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ORIGINAL ARTICLE – OPEN ACCESS

The Relationship Between Diet Quality of Adolescents with Type 1 Diabetes and Nutritional Status and Biochemical Parameters

Gülsüm Şahin Bodur[1], Alev Keser[1], Zeynep Şıklar[2], Merih Berberoğlu[2]

ABSTRACT

Objective: Studies have shown that adolescents with type 1 diabetes do not have adequate diet quality and are, therefore, at risk for macro/microcomplications and growth retardation. This study aims to determine the diet quality of adolescents with type 1 diabetes and evaluate the relationship between diet quality and nutritional status as well as biochemical parameters.

Materials and Methods: This cross-sectional study consisted of adolescents (10–19 years old) with type 1 diabetes. The questionnaire administered to the participants is composed of sociodemographic characteristics, anthropometric measurements, and biochemical data. Furthermore, the food consumption status of the participants was determined by a 3-day food consumption record. HEI-2010 score calculated and adolescents are classified according to their diet quality.

Results: The majority of the adolescents with type 1 diabetes who participated in the study were found to have needs improvement diet quality. However, very few participants were with good diet quality. A weak and negative relationship between exist diet quality scores of the male participants and their waist circumferences and HbA1c ($p<0.05$) values.

Conclusion: Diet quality has been thought to have an important role in the medical nutrition treatment of type 1 diabetes which is related to blood glucose control and blood lipid profile nutritional status. Therefore, the diet quality of adolescents with type 1 diabetes should be increased.

Keywords: Adolescents, anthropometric measures, diet quality, lipid profile, type 1 diabetes

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[1]Department of Nutrition and Dietetics, Ankara University, Ankara, Turkey
[2]Department of Pediatric Endocrinology, Ankara University Faculty of Medicine, Ankara, Turkey

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Correspondence
Gülsüm Şahin Bodur, Ankara University, Department of Nutrition and Dietetics, Ankara, Turkey
Phone: +90 553 636 73 48
e-mail: gulsum_sahn@hotmail.com

INTRODUCTION

Type 1 diabetes (T1DM) is one of the most common childhood endocrine disorders. According to International Diabetes Federation (IDF), 9,500 children aged 0–14 years have T1DM with an incidence rate of 7.2/100,000 in Turkey (1). Moreover, one of the main components of T1DM treatment includes medical nutrition therapy (MNT). MNT aims to maintain blood glucose levels at normal or near-normal limits to prevent and/or delay acute and chronic complications, to provide optimal lipid and lipoprotein profile to reduce the risk of macrovascular complications, and, thus, to ensure and maintain optimal metabolic functions as well as maintain healthy growth and development of T1DM and to have individuals with T1DM gain the habit of adequate and balanced nutrition (2).

Diet quality, one of the MNT components, plays an important role in diabetes management (3). The exact definition of diet quality was not made because of the requirements reflecting optimal conditions in nutrition, toxicology, economics, and food industries and its heterogeneity and versatility (4). In general, diet quality refers to nutritional adequacy. Nutritional adequacy refers to the ability of a diet to meet both energy and all essential nutritional requirements (5). With adequate and balanced nutrition, the diet quality of adolescents with T1DM is increased, the optimal body weight is maintained, the blood glucose level is kept under control, and optimal growth and development are maintained. Thus, quality of life is preserved, and healthy life can be maintained by preventing the emergence of acute and/or chronic complications related to diabetes (2).

Studies have shown that adolescents with T1DM do not have adequate diet quality and are, therefore, at risk for macro/microcomplications and growth retardation (6, 7). Thus, this study aims to determine the diet quality of adolescents with T1DM and evaluate the relationship between diet quality and nutritional status as well as biochemical parameters.

MATERIALS and METHODS

Participant Selection

The sample of this cross-sectional study consisted of 57 male and 53 female adolescents (10–19 years old; mean age, 14.0±2.40 years) with T1DM who were followed up in the Department of Pediatric Endocrinology of the Faculty of Medicine at the University of Ankara between July 2017 and January 2018. A random sample selection method was used for the sample size to be included in the study. Individuals who met the inclusion criteria and agreed to participate in the study were included. Written informed consent from the patients and their parents was obtained.

