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RESEARCH

Assessment and Associations of Nutrients Intake with Glycemic Control in Pediatrics with Type 1 Diabetes

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■ Abstract

Background: Type 1 diabetes mellitus (T1DM) is a chronic metabolic disease and one of the most prevalent chronic conditions in childhood. **Aim:** This cross-sectional study aimed to compare the nutrient intake between a group of Jordanian children and adolescents with T1DM who exhibited good glycemic control and those with poor glycemic control. Additionally, the association between nutrient intake and glycemic control was tested. **Methods:** The study included a sample of 22 children, 51 pre-adolescents, and 34 adolescents, who were selected from patients of King Hussein Medical Center. The participants were divided into two groups based on their glycemic control level: those with good glycemic control (36 participants) and poor glycemic control (71 participants). Valid and reliable questionnaires were used to collect study data. A binary logistic regression analysis was conducted with glycated hemoglobin (HbA1c) as the dependent variable and nutrient intake as the independent variable. **Results and Conclusions:** The poor glycemic control group had significantly higher intake of macronutrients compared to the good glycemic control group, except for trans-fat, soluble fiber, and insoluble fiber, which did not show significant differences between the two groups. The intake of all other vitamins and minerals was significantly higher in the poor glycemic control group. However, the binary logistic regression analysis, adjusted for age, gender, daily insulin dose, type of insulin, BMI, and total energy intake, did not reveal any associations between HbA1c levels and nutrient intake. The group with poor glycemic control exhibited higher energy intake and higher intake of vitamins and minerals, except for trans-fat, soluble fiber, and insoluble fiber.

Keywords: Type 1 Diabetes, Glycemic Control, Nutrient Intake, Pediatrics.

1. Introduction

Type 1 diabetes mellitus (T1DM) is a chronic non-communicable metabolic disease caused by the autoimmune destruction of pancreatic β-cells, resulting in insulin deficiency and hyperglycemia [1]. The symptoms appear only when 70-90 % of β-cells have been destroyed as though the extent of β-cells destruction varies with age, those who are older at onset tend to have more β-cells than children where the loss of 40% of β-cells can be sufficient to induce symptoms in a 20- years-old person [2]. Type 1 diabetes mellitus is one of the most common chronic diseases of childhood. Peaks occur between five and seven years of age and at or near puberty [2]. For many years the incidence of T1DM has been increasing by about 130,000 new cases each year. According to a report by the International Diabetes Federation, T1DM affects over 1.1 million children and adolescents under the age of 20 worldwide [3]. The global trend of the increasing prevalence of T1DM with multiple etiologies operates through multiple mechanisms [4]. European Childhood Diabetes Registers continues to report increasing incidence rates, research found an increase in the prevalence of 21.1% over 8 years [5].

The staging of T1DM is classified as either pre-symptomatic T1DM, which is characterized by a decline in βcell mass without symptoms, or symptomatic T1DM, at which the symptoms of hyperglycemia and some clinical symptoms as polydipsia, polyuria, polyphagia, and weight loss βcell-directed autoimmunity, marked by the presence of autoantibodies targeting βcell autoantigens, is usually present months to years before the onset of βcell loss [6-8]. Coordinating and maintaining a balance between insulin therapy and healthy eating is important for avoiding complications. The goal of medical nutritional treatment for T1DM patients is to help maintain glucose blood levels within normal ranges to prevent both chronic and acute complications of T1DM [9]. International Society for Pediatrics and Adolescents Diabetes recommendations give the following thresholds as a guide: carbohydrate intake should be 45–50% of total daily energy intake, fat intake

no greater than 30–35% (saturated fat < 10%), and protein intake 15–20%. Energy intake should be appropriate for optimal growth in children and adolescents and for keeping an ideal body weight [10]. Carbohydrates are the primary nutrients affecting the postprandial glycemic response. Therefore, by calculating the carb amounts in each meal, the insulin dose required to preserve postprandial blood glucose within normal limits can be predicted [11]. Numerous research has shown that meals high in protein or fat cause a delayed and prolonged rise in postprandial glycaemia that occurs 2 to 6 hours after the meal, with slight variations in ranges depending on the study taken into account [10]. Micronutrient play an important role in patients with T1DM because many vitamins and minerals are vital to control glucose metabolism in different situations (insulin action, oxidative stress, and inflammation), as well as the avoidance of diabetes complications [12].

