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# The Impact of a Gluten-free Diet on the Nutritional Status of Pediatric Patients with Celiac Disease

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## ABSTRACT

Aim: Evaluating the effect of a gluten-free diet on the nutritional status of children with celiac disease was aimed at. Materials and Method: Eleven children recently diagnosed with celiac disease were included in this study. The children's diets were given by a dietitian and followed for six months. Three-day food consumption records and anthropometric measurements were taken before and after the gluten-free diet. Nutrient intake was calculated, and food consumption was evaluated regarding the recommendations of the Turkish Dietary Guidelines. By determining height and body weight according to age, z-score calculations were made, classified, and compared. Results: The ages of the children who participated in this study ranged from three to 12 years old. After the gluten-free diet, it was observed that the percentage of energy that was derived from sucrose decreased ($p<0.05$). It was also seen that the children started to consume more from the milk and milk products group, green-leaved vegetables, and other vegetables except for potatoes. It was observed that the participants' sugar and sweet food consumption decreased ($p<0.05$). After six months, the proportion of children classified as "short" in height with regard to age decreased (45.5% before the diet, 27.3% after). Conclusion and Suggestions: The findings obtained in this study suggest that if the gluten-free diet is planned correctly, adequate energy and nutrient intake can be achieved. It has been observed that the nutritional status of the children has improved after the follow-up. Regularly following gluten-free diets after planning and providing dietitian support is essential to ensuring optimum nutrition.

**Key words:** Celiac Disease, Dietitian, Food Consumption, Growth, Nutrient.

# Glutensiz Diyetin Çölyak Hastalığı Olan Çocukların Beslenme Durumuna Etkisi

## ÖZ

Amaç: Bu çalışmada, çölyak tanısı alan çocukların glutensiz diyet öncesi ve sonrasında beslenme durumlarının değerlendirilmesi amaçlanmıştır. Yöntem: Çalışmaya yeni tanı alan 11 çölyaklı çocuk dâhil edilmiştir. Çocukların diyetleri diyetisyen tarafından düzenlenmiş ve altı ay boyunca takip edilmiştir. Çocukların diyet öncesi ve sonrasında üç günlük besin tüketimler kayıtları ve antropometrik ölçümleri alınmıştır. Besin ögesi alımları hesaplanmış ve besin tüketimleri Türkiye Beslenme Rehberi önerileri doğrultusunda değerlendirilmiştir. Yaşa göre boy ve vücut ağırlığı belirlenerek z-skor hesaplamaları yapılmış, sınıflandırılarak karşılaştırılmıştır. Bulgular: Çocukların yaşları 3-12 yıl arasında değişmektedir. Glutensiz diyet sonrasında öncesine göre enerjinin sükrozdan gelen yüzdesinde azalma sağlanmıştır ($p<0.05$). Çocukların süt ve ürünleri grubunu, yeşil yapraklı sebzeler ile patates hariç diğer sebzeleri daha fazla tüketmeye başladığı, şekerli besinleri ise azalttığı gözlemlenmiştir ($p<0.05$). Altıncı ayda, yaşa göre boy uzunluğu "kısa" sınıflamasına dâhil çocukların oranında azalma görülmüştür (diyet öncesi %45.5, sonrası: %27.3). Sonuç ve Öneriler: Glutensiz diyet doğru planlandığı takdirde yeterli enerji ve besin ögesi alımı sağlanabilir. Bu çalışmada, izlem sonrası çocukların beslenme durumlarının iyileştiği gözlenmiştir. Glutensiz diyetlerin planlandıktan sonra düzenli takip edilmesi ve diyetisyen desteğinin sağlanması, optimum beslenmenin sağlanmasında önemlidir.

**Anahtar kelimeler:** Besin Ögesi, Besin Tüketimi, Büyüme, Çölyak hastalığı, Diyetisyen.

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## INTRODUCTION

Celiac disease is an immune-mediated chronic disease of the small intestine triggered by the consumption of prolamins found in grains, such as wheat, rye and barley, in genetically predisposed individuals (Bai and Ciacci, 2017). Celiac disease patients are at increased risk of anemia, bone fractures, neuropathies, extra-intestinal symptoms, such as hepatitis, and autoimmune diseases, such as thyroid and Type 1 diabetes (Leffler et al., 2015; Lundin and Wijmenga, 2015).