Individuals who were diagnosed with T1DM at least 1 year previously, have a daily insulin dose of >0.5 units/kg, and receive intensive insulin therapy or have used an insulin pump for at least 3 months were included in the study. Those who were diagnosed with celiac and hyperlipidemia, have been on an insulin pump for <3 months and used premixed insulin, and were <10 to >19 years old were excluded from the study.

Design

The questionnaire administered to the participants is composed of sociodemographic characteristics, anthropometric measurements, and biochemical data. The data on biochemical parameters were obtained from the files of the patients. The food consumption status of the participants was determined by a 3-day food consumption record. Dietary intakes were evaluated via Nutrition Information System for Turkey (BeBis).

Evaluation of Anthropometric Measurements and Biochemical Parameters

Bodyweight (BW, in kilogram) and body fat percentages (BFP, in percentage) of the participants were obtained by bioelectrical impedance analysis/BIA method via Tanita BC-545N body analyzer. The BW and BFP of the participants were evaluated following the age-adjusted percentages of the Centers for Disease Control and Prevention (8, 9). The heights of the participants were determined using a SECA201 stadiometer. The heights and body mass index (BMI) percentages of the participants were evaluated following the age-adjusted percentiles of the World Health Organization (10). The waist circumferences (WC) of the participants were evaluated according to the age-adjusted WC percentages of the IDF (11). Moreover, the waist/height ratio (WHR) was evaluated according to the classification of Ashwell and Hsieh (12). Furthermore, biochemical data were evaluated based on the classification of the International Society for Pediatric and Adolescent Diabetes (ISPAD) guidelines (13, 14).

Healthy Eating Index 2010

The Healthy Eating Index HEI-2010 contains 12 components. The amounts consumed are evaluated based on the nutrients in grams per 1,000 kcal. The diet quality of individuals is defined according to the total HEI score (≤50 = poor diet quality, 51–80 = needs improvement diet quality, and 81–100 = good diet quality (15).

Ethics Committee Approval

Ethics Committee Approval (numbered 10-526-17 and dated 22.05.2017) and Research Permit (numbered 15255985-302.01.08[774.99]-E.10299 and dated 15.04.2018) were obtained from Ankara University, Clinical Studies Ethical Committee and Ankara University, Faculty of Medicine, The Children Hospital Pediatric Endocrine Department, respectively, to carry out the study.

Data Analysis

Analysis was conducted using the SPSS statistical package program. The chi-square test was employed to determine this statistical relationship. The chi-square test of independence measured whether a relationship exists between two categorical variables (anthropometric measurements groups, gender of individuals, and so on). The student's t-test was used to compare two independent groups (male and female groups) when both of the variables provided normal distribution assumption, and the Mann–Whitney U test was used when the aforementioned assumption was not met. To reveal whether a statistically significant relationship existed between two quantitative variables, the Pearson's correlation test was used when both of the variables provided normal distribution assumption and the Spearman's correlation test was used when the aforementioned assumption was not met (correlation of diet quality score with anthropometric measurements and biochemical parameters and so on). Correlation coefficients were interpreted as very weak (between 0.00 and 0.20), weak (0.21 and 0.40), medium (0.41 and 0.60), strong (0.61 and 0.80), and perfect relation (≥0.81). The confidence interval was accepted as 95.0% in all statistical tests and evaluated at a p<0.05 significance level.

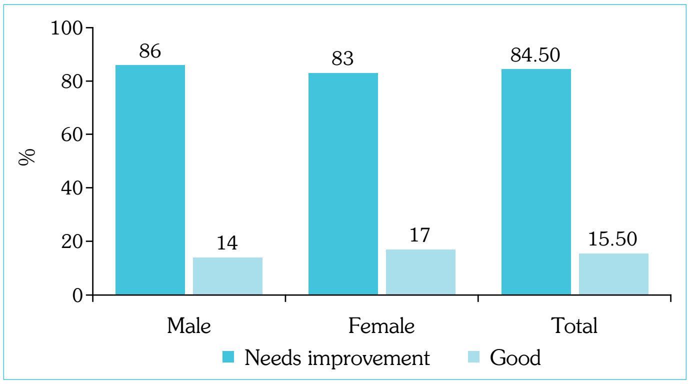

Figure 1. Evaluation of diet quality by individuals according to gender

RESULTS

The evaluation of participants' diet quality according to gender is shown in Figure 1. The mean score of males and females is 69.75±9.66 (male, 68.95±10.23; female, 70.61±9.03).