The objectives of this cross-sectional study were to compare the nutrient and energy intake between individuals with good glycemic control and those with poor glycemic control, as well as examine their association with the glycemic control among Jordanian children and adolescents with type 1 diabetes. This was accomplished by utilizing a culturally sensitive and valid food frequency questionnaire (FFQ).

2. Material and Methods

2.1. Study Population

This cross-sectional study was aimed to assess weight, height, body mass index (BMI), nutrient intake, and glycemic control in a sample of Jordanian children and adolescents with type 1 diabetes. Patients in this study were selected from King Hussein Medical Center (AL-Hussein Hospital and Queen Rania Pediatric Hospital). A total of 140 Jordanian children and adolescents who diagnosed with T1DM from at least 1 year to 10 years and aged between 6- 18 years old were selected. The sample was divided into three groups: children aged between (6-8) years old, pre-adolescents (9-13) years and adolescents (14-18), 22, 51 and 34, respectively. The inclusion criteria were onset of disease was at least 1 year and less than 10 years, children and adolescents aged 6-18 years, on insulin; and Jordanian nationality. The exclusion criteria were patients who suffer from cancers, food allergies, autoimmune diseases, unable to communicate verbally, participants on insulin pumps, and these who newly diagnosed with T1DM. Ethical approval was obtained from the Institutional Review Board of each hospital. The King Hussein Medical Center (AL-Hussein Hospital and Queen Rania Pediatric Hospital) gave the researcher permission to use a private room with good physical conditions to conduct the interviews. Institutional Review Board number 1/2019/2863 was used. During the first meeting with the participants, the researcher explained the purpose of the study. Collected data was treated confidentially in which only the researcher knew the patients' names and he was the only one who gave them ID. The researcher explained to all the caregivers of participants in this study the purpose of the study and required from them to sign a consent form before starting the data collection.

2.2. Data Collection

A hospital setting was utilized for data collection. Hospitals that offer services for patients with T1DM were chosen to conduct the study; King Hussein Medical Center (AL Hussein Hospital and Queen Rania Pediatric Hospital). A three-part package was used for collecting data that meet the purpose of the study. The package consisted of three structured questionnaires: food frequency questionnaire FFQ [13], personal information and physical activity questionnaires [14]. The face-to-face interview technique with the child's caregiver was used as a method for data collection and the questionnaire was filled by the researcher who was the student. In addition, they were divided into two groups good glycemic control with HbA1c ≤8.5 or poor glycemic control >8.5.

2.2.1. The Questionnaires

- **Personal Information Questionnaire:** Personal information sheet includes information about parents such as: age, education, marital status, occupation, family income, smoking status, and history of T1DM in addition to information on the child. This information includes: age, gender, school class level, onset of the disease and daily activities was used, anthropometric measurements (weight, height, BMI), type and doses of insulin used.
- **Dietary Assessment:** The participants' dietary information was gathered using a validated Arabic FFQ with 120 items designed for children and adolescents [13]. The subjects were asked how frequently, on average, they had eaten each food item over the previous 12 months. Each FFQ question had two parts: a food list that was adjusted to be culturally appropriate for Jordanian children and teenagers' food items, along with frequency responses for each of them, and portion size expressed in household measures (such as cups, spoons, and plates) and/or typical packing size. Based on the various types of food, the food list was categorized into multiple groups. There were 10 options for the frequency response: never, 12 years or less, 2-3 months, 1-2 weeks, 3-4 weeks, 5-6 weeks, 1 day, 2-3 days, 4-5 days, and 6 days or less. Foods that are typically consumed at particular times of the year were taken into account for seasonal variations. To calculate the intake throughout a year, the frequency of food consumption was designed. Instead of using terms such as fruits, eggs, crackers, and pastries, common units or usual units were used for some foods such as; one apple, one egg, and one piece of cracker or pastry. To assist participants in evaluating the consumed portion size of foods that cannot be assessed using standard measuring units, food models were used. A metric measurement in grams or milliliters was given for each food category. The FFQ also gathered data on the ways in which food was prepared and cooked, as well as the use of particular kinds of oil, margarine, and butter. To estimate daily intake of energy and nutrients, dietary data from the FFQ was evaluated using the dietary analysis software Food Processor

program (ESHA Food Processor SQL version 10.9.0.0) with more information on types of foods consumed in Jordan [15].