Gluten-free diet therapy is currently the only clinically proven treatment for celiac disease. In general, wheat (gliadin and glutenin), rye (secaline) and barley (hordein) contain prolamins with high celiac reactivity. All products derived from these foods (e.g., bread, pasta, bulgur, vermicelli, cake, cookies, cereals, and many pastry products) must be excluded from the diet (Macdonald, 2007). A rapid regression in gastrointestinal symptoms occurs with the initiation of a gluten-free diet (Nachman et al., 2009). After the elimination of gluten, improvement in nutrient deficiencies, alleviation in extra-intestinal symptoms, reduction in malaise, healing in mouth sores, decrease in body weight loss, improvements in bone health, and after one year, reduced risk of fracture, cancer, and lymphoma occurs (See et al., 2015). In children, growth retardation is prevented, and normal/healthy growth is achieved (Graziano Barera et al., 2000). However, if gluten-free diets are not well-planned, imbalances and deficiencies can be seen (Gobbetti et al., 2018).

Gluten-free products often contain higher carbohydrates and fats to preserve their structure (Bascunan et al., 2017; Melini and Melini, 2019). It has been shown that they contain lower protein and higher saturated fat (especially in gluten-free biscuits, chocolate, and pasta) (Calvo-Lerma et al., 2019; Cornicelli et al., 2018) and lower fiber (in biscuits and bread) (Bagolin do Nascimento et al., 2014; Cornicelli et al., 2018). It may lead to an imbalance in the diet regarding macronutrients, especially in risk groups, such as children and adolescents who like to consume packaged products (Valletta et al., 2010).

It is essential to explain the mechanism behind the gluten-free diet to the patient and conduct a follow-up by an experienced dietitian to ensure the patient's compliance with the diet (Hill et al., 2016; Niewinski, 2008). The dietitian's role in this regard covers a wide range of subjects, such as following diet compliance, raising awareness of the comorbidities, counseling the patient during the application of the gluten-free diet, providing encouragement and support, as well as providing education (See et al., 2015). The success of diet compliance in patients with pediatric celiac disease depends on the nutrition education given to their parents. It has been reported that full compliance with the diet in children remains at a low level of 58%. Gluten-free preferences can be more unpalatable than their counterparts, and the diet limits eating outside the home, the difficulties in accessing gluten-free products, the asymptomatic progression of the disease, social pressures, inadequacies in labeling, and cost (MacCulloch and Rashid, 2014; Roma et al., 2010) can be the reasons for the low compliance. A study conducted in Turkey showed that full compliance with the diet in children was 73.3% (Esenyel et al., 2014).

This study aimed to evaluate the effects of a gluten-free nutritional diet treatment that was administered to children with newly diagnosed celiac disease, under the control of a dietitian and after a six-month follow-up period.

## MATERIAL AND METHOD

### Study Design

This study constituted an original part of the thesis, which was conducted at Gazi University Faculty of Medicine, Department of Pediatric Gastroenterology and Hepatology, and Gazi University Faculty of Health Sciences, Department of Nutrition and Dietetics between January 2018-February 2019 (Ertaş-Öztürk, 2019). Children aged between three and 12 years who were newly diagnosed with celiac disease were included in this study. This study was an observational, descriptive clinical study that included a follow-up.

Fifty-six patients with chronic abdominal pain, diarrhea, growth retardation, dyspeptic complaints, unexplained anemia, arthritis, hepatitis, rickets, delayed puberty, aphthous stomatitis, short stature during the admission process, or those who had celiac disease in the family,

applied to the hospital for screening. Celiac serology was examined in these patients. After the disease's positivity was proven, duodenal and bulbous mucosa samples were taken by endoscopy from children, and Marsh classification was made (Dickson, Streutker, and Chetty, 2006). As a result of the Marsh classification, 18 patients agreed to participate in this study out of 39 patients diagnosed with celiac. During the follow-up period, after seven patients were excluded, this study was completed with 11 patients. The patients included in this study were followed up for six months before (0 months) and after (6 months) the gluten-free diet treatment.

