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ORIGINAL ARTICLE

ASSESSMENT OF DIET QUALITY IN CHILDREN AND ADOLESCENTS WITH TYPE 1 DIABETES

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ABSTRACT

Background. Micronutrient malnutrition is a serious public health problem in most developing countries, including Morocco, due to poor and therefore lower quality diets that lack dietary diversity.

Objective. The present study aimed to assess dietary diversity and variety and their relationship with micronutrient adequacy in children and adolescents with type 1 diabetes (T1D).

Materials and methods. A cross-sectional study was carried among 240 children and adolescents with T1D. Weight and height were measured and BMI was calculated. Dietary intake data were obtained from two 24-h recalls. A Dietary diversity (DDS) and dietary variety scores (DVS) and mean adequacy ratio (MAR) and nutritional adequacy ratios (NARs) were calculated and compared according to sociodemographic/anthropometric categories.

Results. 52.1% of the patients were female. The mean age of the patients was 8.49 ± 4.1 years. The mean BMI was 19.44 ± 5.24 kg/m2; the mean DDS was 4.62±1.20 and the mean MAR was 0.66 ± 0.11. Older children living in rural areas have a low DDS/DVS. Parental education and income level are associated with DDS/DVS. General and central obesity were significantly elevated in children with high DDS. In addition, a high intake of vegetables, eggs, fiber and micronutrients (Magnesium, Calcium, Potassium, Zinc, Phosphorus and Vit B1) is associated with a high DDS; however, high DVS is associated with high consumption of dairy products, carbohydrates and low intake of protein and fat. There are also positive correlations between DDS/DVS and NARs for various nutrients.

Conclusion. The quality of the respondents' diets are moderately diversified. DDS or DVS can be used as indicators of micronutrient adequacy in Moroccan T1D children. Nutritional education needs to be strengthened to improve dietary diversity in children, especially in rural areas.

Key words: *diet quality, dietary diversity score, dietary variety score, nutritional adequacy, child/adolescent, T1D*

INTRODUCTION

Type 1 diabetes (T1D) is an autoimmune disease characterized by the destruction of beta cells in the islets of Langerhans of the pancreas that are responsible for insulin production [1]. Currently, T1D is one of the most common chronic diseases in children and adolescents [2]. The International Diabetes Federation (IDF) estimates that more than 1.1 million children and adolescents are living with T1D [1].

On the other hand, deficiencies of micronutrients constitute a serious nutritional problem in children in both developed and developing countries [3]. Whereas, overweight and obesity have been a public concern for decades in many countries, ranging from high-income to low-and middle-income countries[4]. As a result, Morocco, with respect to developing countries, faces the double burden of undernutrition and overnutrition [5]. On the one hand, more than a third of Moroccan children (31.6%) aged 6 months to 5 years old suffer from iron deficiency anemia; and about a third from folic acid deficiency; while vitamin A deficiency affects 40.90% of children aged 6 to 72 months [5]. Furthermore, the prevalence of childhood overweight

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and obesity has increased alarmingly. Thus, according to the World Health Organization (WHO), Morocco is classified among the countries with a prevalence of overweight/obesity of 10 to 14.9%, alongside Algeria and Tunisia [6]. This increase is partly explained by the nutrition transition in the Moroccan population, which consumes foods and beverages rich in calories and poor in micronutrients with an increase in sedentary activities [7].

Furthermore, dietary diversity (DD) is universally recognized as a measure of the nutritional quality of household access to a variety of foods and also reflects the nutritional adequacy of an individual's diet [8]. There are several indicators to assess dietary quality, such as the Dietary Diversity Score (DDS) and the Dietary Variety Score (DVS) [9]. In addition, several studies have shown that these measures have strong associations with diet quality and nutritional status of individuals [10]. International dietary guidelines recommend improving DD to meet daily nutritional needs and reduce the increased risk of chronic disease [8]. Indeed, most of the micronutrients we need come from the daily diet. In addition, several studies have shown that the nutritional quality of the diet is improved when it is diversified [11]. For this reason, a healthier diet is one that is more varied [12]. Moreover, studies have also shown that DDS is positively associated with micronutrient adequacy in children [13]. However, it is possible that diversified diets provide adequate micronutrients associated with increased energy intake [14]. This is confirmed by some research showing an association of high DDS with general obesity (GO) and central (CO) obesity [15], metabolic syndrome, and with the risk of cardiovascular disease (CVD) [16, 17]. This evidence indicates that DD can increase micronutrient intake and improve children's physical health and cognitive development.

Thus, data on dietary intakes are essential for understanding the role of diet quality in nutritional deficiencies and, eventually, for designing effective nutritional interventions. In low- and middle-income countries, of which Morocco is a part, the diet of children and adolescents lacks variety and consists mainly of cereals, with limited consumption of foods of animal origin, fruits and vegetables and dairy products [18]. To our knowledge, few national studies have assessed diet quality in children and adolescents. Therefore, the aim of the present study is to assess dietary diversity DD and dietary variety (DV) and their association with sociodemographic/anthropometric variables, dietary intakes and micronutrient adequacy in children and adolescents with T1D.

