daily injections), and all were on carbohydrate counting. There were no significant differences in age, diabetes duration, HbA1c levels, height, weight and BMI-SDS, insulin requirements, and the number of meals/snacks per day between gender and treatment models (MDI and IIPT) (Table I). Fifty-four percent of PwD met the target HbA1c for good glycemic control (HbA1c <7%).

The median distribution of energy from carbohydrates, protein and fat in total energy intake was 50.0% (6.2), 17.4% (2.7) and 32.5% (5.1), respectively, and these were in line with international recommendations (1). There were no differences in nutrient intakes between the genders (Table II). The median fiber intake [11.3 (3.6) g/1.000 kcal] was below, and SFA intake [11.3% (3.6) of energy] was above the recommendations.

In PwD, dietary cholesterol (<300 mg/day) intakes met the recommendations, and SFA intakes which should be <10% of total energy intake was above the recommendations. Seventy-eight percent of participants did not consume the recommended daily fiber intake (14 g/1.000 kcal). PwD who met the dietary fiber intake recommendations had a lower median SFA intake than those who did not have adequate intake (p<0.001), and a negative large correlation was found between SFA intake and dietary fiber intake (r=-0.516, p<0.01).

Mean serum cholesterol, TG, LDL and HDL levels were 162.9±33.4 mg/dL, 86.2±49 mg/dL, 87.9±29.2 mg/dL, and 60.7±17.9 mg/dL, respectively. Those with adequate dietary fiber intake (22% of the participants) had lower serum cholesterol (p=0.041) and TG (p=0.028) levels than those who did not, and there was no difference between the HDL and LDL levels of the groups (Table III). In addition, there was a negative medium correlation between serum TG levels and dietary fiber intake (r=-0.395, p<0.01).

Table I. Baseline characteristics of participants

	All (n=82)	**Male (n=45)**	**Female (n=37)**	**p-value**
Age (years)[a]	11.6 (4.3)	11.3 (4.0)	11.9 (4.6)	0.541[c]
Diabetes duration (years)[b]	3.4 (2.9)	2.2 (3.5)	2.8 (4.2)	0.220[d]
Diabetes onset age (years)[a]	8.3 (8.5)	8.6 (3.6)	7.9 (3.7)	0.429[c]
Weight -SDS[a]	0.3 (1.2)	0.4 (1.2)	0.23 (1.3)	0.663[c]
Height- SDS[a]	0.2 (1.2)	-0.12 (1.37)	0.1 (0.9)	0.459[c]
BMI-SDS[a]	0.2 (1.1)	0.2 (1.1)	0.2 (1.2)	0.843[c]
HbA1c (%)[b]	7.0 (1.4)	6.9 (1.2)	7.4 (1.4)	0.634[d]
Insulin (U/kg/d)	0.8 (0.3)	0.8 (0.3)	0.7 (0.2)	0.797[c]
Basal insulin (%)[a]	42.9 (13.0)	41.7 (13.0)	44.4 (13.1)	0.344[c]
Bolus insulin (%)[a]	56.9 (13.1)	58.1 (13.0)	55.6 (1.3.1)	0.386[c]
Number of meals per day[b]	3.0 (0.0)	3.0 (0.0)	3.0 (0.0)	0.026[d]
Number of snacks per day[b]	1.6 (2.0)	2.0 (2.0)	1.0 (1.0)	0.549[d]

[a]Data are mean (standard deviation), [b]Data are median (Interquartile range), [c]Independent sample t-test, [d]Mann-Whitney U test,
p-values refer to the significance of the difference between MDI users and pump therapy users
BMI: Body mass index, HbA1c: Glycated haemoglobin, SDS: Standard deviation score, MDI: Multiple daily insulin injections

Table II. Energy and nutrient intake of participants during the follow-up period

	ISPAD recommendations	**All (n=82)**	**Male (n=45)**	**Female (n=37)**	**p-value***
Carbohydrate (energy %)	40-50	50.0 (6.2)	50.0 (4.8)	50.0 (7.5)	0.863
Protein (energy %)	15-25	17.4 (2.7)	17.0 (2.9)	17.7 (2.8)	0.692
Fat (energy %)	30-40	32.5 (5.1)	32.4 (4.9)	32.3 (5.4)	0.744
SFA (energy %)	<10	15.2 (3.5)	15.1 (3.9)	15.1 (3.7)	0.618
Dietary cholesterol (mg)	<300	300.1 (142.6)	320 (152.3)	284.0 (174.1)	0.091
Dietary fiber (g/1000 kcal)	14	11.3 (3.6)	12.2 (4.4)	11.8 (2.9)	0.150