The inclusion criteria of this study were as follows: being diagnosed with celiac disease and being in the age range of 3-18 years. The exclusion criteria were: smoking tobacco and derivatives (in adolescence), having cardiovascular diseases, diabetes, allergy to various nutrients, being diagnosed with gastrointestinal system disease other than celiac disease, and non-compliance with the diet were also used as exclusion criteria in this study

The ethics approval of the study was obtained from Gazi University, Faculty of Medicine, Clinical Research Ethics Committee (Date: 22.01.2018, Number: 24074710-8/42). The study protocol was explained in detail to the patients who met the inclusion criteria and to their families, and a written consent was obtained. The study was supported by Gazi University Scientific Research Projects (BAP) unit (project number: 47/2019-02).

**Data Collection**

This study used a questionnaire form to collect descriptive information about children. Before the gluten-free diet, anthropometric measurements were taken to evaluate the nutritional status of the children, and a three-day food consumption pattern was questioned. Then, gluten-free diet treatment suitable for the age and gender of the patients was planned and explained to the patients. Children were followed up for six months after starting diet therapy. Data on energy and nutrient intake and anthropometric measurements before and after the gluten-free diet were compared.

**Evaluation of nutritional status and medical nutrition therapy**

Before the gluten-free diet treatment of the children, their families were contacted, and their food consumption was recorded for three consecutive days, one day being at the weekend. Then, the characteristics of the gluten-free diet were explained in detail, and the diet program, which was designed in accordance with the Turkey Nutrition Guideline (TUBER) recommendations, was given in an environment where both the child and the parent who was responsible for the child's nutrition was present. Detailed nutrition education was provided with brochures and lists about the points to be considered in the gluten-free diet and healthy food choices. The education consisted of reading the label, the precautions to be taken at home, the risk of cross-contamination, gluten-free foods, gluten sources, and answering the families. To facilitate the adaptation to the gluten-free diet, regular evaluations of the ongoing nutrition once a week in the first month of this study and once a month until the end of this study were made. The researcher evaluated each food consumption record using the Nutrition Information System (BeBiS) program within the same week. Parents were informed about the energy and nutrient intake of their children, and recommendations were made accordingly.

Children's daily energy, fiber and micronutrient intake were evaluated according to the dietary reference values (DRV) in TUBER. The protein (g/kg) intake of children was evaluated according to the adequate intake (AI) calculated for the average diet of Turkey (digestible amino acid score=83), and the food group intake was evaluated according to the TUBER recommendations (TC Sağlık Bakanlığı, 2015).

**Evaluation of anthropometric measurements**

The height (cm) and body weight (kg) of the children were measured at the beginning (0. month) and the end (6. month) of this study. Children came to engage in the measurement process with an empty stomach on the days when anthropometric measurements were to be taken. Height was measured with a stadiometer using taking deep breaths and while the heels, hips and head were in contact with the stadiometer and while the head was in the Frankfurt plane

(Pekcan, 2008). Body weight (kg) was measured using Tanita BC 418. The body mass index (BMI-kg/m2) was calculated using the height and body weight of the children. It was evaluated with the growth charts designated by the World Health Organization (WHO). Body weight, height and BMI z-score values for age were calculated using the WHO Anthro-program for participants up to five years old and AnthroPlus for the participants who were over five years old, while classifications were made for height and BMI for age (Blössner et al., 2007; Blössner et al., 2009).

### Statistical Analysis

Intergroup evaluations of descriptive values, anthropometric values, energy and nutrients were shown as mean±standard deviation (Mean±SD), median (interquartile range) (M (IQR), number (n) and percentage (%). Wilcoxon test was used in the non-parametric analysis of dependent groups. All data were analyzed using the SPSS (Version 20.0) package program, and the significance level was accepted as 0.05.