MATERIALS AND METHODS

Study population

This is a prospective descriptive study conducted at the level of the pediatric unit of the Mohamed V Provincial Hospital of El Jadida over a period from March 2018 to December 2020. The target population was 240 diabetic children, aged 15 years or less, with T1D for 12 months to avoid the remission period due to the residual secretion of endogenous insulin during recent diabetes. A structured questionnaire was used and completed with the patients or their parents to collect data on the sociodemographic and socioeconomic characteristics, family history, the disease characteristics, diabetes management (number of daily insulin injections and frequency blood glucose self-monitoring per day), and anthropometric measurements (weight, height, waist circumference, WHtR and BMI).

The interview was conducted with the parents (or the participant's guardian) when the child's age was less than 11 years and with the child him/herself when the child's age was 11 years or older. Treating physicians and medical records were also used as sources of data.

Socioeconomic and sociodemographic characteristics

Data collected on participants' socioeconomic (SES) and sociodemographic status are collected through structured interviews included, age, sex, area of residence, parental education level, and household income.

Anthropometric measurements

These parameters were measured on participants in the pediatrics unit on the day of the interview according to the WHO standards [19]. Weight, was measured in kilogram to the nearest 0.1 kg, on children wearing lightly dressed and without shoes, on a mechanical scale. The height was measured in the participants to the nearest 0.1 centimeter using a wall scale with heels joined, legs straight, arms dangling and shoulders relaxed.

Waist circumference (WC) was measured on respondents standing with feet 2.5 cm apart, legs straight, arms hanging down and shoulders relaxed, the measuring tape was placed uncompressed at midway between the iliac crest and the last rib, at the end of expiration. The Waist-to-Height Ratio (WHtR) was calculated and the WHtR cut-off of 0.5 is used to define abdominal obesity for both boys and girls [20].

Finally, the body mass index (BMI) a measure that estimates the fat mass of individuals, was calculated by dividing the weight in kg by the square of the height expressed in meters (kg/m^2): BMI = Weight (kg)/ Height^2 (m^2). The references established by WHO in

2007 are used to calculate Z Score values for BMI for age using WHO software, AnthroPlus (Version 1.0.4, 2010), to assess the growth of children and adolescents worldwide [21]. Thus, children under five years old are considered underweight when Z score < −2 standard deviations (SD), overweight when a Z score > +2 SD and obese if Z score > +3 SD [22]. For the children aged 5 to 19 years, they were classified into 3 categories: underweight when Z Score < −2 SD, overweight if Z Score > +1 SD and obese if Z Score > +2 SD [23, 24].

The 24-hour recall and the food frequency questionnaire

Dietary intake data are collected using two 24-hour dietary recalls technique (including one weekday and one weekend day) to list all foods ingested and participant's macronutrient and micronutrient intak. Each respondent was asked to describe precisely everything they consumed (drunk and eaten) during the previous 24 hours, rising the night before until the same time on the day of the survey. The respondent was also asked to quantify the foods described, with her own measures (household measures), using an iconographic manual [25]. Dietary intakes were converted to estimate energy and their composition in nutritional intakes using the BILNUT software (S.C.D.A. NUTRISOFT-BILNUT, version 2.01). The values obtained were then compared to the reference intakes.

Unlike the 24-hour recall, the food frequency questionnaire (FFQ) is a qualitative method that provides an overall idea of the eating habits of the population. The questions are oriented on the quantity and frequency of usual consumption of foods over a long period, referring to a pre-established list. Indeed, the FFQ is made up of two parts: a closed list of foods and a section where the frequency of consumption can be indicated (for example, several times a day, 3 to 4 times a week, 1 to 2 times a week, once or twice a month, less than once a month and never) and a section with more detailed questions about the size the portion consumed and its composition.

Measurement of DDS and DVS

DDS is defined as the number of unique food groups consumed by the child over a specified period [26]. The diet was classified into nine food groups according to FAO recommendations, which included: (1) starchy foods (cereals, roots and tubers), (2) dark green leafy vegetables, (3) other fruits and vegetables rich in vitamin A, (4) other fruits and vegetables, (5) organ meats, (6) meat, poultry and fish, (7) eggs, (8) legumes, nuts and seeds and (9) milk and milk products [26].

A score of '1' was assigned to each food group if at least one food from the specific food group was consumed during the reference period. A score of '0' was assigned if the child did not consume any food from a given food group. The DDS for each child was calculated as the sum of the scores, with a maximum possible score of '9'. The DDS could be low: consumption of foods from ≤3 groups, medium/moderate: consumption of foods from 4 to 5 groups, or high: consumption of foods from ≥6 groups [27].

The DVS, on the other hand, represents the number of foods consumed in the past 24 hours, 48 hours or 3 days [28]. In other words, the consumption of a mixture of foods belonging to different groups used for the calculation of the DDS (cereals, dairy products, etc.) and a mixture within each group: wheat, corn, rice, barley, bread, pasta, … for the cereals group for example [29].

Indices reflecting nutritional adequacy

To determine the nutritional adequacy of the diet, the Nutrient Adequacy Ratio (NAR) was calculated as the estimated individual daily intake of each nutrient divided by the recommended intake for that nutrient taking into account sex and age category of the subject. In the present study, NAR values were evaluated for 11 micronutrients that are most commonly used for calculating adequacy scores especially in adolescents (Sodium, Magnesium, Calcium, Potassium, Zinc, Iron, Phosphorus, Vit E, Vit B1, Vit C and Folate) [30].

