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Nutritional Quality and Dietary Intake in Children and Adolescents with Celiac Disease

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ABSTRACT

Background: Gluten-free diet (GFD) may influence the nutritional quality and adequacy of celiac disease (CD) patients. The aim of the present study was to evaluate quality of diet and nutrients intake of children and adolescents with CD and compare those with healthy subjects.

Methods: This cross-sectional study included 50 patients with CD (18 boys and 32 girls; mean age: 11.5 y; range:7-18 y) and 50 healthy children and adolescent matched by age, sex and body mass index (BMI). The subjects' height, weight, body composition evaluated by bioelectrical impedance analysis were measured and a food frequency questionnaire (FFQ) was administered. Diet quality was assessed using modified healthy eating index (mHEI) and visual analog scale (VAS) was used to evaluate appetite.

Results: The weight, height, fat-free mass (FFM) and body fat percentage (BF%) were not different between groups. Intake of energy, macro-nutrients and some micro-nutrients like vitamin A, vitamin D, thiamin, riboflavin, niacin, vitamin B12 and zinc was significantly lower in celiac patients. The scores of mHEI were not different between case and control groups (55.24±8.8 vs. 55.84±8.6; p=0.819). VAS results revealed no difference in sensation of hunger, satiety, fullness and prospective food consumption between the groups; but there was a higher desire to eat in celiac patients.

Conclusion: Although intake of macronutrients and a few micronutrients were more than recommended dietary allowance (RDA) in both groups; but diet quality of CD patients is needed to be improved.

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Introduction

Celiac disease (CD) is an immune-mediated systemic disorder elicited by gluten (1). The expected global prevalence of CD is in the range of 0.2%-5.6% and the prevalence of biopsy proven CD in Iranian school children is 0.6% (2, 3). The classical presentation of CD in children includes diarrhea, abdominal pain and failure to thrive (4, 5). CD patients not only have gastrointestinal problems, but also suffer from extra-intestinal manifestations (6). Short stature, fatigue, and headache are the most common symptoms in children (7). A proven effective treatment for CD is a lifelong gluten-free diet (GFD) (8). This study was conducted to evaluate quality and adequacy of diet of children and adolescent with CD and compare it to healthy subjects.

Materials and Methods

This case-control study was designed to evaluate the quality and adequacy of diet in children and adolescents with CD and compare it with healthy subjects. Patients with CD were recruited from Imam Reza CD Clinic as the main center of CD in Shiraz, south of Iran. Subjects in control group were recruited from general community using recruitment fliers. The inclusion criteria for CD group was the age range of 7-18 years, adherence to GFD for at least 6 months before study commencement, not having history of chronic diseases such as diabetes, hypo/hyperthyroidism, and any diseases with significant effects on dietary intake and appetite. Healthy group were in age range of 7-18 years, with normal diet and no chronic diseases as mentioned for CD group. Data on demographic information as well as medical history was gathered through questionnaires and recent laboratory data.

Among the 100 children and adolescents enrolled in the study, 50 were in healthy (control) group and 50 were in patients with CD (case) group. Subjects in case and control groups were matched by age and sex, as well as body mass index (BMI). Participants were first stratified to three age groups (7 to 10, 11 to 14 and 15 to 18 years old) and then were matched by sex and BMI z-scores. Weight and height were measured by an expert using digital scale (Seca, Germany) and a tape, with regard to standard protocols in a standing position with minimum clothes and no shoes. Body composition was measured using Bio-electrical Impedance Analysis (BIA) body analyzer. Height and weight were used to calculate BMI. BMI z-score (BMI-z) and height-for-age z-score (ht-z) were calculated using the World Health Organization (WHO) charts and weight-for-age percentiles was determined utilizing Centre for Disease Control (CDC) charts.

Dietary intake was assessed using a 147 item semi-quantitative food frequency questionnaire (FFQ) by a trained interviewer. Portion sizes of consumed foods, reported in household measures, were then converted to grams. The daily energy, macro-nutrients and micro-nutrients intake were analyzed using Nutritionist 4 software (First Databank; Hearst, San Bruno, CA, USA); Nutrient database in this software was based on USDA food composition table modified for Iranian foods. Adequacy of intake was calculated using USDA dietary guidelines (9).

Furthermore, energy and nutrient intakes were compared to Recommended Daily Intake (RDA). Adequate intake was defined as intake of 75 to 110% of RDA for nutrients and energy, while inadequate and excess intakes were considered as intakes less than 75% and more than 110% of RDA, respectively (10). Acceptable Macronutrient Distribution Range (AMDR) for protein, carbohydrate and fat was considered to be 10 to 30%, 45 to 65% and 25 to 35% of total energy, respectively. Protein intake less than 10% total calorie and carbohydrate intake less than 45% total calorie were considered as low protein-energy and low carbohydrate-energy ratio percentage, respectively. On the other hand, fat intake more than 35% of total calorie was defined as high fat-energy ratio percentage, according to AMDR.