## RESULTS

The ages of the children ranged from three to 12 years. All were born at the standard term range (between 37-41 months) and no complications were reported at birth. Children's descriptive and early feeding practices are given in Table 1.

**Table 1.** Descriptive Data and Early Feeding Practices of Children

| Properties | Mean±SD | M (IQR) |
|---|---|---|
| Age (year) | | |
| Boys (n=6) | 6.8±3.23 | 6.6 (5.88) |
| Girls (n=5) | 5.8±1.98 | 4.5 (3.25) |
| Breastfeeding duration (month) (n=11) | 15.2±13.67 | 8.0 (17.00) |
| Formula feeding duration (month) (n=5) | 13.6±7.63 | 14.0 (15.00) |
| Complementary feeding initiation time (month) (n=11) | 5.7±0.90 | 6.0 (1.00) |
| | n | % |
| Relatives with celiac disease | | |
| Yes | 3 | 37.5 |
| No | 8 | 62.5 |

Energy intake from macronutrients before and after the gluten-free diet treatment is given in Table 2. The energy values (%) which the children derived from protein, fat, saturated, monounsaturated, polyunsaturated fat and carbohydrates were not different before and after gluten-free diet treatment (p>0.05) except energy values from sucrose (p<0.05).

**Table 2.** Energy Intakes from Macronutrients of Children Before And After Gluten Free Diet Treatment

| Nutrients | Before gluten free diet | | After gluten free diet | | Z‡ | p |
|---|---|---|---|---|---|---|
| | Mean±SD | M (IQR) | Mean±SD | M (IQR) | | |
| Protein (% Energy) | 13.2±3.12 | 13.0 (5.00) | 13.8±2.99 | 14.0 (4.00) | -0.898 | 0.369 |
| Fat (% Energy) | 37.8±3.63 | 37.0 (7.00) | 36.3±5.62 | 36.0 (5.00) | -0.953 | 0.341 |
| Saturated fatty acids (% Energy) | 12.8±2.41 | 13.2 (3.40) | 12.8±1.70 | 12.5 (2.40) | -0.089 | 0.929 |
| Monounsaturated fatty acids (% Energy) | 12.5±2.36 | 12.3 (3.40) | 12.1±2.84 | 12.4 (3.60) | -0.445 | 0.657 |
| Polyunsaturated fatty acids (% Energy) | 9.43.35 | 8.1 (5.70) | 9.0±3.02 | 10.3 (5.10) | -0.356 | 0.722 |
| Carbohydrate (% Energy) | 48.8±5.62 | 52.0 (11.00) | 50.3±8.10 | 50.0 (9.00) | -0.936 | 0.349 |
| Sucrose (% Energy) | 9.9±3.91 | 10.2 (6.40) | 6.2±2.12 | 5.9 (3.10) | -2.490 | 0.013* |

‡Wilcoxon test, *p<0.05.

Table 3 shows the meeting of energy and nutrient intake of children before and after gluten-free diet treatment according to DRVs. There was no statistically significant difference between these values before and after gluten-free diet treatment (p>0.05).

The daily food intake of the children before and after the gluten-free diet treatment is given in Table 4. It was observed that children consumed 1.4±0.71 servings/day of milk and milk products group before the gluten-free diet and 1.8±0.61 servings/day after the gluten-free diet (p<0.05). It was observed that the yogurt consumption of children was 0.4±1.87 servings/day before the gluten-free diet and 0.5±0.34 servings/day after the diet (p<0.05).

Vegetables other than green-leaved vegetables and potatoes were consumed more after the gluten-free diet (1.2±0.98 servings/day) than before (mean 0.4±0.36 servings/day) (p<0.05). Moreover, consuming sugar and sugary foods decreased after the gluten-free diet (p<0.05).

The height and body mass index classification of children according to age is shown in Table 5. When the calculated z-scores were classified according to the cut-off points recommended by WHO, 45.5% of the children were observed to be stunted, and 36.4% had normal height before the gluten-free diet, whereas 54.5% of them were classified in the normal range after the gluten-free diet. One child was overweight before and after the diet, one child was underweight, and the rest (81.8%) were within the normal range.