The percentages of participants within the normal range in terms of BW are 82.4% (males) and 80.4% (females). In addition, 15.7% of all participants are overweight and obese. The majority of all participants in the study are within the normal range in terms of BMI (68.3%), BFP (51.0%), and WHR (75.8%) and in the group with normal health risk (85.1%). The distribution between males and females in terms of WC and BFP was found to be statistically significant (p<0.05; Table 1).

Table 2 shows that BMI, BFP, hemoglobin A1C (HbA1c), total cholesterol (TC), very low-density lipoprotein cholesterol (VLDL-C), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) values were higher in females than males and a statistically significant difference was noted between them (p<0.05).

Of the males and females, 19.% and 31.6%, respectively, have optimal FBG, and 69.4% of all participants have high FBG. The percentages of males and females with optimal HbA1c values are 21.6% and 18.4%, respectively. Of all participants, the HbA1c and TV values were 80.0% and 98.7%, respectively. The majority of participants were found to have optimal values considering VLDL-C, LDL-C, HDL-C, and TG. A statistically significant difference was noted between VLDL-C, LDL-C, and TG of the male and female groups (p<0.05; Table 3).

Table 1. Classification of some anthropometric measurements of individuals by gender

	Male		Female		Total		χ^2	p[a]
	n	%	n	%	n	%		
Body weight (kg)							0.522	0.914
Underweight	1	1.8	2	4.0	3	2.8		
Normal	47	82.4	41	80.4	88	81.5		
Overweight	4	7.0	4	7.8	8	7.4		
Obese	5	8.8	4	7.8	9	8.3		
Body mass index (kg/m²)							0.878	0.831
Underweight	2	3.5	2	4.0	4	3.7		
Normal	41	71.9	32	64.0	73	68.3		
Overweight	8	14.0	10	20.0	18	16.8		
Obese	6	10.6	6	12.0	12	11.2		
Waist circumferences (cm)							**6.000**	**0.050***
Health risk is normal (<85.0. p)	54	100.0	43	89.6	97	85.1		
Health risk is high/very high (≥85.0. p)	–	–	5	10.4	5	4.9		
Waist/height ratio							2.361	0.305
Optimal	40	81.6	29	69.0	69	75.8		
Suboptimal	9	18.4	13	31.0	22	24.2		
Body fat percentage (%)							**6.233**	**0.044***
Underweight	32	58.2	17	36.2	49	48.0		
Normal	22	40.0	30	63.8	52	51.0		
Overweight	1	1.8	–	–	1	1.0		

a: Chi-square test; *: p<0.05; p: Percentile

The correlation between the diet quality scores of the participants and anthropometric measurements according to gender is shown in Table 4. Accordingly, a weak and negative relationship between exist diet quality scores of the male participants and their WC (r=−0.274, p=0.045) and HbA1c (r=−0.310, p=0.027; p<0.05) values.

DISCUSSION

The diet quality of the individuals who participated in the study was determined using HEI-2010. In the general sample, the mean total score of the participants is 69.75±9.66, while the mean scores of males and females are 68.95±10.23 and 70.61±9.03, respectively. The percentage of those with needs improvement in diet quality is 84.5%, while the percentage of those with good diet quality is 15.5% (Fig. 1). Nansel et al. (3) found that the mean score of HEI-2005 was 53.4±11.0. In the same study, only 0.4% of the adolescents with T1DM had good diet quality, while 55.2% were found to have needs improvement in diet quality. Nansel et al. (7) found that the mean score of adolescents with T1DM whose mean age was 12.87±2.6 years old was 54.8±11.78 based on HEI-2005. Among 151 adolescents with T1DM between the ages of 8 and18 years old (mean age, 15.6±1.5 years old), the mean scores of HEI-2005 of those at low and high eating disorder risks were found to be 53.7 and 45.9, respectively (16). Selective eating behavior adversely affecting diet quality is known as the rejection of the intake of many nutrients. In selective eating behavior, a lack of vegetable consumption and nutrient diversity usually exist (17). In a study conducted by Nansel et al. (17) on children and adolescents with T1DM, the diet quality of the individuals with and without selective eating behaviors was examined, and the mean diet quality total scores of the participants were found to be 52.8±13.30 and 60.4±15.05, respectively. The behaviors (e.g., not attending to nutrition education, not being able to comprehend the importance of medical nutrition treatment and refusing it, and refusing regular meal consumption) of adolescents with T1DM contribute to poor diet quality. In addition, lack of school education, support of family and friends, and self-confidence are among the main causes of poor diet quality among adolescents with T1DM (18).