The mean adequacy ratio (MAR), which represents the overall adequacy of the daily food intake with the nutritional recommendations, was calculated as the sum of the NARs of all the nutrients evaluated divided by the number of nutrients evaluated, expressed as a percentage [28]. All NARs with values greater than "one" were reduced to "one" to avoid compensation for deficiencies that may be recorded for some nutrients [28]. Thus, the maximum value of NARs should be capped at "one". The reference value of the MAR is also set at "one", which corresponds to 100% of the recommended dietary Allowance (RDA) and reflects an ideal adequacy to the dietary recommendations.

Statistical analysis

Data analysis was performed using SPSS for Windows (Statistical Package for the Social Sciences) version 23.0. A descriptive analysis is performed to describe the characteristics of the study participants, namely sociodemographic and socioeconomic variables and anthropometric measures. The independent sample t-test, ANOVA test and Chi-square test are applied for the comparison of means ± standard deviations and proportions (in percent) of continuous and categorical variables, respectively. P values less than 0.05 are considered statistically significant for all tests. In addition, *Pearson* correlations between the MAR and NARs variables and the DDS and DVS variables were performed.

Ethical considerations

The questionnaire used in this study was validated by a scientific committee of Chouaib Doukkali University of El Jadida and data collection began after obtaining authorization from the Regional Health Department of the Casablanca-Settat region in Morocco. For each child, free and informed written consent was obtained from the parents or guardians before starting the survey. The procedures and objectives of the study were also clearly explained to the participants. The confidentiality and anonymity of the information collected were also respected.

RESULTS

Characteristics of the population

Table 1 brings together the different sociodemographic and anthropometric characteristics of the study population. The survey included a total of 240 diabetic subjects, with a mean duration of T1D of 3.24±2.39 years and a family history of diabetes in almost half of them (48.8%). In addition, 52.1% of the patients were female (sex ratio 0.85). The mean age of the patients was 8.49±4.1 years, ranging from 2 to 15 years with the age group of 11-15 years being the most representative (40.8%), with a majority (68 .5%) of school age, 95.18% of them attending school. The majority of these participants resided in urban areas (61.4% vs. 38.6% in rural areas) and 63% lived in nuclear families. Overall, illiteracy was 75.5% among the patient's parents, with a higher rate among mothers (69%) than fathers (13.6%). However, a higher level of education was found in 3.8% of mothers. The patients came from parents of predominantly low socioeconomic level (83.2%). Table 1 also shows that the population a mean BMI of 19.44±5.24 kg/m2 with normal weight prevalent in 63.6%, underweight in 15.8%, overweight in 17.9%, GO in 2.7% and CO (WHtR ≥ 0.5) in 27.2% of patients.

Sociodemographic and anthropometric characteristics according to DDS and DVS level

The sociodemographic and anthropometric variables of the respondents distributed according to the categories of DDS and DVS are listed in Table 2. Older children and those living in rural areas have a low DDS/DVS. We also found that the higher the parents' education and income level, the more attention they paid to their child's nutrition. No significant association was found between DDS/DVS and gender in this study. The data in the table also show that WHtR was significantly higher in T1D children with a high DDS. In addition, GO and CO was significantly higher in children with high DDS.

Table 1. General characteristics of the study population

Characteristics		N(%) or mean±SD
Sociodemographic characteristics		
Age (years)		8.60±4.08
Sex	Male	115(47.9%)
	Female	125(52.1%)
Age category	≤ 4 years	57(23.8%)
	5-10 years	83(34.6%)
	11-15 years	100(41.7%)
Area of residence	Urbain	143(59.6%)
	Rural	97(40.4%)
Fathers education level	Never attended	161(67.1%)
	Primary school	19(7.9%)
	College school	21(8.8%)
	Secondary school	13(5.4%)
	University	26(10.8%)
Mothers education level	Never attended	176(73.3%)
	Primary school	35(14.6%)
	College school	13(5.4%)
	Secondary school	9(3.8%)
	University	7(2.9%)
Household income	Low	207(86.3%)
	Medium	26(10.8%)
	High	7(2.9%)
Disease characteristics		
Duration of diabetes (years)		3.24±2.395
Family history of diabetes		117(48.8%)
Number of injections / day	2 injections	194(80.8%)
	3 injections	41(17.1%)
	4 injections	5(2.1%)
Self-monitoring of blood glucose	<4times/d	209(87.1%)
	≥ 4times/d	31(12.9%)
Anthropometric characteristics		
Weight (kg)		29.41±14.81
Height (m)		1.25±0.23
BMI (kg/m²)		19.51±5.12
WHtR (cm)		0.45±0.05
BMI categories n (%)	Normal weight	165(68.8%)
	Overweight	38(15.8%)
	Obese	6(2.5%)
	Underweight	31(12.9%)
WHtR categories n (%)	No abdominal obesity (WHtR < 0.5)	184(76.7%)
	Abdominal obesity (WHtR ≥ 0.5)	56(23,3%)

Abbreviations: Data are presented as mean ± standard deviation (SD) or as (%). BMI: Body Mass Index; WHtR: Waist-to-Height ratio.