- **Physical Activity Questionnaire:** The Physical Activity Questionnaire for Older Children (PAQ-C) and Physical Activity Questionnaire for Adolescents (PAQ-A) provide a general measure of physical activity for youth from grades 4-12 (approximately ages 8-20). PAQ-C and PAQ-A are self-administered, 7-day recall questionnaire, which provide reliable and valid assessment of physical activity for children and adolescents with low cost and ease of administration. It is developed to assess general levels of physical activity. The questionnaire does not provide an estimate of caloric expenditure or specific frequency, time, and intensity information nor discriminate between specific activity intensities, such as moderate and vigorous activities. Yet, they simply provide a summary activity score [14].

2.2.2. Anthropometric Measurements

Body weight and height were measured for children, pre-adolescents, and adolescents. BMI was calculated according to Lee*et al.* [16]. The BMI was calculated from weight (kg)/height (m^2). Overweight and obesity values were categorized according to BMI-for-age CDC growth charts, which is defined as Underweight percentile < 5; healthy weight ≥5 and <85; overweight ≥85 and<95; obese ≥ 95 [16]. Body weight was taken barefoot with light clothes using the In-Body composition analyzer (In-Body 770 for adolescents and In-Body 570 for children). Standing height was measured without shoes using a stadiometer with the shoulder in a relaxed position and the arms hanging freely (to the nearest 0.5 cm).

2.2.3. Biochemical Tests

Random blood samples were drawn only from 80 participants from the whole sample by lab technicians to determine biochemical indices of participants' nutritional status. Sixty parents of the participants didn't confirm drawing samples from patients. Blood samples were drawn by a specialized lab technician where 5 ml of blood was drawn from each participant using a 3-ml syringe and a plain tube with gel. Lipid profile parameters are a group of blood tests that include; triglyceride (TG), total cholesterol, high-density lipoprotein cholesterol (HDL) and low-density lipoprotein cholesterol (LDL). HbA1c and Fasting blood glucose (FBG) results were taken from 107 patients' medical record at current.

2.2.4. Statistical Analysis

All statistical analyses were conducted using SPSS version 22.0 (IBM SPSS Statistics for Windows, IBM Corporation). Descriptive analyses were conducted to examine the frequency of different variables. Chi-square was used to detect the statistical differences among categorical variables. To evaluate the association between macronutrient, micronutrient intakes and HbA1c, we conducted a binary logistic regression analysis with an evaluation of the model using three goodness-of-fit chi-squared statistics with HbA1c as the dependent variable with suboptimal glycemic control (HbA1c ≥ 8.5%) [17]. All multivariate analyses were adjusted for age, gender, daily insulin dose (units/kg/day), type of insulin, BMI and energy intake [18]. All macro and micro nutrients were divided into tertiles in multivariate analyses in order to facilitate the calculation of odds ratios and allow a better understanding of the clinical implications of our findings. p-value < 0.05 was considered statistically significant [18].

3. Results

As shown in Table 1, patients were divided into two groups according to glycemic control, good glycemic control (n=36) having (21 males and 15 females) and poor glycemic control (n=71) having (32 males and 39 females). Clinical variables (gender, age group, age occurrence of disease and physical activity score) distribution were not significantly different between the good and poor glycemic control group (p>0.05). Additionally, anthropometric measurements (height, weight, BMI, BMI category, types of insulin and all doses of insulin) were not significantly different between the two groups. All biochemical tests were not significantly different between groups except for TG (p=0.020).

Table 1: Descriptive, Clinical, Anthropometric and Biochemical Data According to Glycemic Control.