Based on these results, most of the adolescents with T1DM have poor diet quality or needs improvement in diet quality. The diet quality is believed to improve with a healthy food choice which is one of the factors determining diet quality. In this context, consulting a registered dietitian having specialization in the field and maintaining nutrition training at regular intervals as soon as possible after the diagnosis of T1DM is critical for diabetics.

Maintaining normal BW to improve the prognosis of T1DM is very important. In addition, body weight regulation and glycemic control can be achieved through healthy food choices, portion control, regular meal consumption, and an increase in physical activity. However, in adolescents with T1DM, additional doses of insulin, excessive amounts of snacks, and additional meal consumption to prevent or treat hypoglycemia may cause an increase in BW (2).

Table 2. Descriptive findings of the anthropometric measurements and biochemical parameters by gender

Anthropometric measurements, Biochemical parameters	Male (n=57)	Female (n=53)	Total (n=110)	u/t	p
Body weight (kg), $\bar{x}$±SD	54.1±16.59	55.2±11.23	54.7±14.36	-0.415	0.679[t]
Body mass index (kg/m^2) $\bar{x}$±SD	20.4±3.46	21.7±3.27	21.0±3.46	**-2.110**	**0.037[t*]**
Waist circumference (cm), Median; Min–Max	68.5; 55.0–94.0	74.0; 47.0–95.0	72.0; 47.0–95.0	155.00	0.790[u]
Waist/height ratio, Median; Min–Max	0.43; 0.36–0.59	0.45; 0.34–0.60	0.44; 0.34–0.60	1.273	0.877[u]
Body fat percentage (%), $\bar{x}$±SD	18.8±5.71	26.8±5.60	22.5±6.94	**-7.077**	**0.001[t*]**
FBG (mg/dL), Median; Min–Max	165.5; 56.9–442.0	210.0; 68.0–435.0	195.0; 56.9–442	734.50	0.130[u]
HbA1c (%), $\bar{x}$±SD	8.7±1.52	9.6±2.18	9.2±1.92	**-2.445**	**0.012[t*]**
Total cholesterol (mg/dL), $\bar{x}$±SD	158.1±29.82	186.3±39.78	173.1±37.99	**-3.590**	**0.004[t*]**
VLDL–C (mg/dL), Median; Min–Max	16.0; 8.0–32.0	18.5; 8.0–68.0	17.0; 8.0–68.0	**530.00**	**0.045[u*]**
LDL–C (mg/dL), Median; Min–Max	87.0; 40.0–168.0	106.0; 64.0–178.0	97.0; 40.0–178.0	**458.50**	**0.000[u*]**
HDL–C (mg/dL), Median; Min–Max	48.0; 7.2–107.2	54.5; 38.0–91.0	52.0; 7.2–107.2	**575.00**	**0.038[u*]**
TG (mg/dL), Median; Min–Max	80.0; 38.0–159.0	92.0; 40.0–340.0	85.0; 38.0–340.0	**523.50**	**0.045[u*]**

t: Student's t-test; u: Mann–Whitney U test; *: $p<0.05$; $\bar{x}$: Arithmetic mean; SD: Standard deviation; Min: Minimum; Max: Maximum; FBG: Fasting blood glucose; HbA1c: Hemoglobin A1c; VLDL-C: Very low-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides

Table 3. Distribution of biochemical parameters by individuals according to gender

Biochemical parameters	Male		Female		Total		χ^2	p[a]
	n	%	n	%	n	%		
FBG (mg/dL)							1.744	0.410
Low	3	6.4	2	5.3	5	5.9		
Optimal	9	19.1	12	31.6	21	24.7		
High	35	74.5	24	63.1	59	69.4		
HbA1c (%)							0.163	0.685
Optimal	11	21.6	9	18.4	20	20.0		
High	40	78.4	40	81.6	80	80.0		
Total cholesterol (mg/dL)							1.15	0.285
Optimal	1	2.7	–	–	1	1.3		
High	36	97.3	42	100.0	78	98.7		
VLDL-C (mg/dL)							**6.451**	**0.015***
Optimal	35	97.2	31	77.5	66	86.8		
High	1	2.8	9	22.5	10	13.2		
LDL-C (mg/dL)							**5.495**	**0.012***
Optimal	6	16.2	3	7.1	9	11.4		
High	31	83.8	39	92.9	70	88.6		
HDL-C (mg/dL)							1.600	0.203
Low	6	16.2	3	7.1	9	11.4		
Optimal	31	83.8	39	92.9	70	88.6		
TG (mg/dL)							**7.55**	**<0.001***
Optimal	35	97.2	30	75.0	65	85.5		
High	1	2.8	10	25.0	11	14.5		