Table 2. Sociodemographic and anthropometric characteristics according to DDS and DVS level

Variables		DDS				DVS		
		Low (n=38)	Medium (n=155)	High (n=47)	P-value	Insufficient (DVS≤6)	Correct (DVS>6)	P-value
DDS		2.73±0.44	4.56±0.49	6.36±0.73	≤0.01			
DVS						4.99±1.06	8.76±1.91	≤0.001
Sociodemographic characteristics								
Sex	Male	18(15.7%)	80(69.6%)	17(14.8%)	0.178	60(52.2%)	55(47.8%)	0.923
	Female	20(16.0%)	75(60%)	30(24%)		66(52.8%)	59(47.2%)	
Age categories	<= 4 yrss	2(3.5%)	41(71.9%)	14(24.6%)	0.019*	20(35.1%)	37(64.9%)	0.005*
	5-10 yrs	12(14.5%)	55(66.3%)	16(19.3%)		44(53%)	39(47%)	
	11-15 yrs	24(24%)	59(59%)	17(17%)		62(62%)	38(38%)	
Area of residence	Urban	13(9.1%)	92(64.3%)	38(26.6%)	≤0.001	60(42%)	83(58%)	≤0.001
	Rural	25(25.8%)	63(64.9%)	9(9.3%)		66(68%)	31(32%)	
Fathers education level	Never attended	34(21.1%)	105(65.2%)	22(13.7%)	0.001*	100(62.1%)	61(37.9%)	≤0.001
	Primary school	2(10.5%)	13(68.4%)	4(21.1%)		9(47.4%)	10(52.6%)	
	College school	1(4.8%)	16(76.2%)	4(19%)		6(28.6%)	15(71.4%)	
	Secondary school	0(0%)	9(69.2%)	4(30.8%)		4(30.8%)	9(69.2%)	
	University	1(3.8%)	12(46.2%)	13(50%)		7(26.9%)	19(73.1%)	
Mothers education level	Never attended	34(19.3%)	117(66.5%)	25(14.2%)	0.001*	105(59.7%)	71(40.3%)	0.003*
	Primary school	2(5.7%)	26(74.3%)	7(20%)		14(40%)	21(60%)	
	College school	1(7.7%)	5(38.5%)	7(53.8%)		3(23.1%)	10(76.9%)	
	Secondary school	1(11.1%)	4(44.4%)	4(44.4%)		3(33.3%)	6(66.7%)	
	University	0(0%)	3(42.9%)	4(57.1%)		1(14.3%)	6(85.7%	
Household income	Low	38(18.4%)	140(67.6%)	29(14%)	≤0.001	120(58%)	87(42%)	≤0.001
	Medium	0(0%)	12(46.2%)	14(53.8%)		5(19.2%)	21(80.8%)	
	High	0(0%)	3(42.9%)	4(57.1%)		1(14.3%)	6(85.7%)	
Anthropometric characteristics								
Weight (kg)		33.34±12.95	28.15±14.33	30.45±17.28	0.133	30.84±14.47	27.85±15.1	0.526
Height (m)		1.36±0.17	1.23±0.23	1.23±0.23	0.008*	1.29±0.22	1.21±0.24	0.117
BMI (kg/m2)		20.36±4.51	19.06±4.84	20.35±6.27	0.175	19.81±4.94	19.19±5.31	0.31
WHtR (cm)		0.42±0.04	0.45±0.05	0.47±0.04	≤0.001	0.44±0.05	0.46±0.05	0.473
BMI categories	Normal weight	20(12.1%)	119(72.1%)	26(15.8%)	≤0.001	82(49.7%)	83(50.3%)	0.062
	Overweight	7(18.4%)	18(47.4%)	13(34.2%)		19(50%)	19(50%)	
	Obese	0(0%)	2(33.3%)	4(66.7%)		2(33.3%)	4(66.7%)	
	Underweight	11(35.5%)	16(51.6%)	4(12.9%)		23(74.2%)	8(25.8%)	
WHtR categories	No abdominal obesity	36(19.6%)	117(63.6%)	31(16.8%)	0.007*	107(58.2%)	77(41.8%)	0.001*
	Abdominal obesity	2(3.6%)	38(67.9%)	16(28.6%)		19(33.9%)	37(66.1%)	

Abbreviations: Data are presented as mean ± standard deviation (SD) or (%).
BMI: Body Mass Index; WHtR: Waist-to-Height ratio; DDS: dietary diversity score; DVS: dietary variety score.
The differences between the sociodemographic and anthropometric characteristics according to the DDS/DVS categories were compared by the t test and Anova for the continuous variables and by the Chi2 test for the categorical variables. The mean difference is significant at the 0.05 level.

Association of dietary intake with DDS and DVS

Dietary intake, including food group intake, is presented in Table 3. High DDS was associated with high intake of vegetables, eggs and micronutrients (fiber, Magnesium, Calcium, Potassium, Zinc, Phosphorus and Vit B1). However, high DVS was associated with high consumption of dairy products, carbohydrates, and low intake of protein and fat.