Variable	HbA1c ≤8.5 N=(36)	HbA1c >8.5 N=(71)	p-value
Gender (N)(%)			
Male	21(58.3)	32(45.1)	0.195
Female	15(41.7)	39(54.9)	
Age Group (N)(%)			
Children	6(16.7)	16(22.5)	
Pre-adolescents	19(52.8)	32(45.1)	0.697
Adolescents	11(30.6)	23(32.4)	
Mean ± SD			
Age (years)	11.9±3.2 [a]	12.0±3.4 [a]	0.672
Onset of diseases (years)	3.3±2.3 [a]	4.0±2.7 [a]	0.168
Physical activity level	2.1±0.55 [a]	2.1±0.50 [a]	0.285
Anthropometric Measurement (Mean± SD)			
Weight (kg)	42.7±16.4 [a]	46.7±19.2 [a]	0.488
Height (cm)	146.5±17.8 [a]	144.6±23.0 [a]	0.415
BMI (kg/m2)	19.3±3.9 [a]	20.5±4.1 [a]	0.533
BMI category (N)(%)			
Underweight	4(11.1)	2(2.8)	
Normal weight	21(58.3)	43(60.6)	0.095
Overweight	9(25)	13(18.3)	
Obese	2(5.6)	13(18.3)	
Types of Insulin (N)(%)			
Rapid-acting	2(5.6)	5(7)	
Pre-mixed	16(44.4)	45(63.4)	0.070
Long-acting	2(5.6)	0	
Rapid+ long	16(44.4)	21(29.6)	
Doses of Insulin (Mean ±SD)			
At morning	1.3±4 [a]	0.8±3.1 [a]	0.233
At breakfast	9.5±5.9 [a]	13.2±6.9 [a]	0.144
At lunch	10.8±5.8 [a]	14.3±7.3 [a]	0.113
At dinner	7.6±5.5 [a]	9.9±6.1	0.770
At bedtime	7.1±10.5 [a]	5.3±9.5 [a]	0.216
Total of insulin	36.3±19.0 [a]	43.5±21.0 [a]	0.493
Biochemical Tests (Mean ± SD)			
HbA1c (%)	7.6±0.8 [b]	10.9±1.9 [a]	**<0.001**
FBG (mg/dL)	148.8±66.2 [a]	174.3±97.4 [a]	0.288
Cholesterol (mg/dL)	166.2±37.8 [a]	168.2±33.7 [a]	0.444
LDL (mg/dL)	95.3±32.3 [a]	92.0±30.6 [a]	0.627
HDL (mg/dL)	55.8±16.2 [a]	54.9±15.4 [a]	0.996
TG (mg/dL)	103.0±46.5 [b]	131.6±113.6 [a]	**0.020**

*Values are means SD or n (%), Significance is at p≤ 0.05. * Underweight = BMI % < 5; healthy weight ≥5 and <85; over weight ≥85 and<95; obese ≥ 95. * Abbreviations: BMI: Body mass index; FBG: Fasting blood glucose; LDL: Low-density lipoprotein; HDL: High-density lipoprotein; TG: Triglycerides

Table 2 and 3 summarize the median, (33.3%-66.6%) percentiles intake of macronutrients and micronutrients per day for each group according to glycemic control. Table 2 shows that total energy intake (p<0.001), kcals from fat intake (p<0.001), proteins intake (p=0.001), carbohydrates intake (p<0.001), fiber intake (p=0.011), were significantly higher in poor glycemic control. While fiber intake was significantly higher in poor glycemic control, soluble and insoluble fibers did not show any significant different between the two groups (p=0.056, p=0.053, respectively). As significant higher intakes of sugar (p<0.001), fat (p<0.001), SFA (p=0.001), MUFA (p=0.013), PUFA (p=0.016), cholesterol (p=0.035), omega-3 (p=0.001) and omega-6 (p=0.022) were detected in poor glycemic control group as compared to good glycemic control group. No significant difference was found in trans-fat (p=0.311).

Table 2: Daily Intake of Macronutrients of Good and Poor Glycemic Control Participants.