a: Chi-square test; *: $p<0.05$; p: Percentile; FBG: Fasting blood glucose; HbA1c: Hemoglobin A1c; VLDL-C: Very low-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides

Table 4. Descriptive findings of the anthropometric measurements and biochemical parameters by gender

Anthropometric measurements, Biochemical parameters	Male (n=57)		Female (n=53)		Total (n=110)	
	p	r	p	r	p	r
Body weight (kg)	-0.197	0.142	0.123	0.394	-0.082	0.399$^{\beta}$
Body mass index (kg/m^2)	-1.171	0.203	-0.014	0.923	-0.097	0.322$^{\alpha}$
Waist circumferences (cm)	**-0.274**	**0.045***	0.095	0.520	0.080	0.425$^{\alpha}$
Waist/height ratio	-0.080	0.567	0.057	0.699	0.019	0.851$^{\alpha}$
Body fat percentage (%)	-0.084	0.547	-0.055	0.716	0.048	0.633$^{\beta}$
FBG (mg/dL)	-0.084	0.598	0.050	0.751	-0.044	0.691$^{\beta}$
HbA1c (%)	**-0.310**	**0.027***	-0.241	0.096	-0.190	0.058$^{\alpha}$
Total cholesterol (mg/dL)	-0.005	0.977	-0.218	0.165	-0.108	0.346$^{\alpha}$
VLDL-C (mg/dL)	-0.176	0.304	-0.128	0.431	-0.189	0.103$^{\beta}$
LDL-C (mg/dL)	-0.122	0.473	-0.170	0.288	-0.070	0.544$^{\beta}$
HDL-C (mg/dL)	-0.106	0.527	0.020	0.899	0.070	0.539$^{\beta}$
TG (mg/dL)	-0.188	0.271	-0.134	0.410	-0.201	0.081$^{\beta}$

Statistical analyses in the same row are similar. α: Spearman's correlation test; β: Pearson's correlation test; *: p<0.05; FBG: Fasting blood glucose; HbA1c: Hemoglobin A1c; VLDL-C: Very low-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; HDL-C: High-density lipoprotein cholesterol; TG: Triglycerides

In this study, according to the BMI percentiles, the majority of participants (68.3%) had normal BW, 16.8% were overweight, and 11.2% were obese (Table 1). In the literature, the percentages of overweight and obese subjects among adolescents with T1DM vary between 11.6%–40.0% and 2.8%–15.4%, respectively (19–22). Such differences between these studies are thought to be mainly originated from obtaining data from children and adolescents from different age groups and ethnic backgrounds, and the evaluation criteria not being standard. Waist circumference and WHR can also be used to determine cardiovascular risk factors in adolescents with T1D (23). According to WC classification, 4.9% of adolescents were in the high/very high health risk group, and the difference between distributions is significant ($p<0.05$). According to WHR, 24.2% of adolescents were at risk of metabolic disease and should be treated ($p>0.05$; Table 1).

According to a study, the BMI of adolescents with T1DM is 2.7 kg/m^2 higher than their healthy peers. A high BMI level is also an indicator of high body fat percentage (23). Visceral fat percentage is particularly associated with increased serum lipid levels and metabolic syndrome. A study stated that metabolic syndrome was an important cause of morbidity and mortality in children with T1DM and increased the risk of cardiovascular disease by 1.7 times (23). Moreover, a study (21) concluded that insulin resistance in individuals with T1DM with a mean age of 16.5±2.3 years old was associated with increased body fat percentage and high-dose insulin, which adversely affected glycemic control. This study ignored the insulin resistance in the participants, but the BMI and WHRS levels at 28% and 24.2%, respectively, were found to be high (Table 1). This case may explain the reason for the high HbA1c levels (Table 3) in 80% of the participants. Furthermore, a study found a weak and negative relationship between the diet quality scores of the male participants and their WC ($r=-0.274$, $p=0.045$) and HbA1c ($r=-0.310$, $p=0.027$; $p<0.05$; Table 4) values. In conclusion, it can be asserted that a relationship between diet quality and some anthropometric measurements of adolescents with T1DM exists. As diet quality is improved, optimal anthropometric measurements will be achieved by providing weight control.