**Table 3.** Energy And Nutrient Intakes of the Children Before And After Gluten Free Diet Treatment According to DRVs

| Energy and nutrients | Before gluten free diet | | After gluten free diet | | Z‡ | p |
|---|---|---|---|---|---|---|
| | Mean±SD | M (IQR) | Mean±SD | M (IQR) | | |
| Energy (kcal) | 94.0±19.19 | 87.7 (32.80) | 99.2±12.67 | 95.5 (15.40) | -0.889 | 0.374 |
| Protein (g/kg) | 191.0±47.9 | 174 (95.00) | 210.9±74.64 | 202.0 (112.00) | -0.623 | 0.533 |
| Fiber (g) | 105.5±44.95 | 86.1 (76.10) | 99.9±31.65 | 97.5 (42.60) | -0.089 | 0.929 |
| Vitamin A (mcg RE) | 273.5±203.91 | 174.4 (435.00) | 414.7±395.09 | 218.0 (332.70) | -1.067 | 0.286 |
| Vitamin E (mg) | 154.7±60.03 | 144.2 (107.60) | 170.8±50.14 | 162.0 (68.30) | -1.067 | 0.286 |
| Thiamine (mg) | 140.0±59.32 | 123.0 (48.90) | 126.8±32.32 | 122.4 (48.70) | -0.178 | 0.859 |
| Riboflavin (mg) | 193.2±128.71 | 143.3 (75.00) | 197.3±60.93 | 198.3 (106.70) | -0.800 | 0.424 |
| Niacin (mg NE) | 151.3±48.84 | 155.5 (69.10) | 183.9±64.86 | 180.1 (106.00) | -1.511 | 0.131 |
| Vitamin B6 (mg) | 171.2±136.77 | 130.0 (95.70) | 164.1±64.31 | 140.7 (104.30) | -0.889 | 0.374 |
| Folate (mcg) | 130.4±46.82 | 113.4 (76.70) | 132.4±43.42 | 118.9 (70.00) | -0.267 | 0.790 |
| Vitamin B12 (mcg) | 1079.0±2997.41 | 182.0 (122.00) | 294.8±214.58 | 285.3 (181.40) | -1.511 | 0.131 |
| Vitamin C (mg) | 294.9±212.66 | 263.7 (302.20) | 294.8±214.58 | 247.6 (218.90) | -0.445 | 0.657 |
| Potassium (mg) | 139.4±46.22 | 128.4 (63.70) | 166.7±49.29 | 150.9 (70.90) | -1.956 | 0.050 |
| Calcium (mg) | 76.6±43.63 | 69.7 (68.90) | 82.7±27.79 | 69.0 (33.70) | -0.889 | 0.374 |
| Magnesium (mg) | 82.5±27.25 | 84.5 (36.10) | 93.4±27.59 | 91.1 (20.20) | -1.245 | 0.213 |
| Phosphorus (mg) | 193.9±74.29 | 190.0 (124.00) | 225.5±78.45 | 204.8 (144.40) | -1.245 | 0.213 |
| Iron (mg) | 172.9±220.59 | 100.4 (92.10) | 90.3±36.93 | 74.9 (46.80) | -1.334 | 0.182 |
| Zinc (mg) | 97.4±31.05 | 101.1 (50.20) | 114.5±49.24 | 110.7 (72.20) | -1.067 | 0.286 |
| Manganese (mg) | 193.1±104.53 | 164.0 (96.00) | 210.6±66.88 | 204.0 (90.70) | -0.756 | 0.450 |

‡Wilcoxon test, *p<0.05.