Energy and Macronutrients	Good Glycemic Control (N=36)	Poor Glycemic Control (N=71)	
	Median (33.3-66.6)%	Median (33.3-66.6)%	P-Value
Energy (kcal/day)	2237.3(2057.8-2442.2)	2859.0(2628.2-2998.9)	**<0.001**
Fat (kcal/day)	915.3(798.1-1010.6)	1129.9(1045.4-1240.4)	**<0.001**
Proteins(g/day)	82.3(69.4-91.5)	98.7(87.2-111.9)	**0.001**
Carbohydrate(g/day)	254.9(219.5-283.1)	321.1(295.5-359.4)	**<0.001**
Fibers(g/day)	28.1(25.5-31.1)	34.1(29.6-37.9)	**0.011**
Soluble Fibers(g/day)	2.7(2.0-3.3)	3.2(2.7-3.8)	0.056
Insoluble Fibers (g/day)	6.1(4.8-8.5)	7.3(6.3-9.4)	0.053
Sugars (g/day)	59.0(53.9-67.3)	85.2(70.7-102.0)	**<0.001**
Fat (g/day)	102.6(89.2-112.7)	126.2(117.1-138.4)	**<0.001**
Saturated Fat(g/day)	22.1(18.3-26.6)	27.9(25.7-31.0)	**0.001**
Monounsaturated Fat(g/day)	36.3(31.1-43.8)	45.5(38.3-55.7)	**0.013**
Polyunsaturated Fat (g/day)	18.1(14.1-26.7)	26.2(21.7-29.3)	**0.016**
Trans Fat(g/day)	0.26(0.23-0.32)	0.32(0.24-0.41)	0.311
Cholesterol (mg/day)	168.2(141.3-276.5)	250.3(197.6-321.7)	**0.035**
Omega-3 (g/day)	1.2(0.92-1.3)	1.4(1.3-1.5)	**0.001**
Omega-6 (g/day)	16.4(12.5-23.8)	23.3(18.9-26.4)	**0.022**

*p-value ≤ 0.05. *All data was performed median 33.3 and 66.6 percentiles of daily food consumption for both groups, * Two sample independent T-test was performed (Mann-Whitney U test).

Table 3 revealed that all fat-soluble vitamins (A, D, K, E) were not significantly different among good and poor glycemic control groups. Vitamin C (p=0.018), B1 (p<0.001), B2(p=0.001), B3(p=0.002), B6 (p=0.018), folate (p=0.003) and pantothenic acid (p=0.008) were significantly higher in poor glycemic control. Vitamin B12 (p=0.117), biotin (p=0.071), and folic acid (p=0.059) were not significantly different in both groups. All minerals were significantly higher in poor glycemic control except for calcium (p=0.149), iodine (p=0.196), iron (p=0.073), selenium (p=0.133) and manganese (p=0.123). GI and GL were significantly lower in the good glycemic control group (p=0.046, and p=0.002, respectively).

Table 3: Daily Intake of Micronutrients Intake of Good and Poor Glycemic Control Participants.

Micronutrients	Good Glycemic Control (N=36)	Poor Glycemic Control (N=71)	
	Median (33.3-66.6)%	Median (33.3-66.6)%	P-Value
Vitamin A (µ/day)	849.3(550.7-1079.6)	1013.4(739.4-1229.0)	0.093
Vitamin D(µ/day)	1.6(0.83-2.5)	1.7(1.2-2.8)	0.493
Vitamin E (mg/day)	12.2(8.8-15.6)	15.1(12.2-16.9)	0.120
Vitamin K (µ/day)	879.1(667.3-967.1)	915.9(505.6-1085.8)	0.406
Vitamin C (mg/day)	137.5(108.5-177.3)	167.8(141.3-203.1)	**0.018**
Vitamin B1 (mg/day)	1.5(1.4-1.6)	1.8(1.7-2.0)	**<0.001**
VitaminB2 (mg/day))	2.0(1.4-2.2)	2.3(2.0-2.6)	**0.001**
Vitamin B3 (mg/day)	18.9(14.8-20.9)	22.5(20.0-24.2)	**0.002**
Vitamin B6 (mg/day)	1.6(1.3-1.7)	1.7(1.6-2.0)	**0.018**
Vitamin B12 (µ/day)	3.1(2.4-3.6)	3.7(2.7-4.2)	0.117
Biotin (µ/day)	26.4(19.8-31.2)	29.5(25.2-35.6)	0.071
Folate (µ/day)	430.0(353.8-497.6)	511.7(456.4-587.3)	**0.003**
Folic Acid (µ/day)	89.3(63.1-107.4)	95.4(79.9-123.9)	0.059
Pantothenic Acid (mg/day)	5.0(4.1-5.8)	5.7(5.2-6.4)	**0.008**
Calcium (mg/day)	1103.0(879.7-1249.3)	1119.0(974.1-1448.6)	0.149
Iodine (µ/day)	98.6(77.8-122.3)	108.1(93.0-129.8)	0.196
Iron (mg/day)	32.6(18.5-41.3)	34.8(25.9-54.4)	0.073
Magnesium (mg/day)	337.3(296.8-386.9)	410.2(360.6-448.1)	**0.003**
Phosphorus (mg/day)	1151.8(932.9-1308.2)	1325.9(1119.2-1419.6)	**0.007**
Potassium (g/day)	3.2(2.8-3.8)	3.8(3.4-4.1)	**0.006**
Sodium (g/day)	2.5(2.1-2.9)	3.1(2.7-3.5)	**0.001**
Selenium(µ/day)	64.7(49.7-88.8)	81.1(68.1-92.4)	0.133
Zinc (mg/day)	9.0(8.1-11.5)	11.7(10.4-12.5)	**0.019**
Chromium (µ/day)	2.7(2.2-3.6)	3.7(2.9-4.3)	**0.003**
Copper (µ/day)	1310.0(1190-1526.4)	1670.0(1469.5-1839.0)	**<0.001**
Manganese (mg/day)	4.2(3.8-5.2)	4.8(4.0-6.0)	0.123
Choline (mg/day)	188.1(141.4-229.4)	235.4(186.4-286.4)	**0.038**
Glycemic index	51.3(49.1-53.3)	53.4(51.0-54.5)	**0.046**
Glycemic load	28.6(14.6-41.4)	44.1(30.8-50.2)	**0.002**