Data as presented as median (interquartile range),[c]Mann-Whitney U test
SFA: Saturated fatty acid, ISPAD: International Society of Pediatric and Adolescent Diabetes

Table III. Comparison of serum lipid profile of children and adolescent with T1D according to dietary fiber intake

	Adequte dietary fiber intake (n=18)	**Inadequate dietary fiber intake (n=64)**	**p-value***
Cholesterol (mg/dL)	151.7±38.2	165.2±30.8	0.124
TG (mg/dL)	102.8±51.5	82.8±51.3	0.148
LDL (mg/dlL)	82.3±34.0	89.4±27.5	0.366
HDL (mg/dL)	58.7±19.6	61.6±17.1	0.546

Data are mean (standard deviation), *Independent sample t-test
p-values refer to the significance of the difference between participants with adequate dietary fiber intake and with inadequate fiber intake
TG: Tryglycerid, LDL: Low density lipoprotein, HDL: High density lipoprotein

Discussion

This study aimed to analyze the nutrient distribution of energy intakes and investigate the effects of serum lipid profiles in children and adolescents with T1D in real-time settings.

Nutrition management recommendations for children and adolescents with diabetes reflect guidelines for healthy eating developed for the general population. The optimal macronutrient distribution varies depending on the individualized assessment and metabolic priorities of the PwD. However, the International Society of Pediatric and Adolescent Diabetes (ISPAD) gives the following thresholds as a guide: "carbohydrate intake should be 40-50% of total daily energy intake, fat intake no greater than 30-40% (SFA <10%), and protein intake of 15-25%" (1).

In our study, the participants' carbohydrate, fat, and protein intakes met the recommended levels of ISPAD nutritional management of T1D guideline (1). However, our findings regarding low fiber and high SFA in children with T1D supported previous studies (4,5,12,13). Dietary factors which raise VLDL and LDL-cholesterol increase the likelihood of the formation of atherosclerosis in teenagers and young adults, and the amount of SFA in the diet is one of the main determinants of plasma LDL cholesterol levels (14). In our study group, there was no correlation between dietary SFA intake and serum LDL levels. This can be explained by the different relationship, reabsorption in the gastrointestinal system between individuals between and genetic polymorphisms contribute to the interindividual variation between dietary fat and serum LDL cholesterol response (15).

Even though our study data showed no correlation between dietary SFA intake and serum LDL levels, dietetic interventions in the clinical setting can focus more specifically on fiber and SFA intake.

The American Heart Association suggests that children and adolescents consume a healthy diet which limits SFA and recommends replacement with polyunsaturated and monounsaturated fat in order to reduce CVD risk in later life (16). Medical nutrition therapy of T1D should be provided in order to prevent and treat co-morbidities including obesity, dyslipidemia, hypertension, and micro- and macro-vascular complications.

Study Limitations

This current analysis has strengths and limitations. This study's strength was its real-world setting and its energy and nutrient intake evaluation based on 3-day food diary records. The main limitation was its sample size. Additional evaluations with larger samples should be performed in order to confirm these results.

Conclusion

These findings associated with the participants' high SFA and low fiber intakes have potential implications for clinical practice and nutritional education. In order to maintain healthy eating, consuming foods high in SFA should be limited, and children and adolescents with T1D should be supported by their families and healthcare professionals in the consumption of legumes, fruits and vegetables, and whole grains containing fiber.

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Ethics

Ethics Committee Approval: This study was approved by the Ege University Faculty of Medicine Clinical Research Ethics Committee (approval number: 22-4T/13, date: 07.04.2022).

Informed Consent: The aim of this study was explained to each participant, and written informed consent was obtained.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: Y.A.A., Design: Y.A.A., D.G., Data Collections or Processing: Y.A.A., Analysis or Interpretation: Y.A.A., D.G., Literature Search: Y.A.A., D.G., Writing: Y.A.A., D.G.

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