Pearson correlation coefficients between the NAR of some nutrients, MAR, DDS and DVS

Table 4 revealed that the average MAR of the studied population is 0.66±0.11 and the nutrients with the lowest NARs are Calcium, Potassium, Vitamin E and folate. The use of bivariate correlation analyses showed that there are significant and positive correlations between the DDS/DVS and most of the NARS for various nutrients, except Sodium, Potassium for the DDS and Sodium, Potassium and Iron for the DVS.

Table 3. Association of food intake with DDS and DVS

	DDS				DVS		
	Low (n=38)	Medium (n=155)	High (n=47)	P-value	Insufficient (DVS≤6)	Correct (DVS>6)	P-value
Food groups intake (g/d)							
Cereals	381.82±95.80	380.24±170.88	371.68±178.28	0.944	390.75±152.88	365.62±171.98	0.526
Vegetables	210.15±70.60	205.84±66.15	239.18±85.56	0.019*	214.54±74.91	211.41±68.71	0.366
Legumes	7.38±4.74	7.09±4.14	7.26±4.55	0.923	7.46±4.66	6.86±3.87	0.153
Fruits	92.31±36.66	94.57±41.60	108.81±39.99	0.082	95.00±39.31	99.22±42.48	0.701
Meat/poultry	46.99±17.97	41.38±18.15	43.09±29.62	0.082	43.90±18.05	41.17±23.59	0.418
Fish	14.48±8.09	13.26±7.89	15.53±11.56	0.27	13.62±7.45	14.21±10.04	0.113
Eggs	17.79±8.34	18.89±9.20	24.63±21.35	0.012*	18.53±9.16	21.28±15.46	0.627
Dairy products	202.33±91.67	240.41±112.51	245.11±120.83	0.136	216.11±101.34	256.51±119.02	0.019*
Oils/fats	21.34±9.26	17.78±10.22	19.58±11.73	0.138	19.88±10.58	17.40±10.15	0.636
Macronutrients and energy intakes							
Calories (kcal/d)	1540.68±443.89	1419.33±485.86	1467.79±508.62	0.367	1422.32±428.98	1476.47±539.06	0.071
Carbohydrates (%TEI)	50.18±7.15	52.67±6.52	51.81±5.24	0.096	51.20±7.29	53.11±5.19	0.002*
Proteins (%TEI)	14.65±2.87	13.86±2.52	14.51±2.39	0.115	14.18±2.89	14.03±2.15	0.02*
Lipids (%TEI)	35.16±6.20	33.46±5.63	33.71±4.87	0.246	34.60±6.14	32.86±4.78	0.006*
Micronutrients intake							
Fibres (g/d)	10.27±4.35	11.10±6.78	15.26±8.75	0.001*	10.82±5.88	12.85±8.13	0.007*
Cholesterol	125.36±90.42	100.44±80.00	122.85±73.19	0.097	115.11±80.51	101.77±81.14	0.65
Sodium	2643.47±1330.47	2268.79±1223.37	2660.48±1253.09	0.076	2401.74±1256.48	2408.22±1258.49	0.196
Magnesium	201.71±160.88	183.90±85.09	242.85±107.22	0.004*	190.97±110.05	206.32±103.03	0.126
Calcium	448.13±374.18	570.20±326.44	758.83±432.17	≤0.001	536.47±355.06	644.56±374.984	0.368
Potassium	1729.79±1338.88	1555.88±713.59	1899.94±744.26	0.044*	1652.54±950.76	1648.87±739.42	0.688
Zinc	4.58±1.85	4.87±2.60	6.52±3.15	≤0.001	5.03±2.58	5.27±2.83	0.741
Iron	5.49±1.81	5.89±2.63	7.19±2.44	0.002*	5.80±2.33	6.38±2.73	0.082
Phosphorus	1079.18±483.45	895.32±427.42	1087.66±440.83	0.007*	969.02±443.45	954.46±451.94	0.985
Vit E	2.06±1.86	2.12±1.62	2.51±2.20	0.389	2.11±1.90	2.28±1.65	0.888
Vit B1	0.53±0.20	0.50±0.20	0.63±0.24	0.003*	0.52±.21	0.54±.22	0.954
Vit C	28.76±17.04	25.75±18.51	29.36±18.18	0.395	26.45±17.02	27.47±19.51	0.309
Folates	178.24±73.78	171.82±89.13	202.68±97.73	0.115	178.32±85.38	179.50±93.47	0.589

Abreviations: Data are presented as mean ± standard deviation (SD) or number (%). TEI: Total Energy Intake; DDS: dietary diversity score; DVS: dietary variety score. Differences between sociodemographic and anthropometric characteristics according to the DDS/DVS were compared by t-test and ANOVA for continuous variables. The mean difference is significant at the 0.05 level.