## DISCUSSION

Nutrient deficiencies in celiac patients may develop due to the damage caused in the intestines or as a result of gluten-free diets. Low quality of gluten-free special products, inability to plan the diet correctly, and restrictions in food consumption are the factors that affect gluten-free diets to have inadequate or unbalanced patterns (Rybicka, 2018; See et al., 2015). Elevated fat content in the diet is one of the most frequently reported changes in the nutrition programs of children diagnosed with celiac disease. In most studies, it was reported that there were significant increases in total fat and saturated fatty acid intake of children with celiac disease than the control group (Babio et al., 2017; Balamtekin et al., 2015; Ferrara et al., 2009; Kautto et al., 2014; Zuccotti et al., 2013). In a Spanish study, gluten-free diet contributed with a high percentage (>25%) to total energy, carbohydrates, fiber, and salt intakes (González et al., 2022). Moreover, ultra-processed food consumption was shown to increase in diet (Martín-Masot et al., 2022). In this study, the percentage of children's energy which came from fat decreased from 37,8±3,63% to 36,3±5,62% (p>0.05); however, it was observed that both values were above the recommended value (35%) for fat intake. It can be thought that the lack of desired structure of gluten-free breads may contribute to an increase in the energy from fat by causing a decrease in bread consumption with the gluten-free diet

**Table 4.** Daily Food Intakes of Children Before and After Gluten Free Diet Treatment

| Food groups | Before gluten free diet | | After gluten free diet | | Z‡ | p |
|---|---|---|---|---|---|---|
| | Mean±SD | M (IQR) | Mean±SD | M (IQR) | | |
| **Dairy** | 1.4±0.71 | 1.4 (1.54) | 1.8±0.61 | 1.7 (0.75) | -2.002 | 0.045* |
| Milk | 0.7±0.48 | 0.5 (0.85) | 0.8±0.63 | 0.8 (1.20) | -1.067 | 0.286 |
| Yogurt | 0.4±1.87 | 0.4 (0.40) | 0.5±0.34 | 0.5 (0.35) | -2.207 | 0.027* |
| Cheeses | 0.3±0.21 | 0.4 (0.40) | 0.5±0.18 | 0.5 (0.35) | -1.906 | 0.057 |
| **Meats** | | | | | | |
| Meat, poultry, fish | 0.5±0.64 | 0.3 (0.40) | 0.9±0.73 | 0.8 (0.85) | -1.633 | 0.102 |
| Eggs | 0.5±0.31 | 0.4 (0.40) | 0.4±0.26 | 0.5 (0.30) | -0.102 | 0.919 |
| Legumes | 0.3±0.25 | 0.3 (0.40) | 0.3±0.23 | 0.3 (0.30) | -0.656 | 0.512 |
| Nuts and seeds | 0.4±0.53 | 0.0 (0.80) | 0.3±0.48 | 0.0 (0.35) | -0.631 | 0.528 |
| **Grains** | 3.2±1.86 | 2.9 (2.65) | 3.8±1.28 | 3.6 (1.00) | -1.245 | 0.213 |
| Breads | 1.0±0.96 | 0.7 (0.85) | 1.1±0.94 | 0.8 (1.35) | -0.044 | 0.965 |
| Other grains | 2.2±1.14 | 2.1 (2.10) | 2.7±1.04 | 2.8 (2.10) | -1.305 | 0.192 |
| **Vegetables** | 1.1±0.82 | 0.9 (1.70) | 2.0±1.81 | 1.8 (1.70) | -1.326 | 0.185 |
| Green leafy vegetables | 0.3±0.51 | 0.0 (0.55) | 0.2±0.26 | 0.0 (0.40) | -0.357 | 0.721 |
| Potatoes | 0.4±0.38 | 0.3 (0.60) | 0.7±0.96 | 0.3 (1.30) | -0.492 | 0.623 |
| Other vegetables | 0.4±0.36 | 0.4 (0.60) | 1.2±0.98 | 1.1 (0.60) | -2.937 | 0.003* |
| **Fruits** | 1.6±1.09 | 1.5 (1.30) | 2.0±0.84 | 1.7 (1.40) | -1.113 | 0.266 |
| **Sugar and sweet foods** | 3.3±2.29 | 3.0 (4.30) | 1.5±1.81 | 0.9 (1.06) | -2.090 | 0.037* |
| **Oil and fats** | 2.2±0.75 | 1.9 (1.30) | 2.2±0.99 | 2.0 (1.55) | -0.153 | 0.878 |
| Oils | 1.4±0.70 | 1.3 (1.10) | 1.7±0.87 | 1.6 (1.40) | -1.112 | 0.266 |
| Fats | 0.8±0.84 | 0.8 (0.80) | 0.4±0.87 | 0.3 (0.30) | -0.970 | 0.332 |