*p-value ≤ 0.05. *All data was performed median 33.3 and 66.6 percentiles of daily food consumption for both groups. *Two sample independent T-test was performed (Mann-Whitney U test).

Tables 4 and 5 delineate all the nutrients by categorizing them into tertiles, providing odds ratios and their respective 95% confidence intervals for the dietary intake of study participants, contingent upon their HbA1c levels. In binary logistic regression analyses, which were adjusted for age, gender, daily insulin dosage, insulin type, BMI, and total energy intake, no significant associations were observed between HbA1c and nutrient consumption.

Table 4: Odd Ratios (OR) for HbA1c and Corresponding 95% Confidence Intervals (95%CI) According to Tertile Level of Intake of Macronutrients.

Energy and Nutrients	OR (95% CI) (HbA1c)			
	T1	T2	T3	*P*- trend
Energy and Macronutrients				
Energy	1	1.25 (0.43-3.65)	1.13 (0.38-3.36)	0.832
Fat	1	1.49(0.42-5.31)	1.51 (0.44-5.25)	0.659
Proteins	1	0.93(0.27-3.21)	0.90 (0.25-3.19)	0.773
Carbohydrate	1	1.61 (0.45-5.80)	1.38(0.39-4.88)	0.670
Fibers	1	1.40 (0.40-4.90)	1.16 (0.34-3.92)	0.859
Soluble Fibers	1	1.14(0.34-3.77)	1.09(0.31-3.86)	0.873
Insoluble Fibers	1	0.77(0.23-2.60)	1.10(0.30-3.96)	0.949
Sugars	1	0.92(0.26-3.22)	0.82(0.24-2.83)	0.678
Fat	1	1.49 (0.42-5.31)	1.51(0.44-5.25)	0.659
Saturated Fat	1	1.02 (0.30-3.46)	0.94(0.29-3.04)	0.873
Monounsaturated Fat	1	1.42 (0.42-4.86)	1.72 (0.50-5.89)	0.389
Polyunsaturated Fat	1	0.98 (0.28-3.46)	1.27 (0.37-4.37)	0.693
Trans Fat	1	2.56 (0.73-8.94)	1.01(0.31-3.34)	0.815
Cholesterol	1	0.94 (0.24-3.67)	0.91(0.26-3.18)	0.934
Omega-3	1	1.14(0.31-4.17)	0.94(0.26-3.36)	0.944
Omega-6	1	0.99(0.28-3.47)	1.30(0.38-4.46)	0.656

*OR and CI: odd ratio and confidence interval. * Adjusted for age and gender, BMI, type of insulin, the total dose of insulin, and energy intake [18]. Odds ratios are considered statistically significant at $P \leq 0.05$.

Table 5: Odd Ratios (OR) for HbA1c and Corresponding 95% Confidence Intervals (95%CI) According to Tertile Level of Intake of Micronutrients.