Table 4. Pearson correlation coefficients between NAR of some nutrients, MAR, DDS and DVS

	Mean ±SD	DDS r(p)	DVS r(p)
MAR	0.66±0.11	0.294** (≤0.001)	0.217** (≤0.001)
NAR Sodium	1.78±0.87	0.06 (0.354)	0.004 (0.945)
NAR Magnesium	1.16±0.71	0.298** (≤0.001)	0.302** (≤0.001)
NAR Calcium	0.56±0.41	0.322**(≤0.001)	0.330** (≤0.001)
NAR Potassium	0.40±0.18	0.126 (0.052)	0.045 (0.484)
NAR Zinc	0.88±0.55	0.329** (≤0.001)	0.326** (≤0.001)
NAR Iron	0.69±0.29	0.207** (0.001)	0.095 (0.143)
NAR Phosphorus	1.20±0.65	0.263** (≤0.001)	0.274** (≤0.001)
NAR VitE	0.24±0.20	0.188** (0.004)	0.140* (0.030)
NAR VitB1	0.71±0.28	0.319** (≤0.001)	0.255** (≤0.001)
NAR Vit C	0.82±0.60	0.135* (0.037)	0.127* (0.050)
NAR Folates	0.04±0.02	0.291** (≤0.001)	0.244** (≤0.001)

Abbreviations: mean ± SD: mean ± standard deviation; r: correlation coefficient; NAR: nutritional adequacy ratio; MAR: average adequacy ratio; DDS: dietary diversity score; DVS: dietary variety score. ** Significance level: <0.01; * significance level: <0.05.

DISCUSSION

The objective of this study was to assess the dietary quality of Moroccan children and adolescents with T1D. The results showed significant associations between sociodemographic, anthropometric and dietary intake characteristics with DDS/DVS. The mean DDS was 4.62±1.20 with a MAR of 66%; the majority of patients (64.6%) had a moderate DDS, whereas, only 19.6% of respondents had a high DDS. Similar results were found in other studies which reported that the majority of adolescents had an average DDS of 5 [31]. However, the South African study found a mean DDS of 3.58 with a mean MAR of 50% [32].

Several socioeconomic and demographic factors are significantly associated with DDS/DVS. One of these factors is the area of residence of T1D children. In this study, children from rural areas have poorer DD than those from urban areas. This result is consistent with other studies that have shown that people in urban areas consume more diverse foods than rural areas [33]. This could be explained by socioeconomic factors of households in these areas [34]. In addition, older children have a low DDS which is consistent with previous studies [13]. However, other studies have shown that older children have a better appetite for consuming more varied and diverse food groups [35]. Contrary to research findings that have shown a difference in DDS between the sexes due to gender inequality [36], in this study, no significant association was found between DDS and gender. Education level and income are also implicated. We also found that the higher parents' education and income level, more attention they paid to their child's nutrition. Several studies have found that lower levels of education are associated with less diverse and poor quality diets [37]. In addition, in this study, about the majority (86.3%) of the respondents have low monthly income and the middle and high family income groups have high DD. Similar studies have shown that DDS/DVS is related to socioeconomic status [38].

In our study, the majority of T1DM children had normal nutritional status (68.8%); about 13% are underweight and 18% were either overweight or obese. Moreover, as in previous studies, an association is found between DDS and CO and GO and a relationship between DVS and CO [15]. Although other research, they found no relationship between DD and obesity [39]. This may be because in children of high socioeconomic status or living in urban areas, obese children tend to have low DD [39]. In addition, studies have shown that high DD and variety is associated with a reduced risk of nutritional insufficiency [32]. The different results in the literature on DV and DD can be attributed, in part, to the use of different food groups and scoring methods [40].

In addition to analyzing sociodemographic and anthropometric factors, this study also explored associations between daily dietary intake and DDS/DVS in T1D children. Indeed, high DDS is associated with high intake of vegetables, eggs and micronutrients (fiber, Magnesium, Calcium, Potassium, Zinc, Phosphorus and Vit B1), and high DVS with high consumption of dairy products, carbohydrates, and low intake of protein and fat. Similar studies have reported that people with diabetes consumed onion, tomato and bell pepper vegetables [41]. Similarly, the low protein consumption among patients was attributed to the high cost of these foods due to low socioeconomic status [42]. However, other research has shown that individuals with high DDS had increased protein intake [43]. In addition, diets that cost less were commonly consumed than those that cost more [40].

On the other hand, micronutrient deficiencies remain a public health problem, especially in developing countries [3]. This study revealed that the mean MAR of the study population was 0.66 ± 0.11 and the nutrients with the lowest NARs were Calcium, Potassium, Vitamin E and folate. This is consistent with other studies that have shown low intake adequacy for Calcium, Vitamin A and folate [44]. In addition, there are significant and positive correlations between the DDS/DVS and most NARs for various nutrients, meaning that the more food groups one consumes, the less likely he or she is to be exposed to micronutrient deficiency. Similar results have been reported in other studies confirming the validity of using the DDS as a measure of micronutrient adequacy in children [28].

Strengths and limitations of the study

To our knowledge, this is the first study in Morocco to assess DD and DV and their relationship with micronutrient adequacy in Moroccan T1D children and adolescents. Among the strengths of this study are the use of two 24-hour recalls to assess dietary intake, which is one of the best methods for collecting dietary data, and the use of the FFQ to more accurately determine the amount of food portions ingested. However, this study has some limitations that need to be considered. First, it should be mentioned that the estimation of food intake is frequently poorly reported, and especially underreported, by children and adolescents with T1D; second, the number of subjects who participated in the study should be larger. This limitation is, however, offset by the accurate clinical measures that were collected. Finally, the study population may not be representative of the Moroccan population of T1D children. It would be wise to extend this study to a larger representative sample in order to generalize the results obtained.