‡Wilcoxon test, *p<0,05

**Table 5.** Height and Body Mass Index Classification of Children by Age

| Classification | Before gluten free diet | | After gluten free diet | |
|---|---|---|---|---|
| | n | % | n | % |
| **Height (cm)** | | | | |
| Very tall (+2<z-score≤+3) | 1 | 9.1 | 1 | 9.1 |
| Tall (+1<z-score≤+2) | 1 | 9.1 | 1 | 9.1 |
| Normal (-1≤z-score≤+1) | 4 | 36.4 | 6 | 54.5 |
| Stunted (-2<z-score≤-1) | 5 | 45.5 | 3 | 27.3 |
| **Body mass index (kg/m2)** | | | | |
| Overweight (+1<z-score≤+2) | 1 | 9.1 | 1 | 9.1 |
| Normal (-1≤z-score≤+1) | 9 | 81.8 | 9 | 81.8 |
| Underweight (-2<z-score≤-1) | 1 | 9.1 | 1 | 9.1 |

(Valitutti et al., 2017). At this point, it is a fact that the type of carbohydrate which the bread contains will be crucial. It is also possible that bread with a high starch content and which are mostly made without using alternative grains, are consumed in high amounts or is in the diet as the sole grain source, leading to an imbalance in the diet both in terms of having a high glycemic index and low fiber and protein content (Segura and Rosell, 2011). In this study, it was observed that there was a decrease in bread consumption.

Since the content of gluten-free cereal products consists mostly of starch, these products are known to have a low fiber content and a high glycemic index score (Cornicelli et al., 2018). Removing the grains which comprise gluten from the diet may cause significant imbalances regarding fiber. In recent years, it has been possible to increase the fiber content of the diet by adding alternative gluten-free pseudo-grains, such as quinoa, amaranth, buckwheat and sorghum (Bascunan et al., 2017). These alternatives are sold separately, or they are used to enrich gluten-free flours regarding fiber, protein, iron, zinc and calcium (Saturni, Ferretti, and Bacchetti, 2010). However, it has been shown that most gluten-free packaged products are still low in fiber (Missbach et al., 2015). In the literature, it has been reported that there was a decrease in fiber intake in children with celiac disease (Hopman, le Cessie, von Blomberg, and Mearin, 2006; Öhlund et al., 2010). Among the results of the current study, there was no significant difference in the fiber intake of children before and after the gluten-free diet, and the fiber intake before and after the diet remained at the level of standard fiber requirements. This may be due to the increase in children's consumption of other grains other than bread, vegetables and fruits.

With the elimination of gluten from the diet, a decrease in vegetable protein intake is expected. Most gluten-free breads are economical and they contain lower amounts of protein than their gluten-containing counterparts (Melini and Melini, 2019). In a study, it was reported that the plant-based protein intake of adult celiac patients was 7.8 g lower than the control group (Van Hees et al., 2015). Supporting these data, the limited preferences of children regarding cereal-based foods may cause an increase in terms of animal-based protein consumption (Babio et al., 2017). Although gluten-free diets have been shown to be sufficient regarding protein (Sue, Dehlsen, and Ooi, 2018), to our knowledge, changes in protein consumption patterns have not been examined. While there is no change in the percentage of energy from protein in this study, decreases in plant-based protein intake and increases in animal-based protein intake (data not shown in the table) were found. It was thought that the decrease in plant-based protein intake may be due to the low protein content of gluten-free bread. In addition, the increase in animal-based protein intake is due to the increase in children's consumption of milk and dairy products, and furthermore, of meat/chicken/fish.