Energy and Nutrients	OR (95% CI) (HbA1c)			
	T1	T2	T3	*P*- trend
Vitamin B1	1	1.37(0.39-4.89)	1.08(0.29-4.03)	0.988
Vitamin B2	1	0.71 (0.20-2.57)	0.82 (0.23-2.84)	0.757
Vitamin B3	1	1.58 (0.45-5.61)	1.26(0.34-4.68)	0.957
Vitamin B6	1	0.83 (0.24-2.89)	1.1(0.29-4.09)	0.869
Vitamin B12	1	0.78(0.22-2.82)	0.92(0.27-3.18)	0.746
Vitamin C	1	0.64(0.18-2.21)	1.53(0.42-5.58)	0.719
Vitamin E	1	1.50(0.41-5.54)	1.51 (0.45-5.11)	0.405
Folate	1	0.47 (0.13-1.76)	1.40(0.36-5.52)	0.680
Vitamin K	1	0.90 (0.25-3.2)	1.14(0.32-4.07)	0.834
Calcium	1	1.02 (0.29-3.58)	0.87(0.26-2.90)	0.972
Iodine	1	1.00 (0.28-3.57)	0.63 (0.18-2.18)	0.534
Iron	1	1.35 (0.39-4.65)	0.85 (0.25-2.89)	0.947
Magnesium	1	0.80(0.23-2.77)	1.12(0.32-3.89)	0.862
Phosphorus	1	0.81(0.23-2.80)	0.93(0.25-3.40)	0.917
Potassium	1	0.83 (0.25-2.72)	1.18(0.32-4.26)	0.917
Selenium	1	0.85(0.24-3.01)	0.82(0.23-2.93)	0.781
Sodium	1	1.30(0.38-4.47)	1.20(0.35-4.17)	0.726
Zinc	1	0.52 (0.13-2.08)	0.72(0.19-2.66)	0.799
Vitamin D	1	1.73(0.48-6.16)	0.75(0.22-2.55)	0.765
Vitamin A	1	0.94 (0.27-3.26)	1.32 (0.38-4.58)	0.927
Chromium	1	1.70 (0.49-5.92)	1.30(0.37-4.49)	0.980
Copper	1	1.40 (0.39-4.99)	1.05(0.30-3.63)	0.940
Manganese	1	1.22 (0.35-4.26)	0.89 (0.26-3.01)	0.935
Choline	1	0.60(0.15-2.35)	0.52 (0.14-1.97)	0.376
Glycemic Index	1	1.04(0.31-3.53)	1.27(0.39-4.17)	0.574
Glycemic Load	1	1.11(0.33-3.66)	1.06(0.33-3.48)	0.849

*OR and CI: odd ratio and confidence interval. * Adjusted for age and gender, BMI, type of insulin, the total dose of insulin, and energy intake [18]. Odds ratios are considered statistically significant at $P \leq 0.05$.

4. Discussion

In this study, we divided the sample into two groups according to glycemic control, good glycemic control n=36 (21 males and 15 females) and poor glycemic

control n=71 (32 males and 39 females). Clinical variables (gender, age group, age occurrence of disease, types of insulin and all doses of insulin) were not significantly different between the good and poor glycemic control groups (p>0.05). With this contrast, another study results did not show any differences in age, gender, and disease duration between the two groups [19]. As well as, in a retrospective chart review study of children with type 1 diabetes also showed no significant difference between the two groups concerning gender, age at diagnosis, and type of insulin regimen [20]. Another study found that poor glycemic control was 41% in participants aged between 38, 67% in those aged 912, and 76% in those aged 1318 years and this shows that as age increases glycemic control deteriorates [21]. Moreover, they have found that a longer duration of diabetes is associated with significantly poor glycemic control. They had a mean duration of 7.3 ± 3.5 years [21]. All biochemical tests including lipid profile and FBG were not significantly different between groups except for TG (p= 0.020). A cross-sectional prospective study aimed to determine whether lipid parameters were altered in children with T1DM. It resulted in a significant statistical increase in serum cholesterol, and LDL (p = 0.0016, p = 0.0004, respectively) when comparing good and poor glycemic control [22]. A cross sectional study also agrees with these results and concluded that serum cholesterol, HDL, and TG were statistically significant when compared between good and poor glycemic control (p= 0.003, p=0.005, p=0.022, respectively) and that agreed with our findings considering only TG [23]. Moreover, we obtained the median, (33.3%-66.6%) percentiles intake of macro and micronutrients per day for each group according to glycemic control.