CONCLUSION

In conclusion, the results of the study revealed that the quality of the respondents' diet is moderately diversified. Moreover, the DDS or DVS are associated with sociodemographic factors, obesity and micronutrient adequacy in Moroccan T1D children. These indices are valuable tools for global dietary assessment and could be effective tools for nutrition education.

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Abbreviations:

T1D: Type 1 diabetes; **IDF:** International Diabetes Federation; **CVD:** cardiovascular diseases; **WHO:** World Health Organization; **WHtR:** Waist-to-Height ratio; **BMI:** Body Mass Index; **SD:** standard deviations; **TEI:** Total Energy Intake; **NAR:** nutritional adequacy ratio; **MAR:** mean adequacy ratio.

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Conflicts of interest

The authors declare that they have no competing interests.

REFERENCES

1. International Diabetes Federation (IDF): Diabetes in the young: a global perspective. In: IDF Diabetes Atlas. Ninth Edition. Brussels: International Diabetes Federation 2019. Available from: www.idf.org.
2. *Simmons KM.:* Type 1 Diabetes: A Predictable Disease. World J. Diabetes 2015; 6, 380–390.
3. *Ahmed T., Hossain M., Sanin KI.:* Global burden of maternal and child undernutrition and micronutrient deficiencies. Ann Nutr Metab 2012;61(Suppl 1):8–17.
4. *Tzioumis E., Adair LS.*: Childhood dual burden of under- and overnutrition in low- and middle-income countries: a critical review. Food Nutr Bull 2014;35(2):230–43.
5. OMS., UNICEF.: Stratégie nationale de la nutrition 2011;2011-2019.
6. World Health Organization. World diabetes report 2016. Available from: https://apps.who.int/iris/bitstream/handle/10665/254648/9789242565256-fre.pdf.
7. *Belahsen R.*: Nutrition transition and food sustainability. Proc Nutr Soc 2014; 73: 385–388.
8. *Kennedy G., Ballard T., & Dop M.*: Guidelines for Measuring Household and Individual Dietary Diversity 2010; FAO: Rome, Italy.
9. *Wirt A., & Collins CE.*: Diet quality – what is it and does it matter? Public Health Nutr 2009;12, 2473–2492.
10. *Meng L., Wang Y., Li T., et al*: Dietary diversity and food variety in Chinese children aged 3–17 years: are

they negatively associated with dietary micronutrient inadequacy? Nutrients 2018;10:1674.