Scores for appetite were measured using visual analogue scales (VAS; 0 to 100 mm or 10 cm). VAS questionnaire evaluated “hunger”, “satiety”, “desire to eat”, “fullness” and “prospective food consumption”. Each scale is 100 mm in length with words anchored at each end, expressing the most positive and negative rating of the category. Its range from lowest intensity feelings were ‘not at all’ to the high end (‘extremely’). Participants completed this questionnaire in fasted state. Modified Healthy Eating Index (mHEI) was used to evaluate dietary quality in both groups. The mHEI consisted of 10 components including whole grains, vegetables, fruits, dairy, meat ratio, butter and margarine, sugar-sweetened beverages, fast foods, sweet snacks, and salty snacks. Each component was scored from 0 (for lack of compliance) to10 (for full compliance). The score for each item was then summed to reflect the level of attainment toward the recommended goal; and total mHEI score ranged from 0 (worst) to 100 (best) (11).

The criteria for scoring each component was obtained from Tehran Lipid And Glucose Study (11). The mHEI scores were then categorized to less than 51 for poor quality, between 51 and 80 indicating to a need for improvement, and more than 80 for good nutritional quality. For more accurate comparisons in this study, the energy adjusted mHEI was calculated besides mHEI to remove effect of energy intake on diet quality. Data was analyzed using SPSS software (version 22.0, SPSS Inc., Chicago, IL, USA). Descriptive variables such as mean, median and standard deviation were determined. Qualitative and discrete qualitative variables were presented as absolute frequency and relative frequency (%). Continuous variables were compared using t-test and when the variables were not normally distributed, they were compared using Mann–Whitney test. The $p<0.05$ was considered statistically significant.

Results

In each group, 32 were girls and 18 were boys (64% and 36%, respectively). Mean duration of adherence

to GFD was 41.4 months in CD group. There were no significant differences in age, BMI and body composition between two groups (Table 1). Intake of most nutrients like protein, carbohydrate, fat, energy, vitamin A, vitamin D, thiamin, riboflavin, niacin, vitamin B12 and zinc were significantly higher in healthy group. However, vitamin E, iron and calcium intakes were not significantly different between two groups (Table 2). All of subjects in both groups had inadequate intake of vitamin D. Subjects in CD group were more likely to have inadequate intake of vitamin A, E and calcium. The analysis showed that subjects in this group tended to have adequate intake of zinc (Table 3).

Most of subjects in case and control groups had normal macronutrient-energy ratio% with no significant differences in protein-energy ratio% (12.8±0.2 (CD) vs. 13.4±0.2 (healthy); p=0.06), carbohydrate-energy ratio% (58.1±0.6 (CD) vs. 58.2±0.5 (healthy); p=0.89) and fat-energy ratio% between groups (30.7±0.7 (CD) vs. 30.7±0.6 (healthy); p=0.98). The results of appetite assessment in fasting condition were shown in Table 4. Study groups were not different regarding various VAS categories, except for "desire to eat", which was significantly higher in CD group. Diet quality was almost similar in CD and healthy groups according to mean scores of mHEI (55.2±8.8 (case) vs. 54.8±8.6 (control); p=0.81) and energy-adjusted mHEI (55±8.3 (case) vs. 55±10 (control); p=0.90). The mean score of both groups indicated that there were a need to improve their nutritional intake (51<mHEI≤80) (Table 5). Subjects in neither groups had a good diet quality (mHEI>80).

Discussion

Adherence to GFD as well as maintaining a high quality diet is one of the most important challenges in children and adolescents with CD. In Iran, CD patients face substantial problems to adhere to GFD,

Table 1: Anthropometric and body composition data in celiac disease and healthy groups.

Variable	Group		p[b]
	Celiac[a]	Healthy (control)[a]	
Age (y)[c]	11.5±2.5	11.5±2.8	0.96
Weight (kg)[c]	33.5±11.2	36±12.7	0.33
Height (cm)[d]	143.5±14.9	147.4±17.1	0.22
BMI (kg/m^2)[c]	15.8±2.8	16±2.6	0.58
Basal metabolism (kcal)[c]	1179.5±183.4	1215±215.3	0.35
Fat mass (kg)[c]	6.4±3.4	7.1±3.6	0.20
Fat-free mass (kg)c	27.1±8.7	28.9±9.9	0.32
Fat mass (%)[d]	18.6±5.5	19.3±5	0.48
Total body water (l)[c]	19.8±6.3	21.1±7.2	0.32
Total body water (%)[d]	59.5±4	59±3.7	0.48

[a]Value were presented as means±SE. [b]p values<0.05 were considered statistically significant. [c]Analyzed by Mann–Whitney. [d]Analyzed by independent t test.