The intakes of total energy (p<0.001), energy from fat (p<0.001), protein (p=0.001), carbohydrate (p<0.001), fiber (p=0.011), sugar (p<0.001), fat (p<0.001), SFA (p=0.001), MUFA (p=0.013), PUFA (p=0.016), cholesterol (p=0.035) omega-3 (p=0.001) and omega 6 (p=0.022) were significantly higher in poor glycemic control group as compared to the good glycemic control group. Another study showed no significant difference in any macronutrient between good and poor glycemic control except for energy from median fat intake (30.5 ±3.3 and 32.8±3.0, respectively: p=0.003) [24]. A cross sectional study reported higher energy intake in good glycemic control (p=0.0006), higher carbohydrate intake (p=0.04), higher fiber intake (p=0.007) and lower energy from fat intake (p=0.02) and these results support our results only in energy from fat. GI and GL were significantly lower in the good glycemic control group (p=0.046, and p=0.002, respectively) [17]. This result agrees with Queiroz*et al.* [25] who showed that participants with good glycemic control consumed diets with lower GI and GL (54.8 ± 2.7/118.3 ± 29.8, respectively) than the ones with poor glycemic control (60.3 ± 4.1/153.7 ± 40.7, respectively) [25].

In multivariate analyses adjusting for age, gender, daily insulin dose, type of insulin, BMI, and total energy intake, no associations were found between HbA1c and nutrient intake in bivariate analyses. Katz *et al.* (2014) found a significant association between higher fat intake and HbA1c level of ≥8.5 (p-value for trend = 0.007) and HbA1c level of < 8.5% was associated with less fat intake (p= 0.001) association between an HbA1c level of < 8.5% and more daily fiber (p= 0.02), but these significant associations were only on youths who were treated by insulin pump. Considering Katz*et al.* [17] findings on youth treated with injection, no association were found between fat intake, daily fibers intake and suboptimal HbA1c (p-value of trend = 0.7, 0.1), respectively [17]. No association was detected between HbA1c and protein intake in bivariate analysis. In 114 youth with T1DM, the odds of having an HbA1c > 7.5 increases by 53% per 1% of energy from SFA intake [18].

Due to the nature of the sample study adopted in this research, there were certain weaknesses. The study's methodology significantly relied on children's and parents' ability for recalling accurate information regarding the consumed food and physical activity. It's possible that some individuals could remember things more intensely than others, and that bias might exist in the minds of those being interviewed as well as the interviewer. As mentioned above, the parents and their children were answering the FFQ about the dietary intake over the past year and because the majority of the participants were children, some of the children may have concealed answering the question regarding the type of sweets they consumed, such as chocolate, candy, and several types of chips, out of fear of their parents. While trying to account for a variety of potential confounders, we did not take into account the potential impact of cooking on the bioavailability of the different nutrients. A major strength of our study is the validated and detailed FFQ used to collect dietary data from our study population. Even though dietary data was collected at only one time, the FFQ has excellent reproducibility and good relative validity for most food groups among Jordanian children and adolescents. Moreover, this study was the first to assess the dietary patterns, lifestyle, and nutrient intake of children and adolescents with T1DM.

5. Conclusion

In light of the results and discussion conducted in the current study, Higher TG serum level was detected among participants with poor glycemic control compared to good glycemic control. High-Vegetables dietary pattern showed a protective effect against poor glycemic control. Further investigation is needed using prospective studies to confirm our results. Future studies with a higher number of participants are required to confirm these results and find more associations that connect nutrient intake and dietary patterns with glycemic control. Family monitoring and modification of the eating habits of children to control their energy and nutrient intake are necessary.

Disclosure of Potential Conflicts of Interest: The authors declare that they have no conflict of interest.

Human or Animal Rights Statement: The study protocol was approved by King Hussein Medical Center Institutional Review Board (IRB) committee. The IRB number of the study was 1/2019/2863 and it was obtained on June, 2019. Consent form was obtained from the caregivers of participants after explaining the purpose of the study and before starting the data collection.

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Authors' Contribution: RT was responsible for the study conception and design and responsible for the development of the methodology. SZ was responsible for the acquisition of data. RT, SA and SZ were responsible for the analysis and interpretation of data. RT, SA, and SZ were responsible for drafting the manuscript, critically revising the manuscript, and reading and approving the final manuscript.

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