11. *Torheim L., Barikmo I., & Parr C.*: Validation of food variety as an indicator of diet quality assessed with a food frequency questionnaire for western Mali. European Journal of Clinical Nutrition 2003;1283-1291.
12. *Hann CS., Rock CL., King I., Drewnowski A.*: Validation ofthe Healthy Eating Index with use of plasma biomarkers in a clinical sample of women. Am J Clin Nutr 2001;74:479-86.
13. *Zhao W., Yu K., Tan S., et al*: Dietary diversity scores: an indicator of micronutrient inadequacy instead of obesity for Chinese children. BMC Public Health 2017;17:440.
14. *Hoddinott J., Yohannes Y.* : Dietary diversity as a food security indicator. Washington: International Food Policy Research Institute, Food Consumption and Nutrition Division; 2002. Discussion Paper No. 136.
15. *Azadbakht L., & Esmaillzadeh A.*: Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. Public Health Nutr 2011;14:62–69.
16. *Torheim LE, Ouattara F, Diarra MM, et al.,* Nutrient adequacy and dietary diversity in rural Mali: association and determinants. Eur J Clin Nutr. 2004;58(4):594-604. doi:10.1038/ sj.ejcn.1601853.
17. *Azadbakht L., Mirmiran P., Esmaillzadeh A., Azizi F.*: Dietary diversity score and cardiovascular risk factors in Tehranian adults. Public Health Nutr 2006;9(6):728-736.
18. *Ochola S., Masibo PK.*: Dietary intake of schoolchildren and adolescents in developing countries. Ann. Nutr. Metab 2014;64(Suppl. 2):24–40.
19. *Purnell JQ.*: Definitions, Classification, and Epidemiology of Obesity 2000. [Updated 2018 Apr12]. In: Feingold KR, Anawalt B, Boyce A, and al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279167.
20. *McCarthy HD., Ashwell M.*: A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message—"keep your waist circumference to less than half your height". Int J Obes (Lond) 2006;30:988–992.
21. WHOAnthro (version 1.0.4, January 2011) and macros [Internet]. [cité 5 mai 2012]. Available from: http://www.who.int/childgrowth/software/en/.
22. WHO Child Growth Standards. Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age. Methods and development 2006. Available from: https://www.who.int/childgrowth/standards/Technical_report.pdf?ua=1.
23. World Health Organization: WHO Child Growth Standards. Growth reference data for 5–19 years 2007. Available from: http://www.who.int/growthref/en/.
24. *Butte NF., Garza C., de Onis M.*: Evaluation of the feasibility of international growth standards for school-aged children and adolescents. J Nutr 2007;137:153–157.
25. *Elmoumni K*: Typical foods and preparations of the Moroccan population, Tool for estimating food consumption, Center for Information and Research on Food Intolerances and Hygiene (CIRIHA) 2008.
26. *Kennedy G., Ballard T., & Dop MC.*: Guidelines for Measuring Household and Individual Dietary Diversity. Rome, Italy: Nutrition and Consumer Protection Division, Food and Agriculture Organization of the United Nations 2013.
27. FAO. Nutrition and Consumer Protection Division with Support from the EC/FAO Food Security Information for Action Programme and the Food and Nutrition Technical Assistance (FANTA) Project. Guidelines for measuring household and individual dietary diversity; Rome, Italy. 2008.
28. *Hatloy A., Torheim LE., Oshaug A.*: Food variety-a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. Eur J Clin Nutr 1998;52: 891–898.
29. *Mirmiran P., Azadbaht L., Esmailzadeh A., et al.* Dietary diversity score in adolescents-a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study. Asia Pac J Clin Nutr 2004;13:56–60.
30. *Martin-Prével Y., Allemand P.,Wiesmann D., Arimond M., Ballard T., Deitchler M., DopMC., Kennedy G., Lee WT., Mousi M.*: Moving Forward on Choosing a Standard Operational Indicator of Women's Dietary Diversity; Food and Agriculture Organisation of the United Nations 2015: Rome, Italy.
31. *Kersting M., Sichert-Hellert W., Vereecken CA., et al.* Food and nutrient intake, nutritional knowledge and dietrelated attitudes in European adolescents. Int J Obes (Lond) 2008;32:35–41.
32. *Steyn N., Nel J., Nantel G., Kennedy G., Labradarios D.* : Food variety and dietary diversity scores; are they good indicators of dietary adequacy? Public Health Nutr 2006;9:644–50.
33. *Khed V.* Nutritional Status and Dietary Diversity of Households in Vijayapura district of Karnataka. In Proceedings of the 2018 Conference, Vancouver, BC, Canada, 28 July–2 August 2018.
34. *Liu J., Shively GE., Binkley JK.* : Access to Variety Contributes to Dietary Diversity in China. Food Policy 2014;49:323–331.
35. *Birch LL.* Development of food preferences. Annu Rev Nutr 1999;19(1):41–62.
36. *Aurino E.* Do Boys Eat Better than Girls in India? Longitudinal Evidence on Dietary Diversity and Food Consumption Disparities among Children and Adolescents. Econ. Hum. Biol 2017;25:99–111.
37. *Tiew KF., Chan YM., Lye MS., Loke SC.* Factors associated with dietary diversity score among individuals with type 2 Diabetes mellitus. J Health Popul Nutr. 2014;32(4):665-676.
38. *Savy, M., Martin-Prevel Y., Danel, P., Traissac, P., Dabiré H., Delpeuch F.* Are dietary diversity scores related to the socio-economic and anthropometric status of women living in an urban area in Burkina Faso? Public Health Nutr 2008;11:132–141.
39. *Salehi-Abargouei A., Akbari F., Bellissimo N., Azadbakht L.* Dietary diversity score and obesity:

a systematic review and meta-analysis of observational studies. Eur J Clin Nutr. 2016;70(1):1–9.

40. *Conklin AI., Monsivais P., Khaw K-T., Wareham NJ., Forouhi NG.* : Dietary diversity, diet cost, and incidence of Type 2 Diabetes in the United Kingdom: A prospective cohort study. *Basu S, ed. PLOS Med* 2016;13(7):e1002085. doi:10.1371/journal.pmed.1002085.
41. *Déré KAL., Djohan YF., Koffi KG., Manhan K., Niamké AG., Tiahou GG.*: Individual dietary diversity score about mellitus Diabetics and hypertensive patients in Cote D'Ivoire. *Li J (ed.), Int J Nutr* 2016;2(1):38-47. doi:10.14302/ issn.2379-7835.ijn-16-943.
42. *Mayega RW., Guwatudde D., Makumbi F., et al.,* Diabetes and pre-Diabetes among persons aged 35 to 60 years in Eastern Uganda: Prevalence and associated factors. *Herder C, ed. PLoS One* 2013;8(8):e72554. doi:10.1371/journal.pone.0072554.
43. *Sultana S., Lina N N., Hasan MT., Ferdaus MJ., Dash BK., Ahmed T., Roy R K.:* Dietary Diversity and Associated Health Status of Newly Diagnosed Type 2 Diabetic Patients in Jashore Region of Bangladesh. Curr Res Nutr Food Sci 2020; 8(2). Doi : http://dx.doi.org/10.12944/CRNFSJ.8.2.09.
44. *Arsenault JE., Yakes EA., Islam MM., Hossain MB., Ahmed T., Hotz C., Lewis B., Rahman AS., Jamil KM., Brown KH.*: Very low adequacy of micronutrient intakes by young children and women in rural Bangladesh is primarily explained by low food intake and limited diversity. J Nutr 2013;Feb;143(2):197-203. doi: 10.3945/jn.112.169524. Epub 2012 Dec 19. PMID: 23256144.

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