HbA1c, which reveals the mean of the blood glucose values of diabetics in the last 3 months, is accepted as the gold standard in the follow-up for diabetes. The mean HbA1c values of all participants in this study (Table 2) was 9.2%±1.92%. The ISPAD has determined the optimal HbA1c value as <7.5% for adolescents with T1DM (13). In addition, the mean HbA1c of 80% of all participants was >7.5% (Table 3). In the national and international literature, the mean HbA1c value of children and adolescents with T1DM varies between 8.1%–13.2% and 43.2%–72.0% of individuals with poor glycemic control (7, 24, 25). Maintaining good glycemic control is extremely important for people with diabetes. It requires measurement of blood glucose more than once a day, a correct interpretation of the blood glucose result and proper intervention with insulin when needed, controlled carbohydrate intake, low-fat diet intake, and regular exercise (26). Individuals with diabetes are to have special knowledge in more than one field, and decision-making and application skills to ensure the optimal level of diabetes self-care. This may be possible by having a sufficient level of health/arithmetic literacy (27). Moreover, reliable and valid data collection tools should be developed to measure nutritional literacy before the designation of the direction and content of nutrition education for patients (28).

A study (7) stated that diet quality was effective in ensuring glycemic control. According to the study by Tse et al. (16), HbA1c levels of adolescents who are at a high risk of eating behavioral disorders are higher. Moreover, some studies failed in finding a correlation between diet quality scores and HbA1c values (3, 29). A similar result was achieved in the study of Dłużniak-Gołaska et al. (29). Overall, this case may adversely affect metabolic control and increase the risk of complications. In the current study, the TC, VLDL-C, LDL-C, and TG levels at 97.8%, 13.2%, 43.6%, and 14.5% of the participants, respectively, were high. In terms of these parameters, the difference between the gender was in favor of males and statistically significant ($p<0.05$), and the HDL-C levels were found to be low at 11.4% (Table 3). In the literature, 21.7%, 13.1%, and 17.4% of the patients with diabetes were determined to have high TC, LDL-C, and TG levels, respectively. However, 95.7% had normal HDL-C levels (30). These results indicate that the adolescents in this study are at risk for cardiovascular disease because increased LDL-C particles undergo glycation and cause endothelial dysfunction by revealing more atherogenic effects. Thus, considering these parameters in the regulation of medical and nutritional treatments of people with diabetes is important.

CONCLUSION

Diet quality has been thought to have an important role in the medical nutrition treatment of T1DM, related to blood glucose control and blood lipid profile nutritional status. The majority of the adolescents with T1DM who participated in the study were found to have needs improvement in diet quality, and very few participants were with good diet quality. Thus, to improve the diet quality of adolescents with T1DM, they should increase the consumption of fruits, vegetables, milk and dairy products, dark green leafy vegetables, and dried fruits and vegetables but reduce the consumption of refined grains, ready-to-pack products with empty energy sources, and sodium. In addition, main meals and snacks should be consumed regularly; healthy food groups should be preferred in meals; and necessary legal actions should be taken for school canteens and markets, restaurants, and cafes around schools to ensure access to healthy food groups. Teachers and friends of the adolescent with T1DM should be informed, and they should be ensured to support the diabetics for healthy eating behaviors.

No meal-based evaluation was made in this study in which diet quality of adolescents with T1DM was determined and a relationship was found between diet quality and some parameters related to diabetes. Therefore, developing new scales measuring the diet quality of adolescents with T1DM and presenting meal-based recommendations would be beneficial. In addition, further research is needed to determine the diet quality of adolescents with T1DM using insulin pumps.

Ethics Committee Approval: The Ankara University Clinical Research Ethics Committee granted approval for this study (date: 22.05.2017, number: 10-526-17).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – GSB, AK; Design – GSB, AK; Supervision – GSB; Materials – ZŞ, MB; Data Collection and/or Processing – GSB; Analysis and/or Interpretation – GSB; Literature Search – GSB, AK; Writing – GSB; Critical Reviews – GSB, AK, ZŞ, MB

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