Table 2: Energy and nutrients intake in celiac disease and healthy groups.

Variable	Group		p[b]
	Celiac[a]	Healthy (control)[a]	
Energy (Kcal)c	1967.6±711.3	2369.4±825.4	0.009
Protein (g)c	62.34±32.3	80.1±31.6	0.002
Carbohydrate (g)c	286±111.4	346.7±127.5	0.01
Fat (g)c	66.7±25.8	78.8±26.8	0.01
Vitamin A (mg)c	521.9±422.3	615.1±310.8	0.02
Vitamin D (mcg)c	1.9±1.6	2.9±2.4	0.01
Vitamin E (mg)c	11±4.1	11.7±3.7	0.28
Thiamin (mg)c	1.7±0.7	2±0.8	0.02
Riboflavin (mg)c	1.8±0.9	2.3±1	0.005
Niacin (mg)c	19±8	22.6±8.7	0.01
Vitamin B12 (mcg)c	2.9±3	3.5±1.9	0.03
Iron (mg)c	26.5±14.1	32.2±16.7	0.07
Zinc (mg)c	8.1±3	11.3±5	0.001
Calcium (mg)c	1090.6±484.7	1336±659.4	0.08

[a]Values were presented as means±SE. [b]p values<0.05 were considered statistically significant. [c]Analyzed by Mann–Whitney.

Table 3: Frequency (%) of subjects in case and control groups according to Sub-Categories of Adequacy of Macronutrient and Micronutrients.

Variable	Group					
Nutrients (n%)	Inadequate (<75%)		Adequate (75-110%)		Excess (>110%)	
	Case	Control	Case	Control	Case	Control
Macronutrients						
Protein	2 (4)	0 (0)	4 (8)	3(6)	44(88)	47 (94)
Carbohydrate	0 (0)	0 (0)	2 (4)	0(0)	48(96)	50 (100)
Energy	5 (10)	3 (6)	22 (44)	14(28)	23(46)	33 (66)
Micronutrients						
Vitamin A	26 (52)	18 (36)	14 (28)	14 (28)	10 (20)	18 (36)
Vitamin E(AT)[a]	23 (46)	21 (42)	19 (38)	19 (38)	8 (16)	10 (20)
Vitamin D	50 (100)	50 (100)	0 (0)	0 (0)	0 (0)	0 (0)
Thiamin	0 (0)	0 (0)	4 (8)	3 (6)	46 (92)	47 (94)
Riboflavin	0 (0)	0 (0)	6 (12)	3 (6)	44 (88)	47 (94)
Niacin	3 (6)	0 (0)	9 (18)	5 (10)	38 (76)	45 (90)
Vitamin B12	7 (14)	5 (10)	8 (16)	9 (18)	35 (70)	36 (72)
Zinc	9 (18)	6 (12)	24 (48)	12 (24)	17 (34)	32 (64)
Iron	0 (0)	1 (2)	4 (8)	2 (4)	46 (92)	47 (94)
Calcium	21 (42)	15 (30)	18 (36)	11 (22)	11 (22)	24 (48)

[a]Alpha-tocopherol.

Table 4: VAS score in celiac disease and healthy group.

Variable	Group		*p*[b]
	Celiac[a]	Healthy (control)[a]	
Hunger[c]	5.5±2.1	4.72±2.2	0.07
Satiety[c]	4.12±2	4.3±2.3	0.76
Desire to eat[c]	5.8±2.1	4.7±2.1	0.01
Fullness[c]	4±2.1	4.5±2.3	0.19
Prospective food consumption[c]	4.3±2.4	4.5±2.5	0.82

VAS: Visual analog scale; [a]Value were presented as means±SE. [b]*p* values<0.05 were considered statistically significant. [c]Analyzed by Mann–Whitney.

Table 5: Modified healthy eating index (mHEI) score in celiac disease and healthy group.

Variable	Group		*p*[b]
	Celiac[a]	Healthy (control)[a]	
mHEI[c]	55.2±8.8	54.8±8.6	0.81
Adjusted mHEI[d]	55±8.3	55±10	0.90

[a]Value were presented as means±SE. [b]*p* values<0.05 were considered statistically significant. [c]Analyzed by independent t test. [d]Analyzed by Mann–Whitney.

since they cannot afford expenses of gluten-free products (GFPs) (12, 13). Lack of insurance coverage for the costs of GFPs in our country is another obstacle for strict adherence to the GFD (14). Our study showed that almost half of subjects in case group and two third of subjects in control group consumed excess calories, which indicates that excess energy intake in patients does not completely relate to GFD. A logical explanation for excess energy intake in participants is the high consumption of junk foods (fast foods, salty and sweet snacks and sugar-sweetened beverages) in both groups as well as high consumption of refined grain in healthy group, based on criteria for scoring each component of mHEI (11).

In spite of high energy consumption, almost 70% of subjects in both groups were categorized as normal regarding their BMI z-scores. A vast number of studies have shown that physical activity in children is negatively related to obesity (15-17). The analysis of physical activity showed that 86% of CD subjects and 94% of healthy subjects had moderate-to-vigorous physical activity according to level of Met hour/day, which can explain normal BMI z-scores in both groups. Excess energy intake has led to excess carbohydrate and protein intake in

majority of participants in both groups. Subjects in CD group consumed more fats (especially saturated), protein and simple carbohydrates than recommended levels (18).

By comparing two groups, it was found that healthy control group had significantly higher intakes of energy and macronutrients than CD patients. Several studies with conflicting results have been conducted comparing nutrient intake between healthy and CD subjects. One study found that protein consumption did not differ between CD and control groups and daily intake of carbohydrates was lower in CD group. The results of this study also showed that fat intake was higher in CD group (19). Fernandez's study demonstrated that the comparison between two groups denoted to a significantly lower consumption of proteins in the participants with CD compared to the non-celiac children and adolescents (18). Furthermore, a study revealed that children with CD on a GFD had significantly lower daily energy, protein and carbohydrate intakes compared to healthy controls; but the difference for fat consumption was not significant (20).

Our Findings exhibited that the proportion of patients with inadequate intake of vitamins A, E, D, and calcium was higher than those with adequate or excess intakes. Among micronutrients, only zinc intake was adequate but thiamin, riboflavin, niacin, vitamin B12 and iron intake was more than reference value. Some studies have been carried out to evaluate micronutrient intake in children and adult patients with CD. Inadequate intake of vitamin D was found in children who were following GFD (4, 21). Intake of thiamin, riboflavin, niacin, vitamin B12, calcium and iron in children on GFD was more than average requirements (21). One study showed that 60% of children with CD and type 1 diabetes met the average daily recommended for zinc and only 30% met the average daily recommended for iron and calcium (22)</EndNote>.

In our study, the intake of vitamin E, iron and calcium was not different between groups; although intake of other nutrients was higher in healthy group. In contrary to our results, a study found that iron intake was significantly higher in control group than CD patients (20) . Intakes of iron, zinc and thiamin were also higher in healthy group, while vitamin E intake was lower in this group when compared with CD group; and differences in intake of vitamin A, riboflavin and calcium were not significant (20). One study showed that, the nutrient density of vitamin D, riboflavin, niacin, and thiamine were lower among CD children than healthy ones (21). Vitamin E and A levels were affected by amounts ingested orally, as well as their absorption. No suggestive difference was established between CD and healthy groups regarding vitamins E intake (23). In celiac patients, vitamin A and D levels were significantly lower than those in healthy control group (23).

There are limited data regarding diet quality in children and adolescents with celiac disease in Iran. Our results indicated that both CD patients and healthy group were similar in terms of diet quality scores suggesting that both groups need an improvement in their diet quality. The main reason for low quality scores in the present research is the high consumption of junk foods, medium consumption of fruits and vegetables, as well as low consumption of whole grains, especially in CD group, according to scores of mHEI components. Mean junk food consumption is high in Iran, especially in children and adolescents (24).

A study on diet quality among Iranian adolescents and young adults showed that youth population consumed lower whole grains, fruits, vegetables, dairy products and unsaturated fatty acids, while their diet lacked diversity as well (25). It was shown that there is no difference in HEI score between CD and healthy groups (5). Even though celiac children and adolescents' diet is unhealthy due to its inappropriate dietary pattern, following a diet based on GFD products raises extra-difficulty in complying with the nutritional recommendations (26, 27).

Conclusion

In conclusion, half of CD patients consumed excess calories and a majority of them had higher intake of protein, carbohydrate, thiamin, riboflavin, niacin, vitamin B12 and iron in comparison to the recommended levels. Furthermore, according to RDA, all subjects in CD group had low intake of vitamin D and half of them had low intake of vitamin A and E. Intake of a majority of nutrients were higher in healthy group and the quality of diet was similar in both groups, indicative of a need to diet improvement.

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Conflict of Interest

None declared.

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