In a systematic review, it was reported that gluten-free diets were deficient in micronutrients, such as calcium, iron, zinc, folate and vitamin B12 (Dennis, Lee, and McCarthy, 2019; Di Nardo et al., 2019; Penagini et al., 2013). In a recent review, it has been found that most children have iron and calcium intake below the recommendations, even if they do not receive gluten-free diet treatment (Di Nardo et al., 2019). On the other hand, in a study conducted in Spain, it was shown that calcium, phosphorus, iron, folate and vitamin B12 consumption levels meet the recommendations who have been on a gluten-free diet for one year (Quero et al., 2015). Similarly, in this study, with the increase in the consumption of milk and dairy products, the calcium intake of children increased. With the consumption of adequate amounts of meat products, iron, zinc and vitamin B12, and with the increase in the consumption of vegetables and other grains, the decrease in folate intake after a gluten-free diet was prevented and intake at the level of recommendations was achieved.

It has been reported that there is an increase in sucrose consumption in gluten-free diets (Di Nardo et al., 2019). In a study, individuals with celiac disease (10-23 years old) consumed more foods that contained added sugar, apart from the healthy control group. The mean energy intake from sugar was 18.6% (Babio et al., 2017). In another study, energy intake from sucrose in children with celiac disease was above the recommendations and was similar to their healthy peers (Öhlund et al., 2010). In this study, it was observed that after the gluten-free diet, the energy intake from sucrose decreased from 9.9±3.91% to 6.2±2.12%. This change results from the decrease in the consumption of sugar and sugary foods in the

children's eating patterns, who transitioned to a gluten-free diet.

Late diagnosis of celiac disease in children is associated with growth retardation (Van Rijn et al., 2004). In a study in which early growth outputs were followed longitudinally, 58,675 children were followed between 4.6 and 14.2 years, and their height and body weights were evaluated. At the end of the study, children diagnosed with celiac disease had lower z-scores for height from 12 months and 15-18 years. It was observed that they had a lower body weight than their age, starting from the 6th month (Kahrs et al., 2017). In this study, it was determined that 45.5% of the children were stunted before the diet treatment, and this value decreased to 27.3% after the diet. Positive changes were observed in the height of the children after the diet. When examined individually, it was determined that most children with a height close to -2 z-score rapidly improved in the first month of treatment (data not shown in the table).

Recently, children had lower body weight than their peers when diagnosed with celiac disease (Graziano Barera et al., 2000). Today, it has been reported that the disease may progress with both low and high body weight (Brambilla et al., 2013). In a study conducted in Italy, 16% of children with celiac disease were underweight. This showed that being overweight and obese were at the rate of 12% (Brambilla et al., 2013). In some studies, it was shown that the tendency of obesity is increasing, and most children at the time of diagnosis were overweight or even obese (Reilly et al., 2011; Valletta et al., 2010; Venkatasubramani, Telega, and Werlin, 2010).

In one of the studies, it was observed that 74.5% of the children diagnosed with celiac disease had normal BMI at the time of diagnosis, 12.6% were classified as overweight, and 6.0% were classified as obese. The same study stated that after a gluten-free diet treatment, BMI values returned to normal ranges in 44% of children, and decreases were determined in 75% of the children with especially elevated BMI. On the other hand, one of the most striking results of the study was that 13% of the children entered the overweight range after a gluten-free diet (Reilly et al., 2011). Similarly, in another study, an almost two-fold increase in the frequency of being overweight or obese was found (before 11.0%; after 21.0%). This trend may be due to excessive consumption of gluten-free high-fat ready-to-eat junk foods by children (Valletta et al., 2010). In a recent study, the mean BMI increased significantly on the short-term follow-up and the long-term trend depends on their symptoms (Vereczkei et al., 2023). In this study, similar to the trend seen in recent years, it was observed that most children (81.8%) were classified between normal BMI values at the time of diagnosis. One child was overweight, and one child was underweight. It was determined that these classifications were preserved within the first sixth month of the gluten-free diet treatment. However, when BMI changes are evaluated individually, it was observed that the z-score values decreased over time in the overweight child and increased in the underweight child (data not shown in the table). This situation reveals the necessity of regular follow-up of obesity assessment in children on a gluten-free diet. Strict follow-up of the gluten-free diet treatment by a dietitian is suggested for the BMI values of children with celiac disease to be improved and to prevent the elevation regarding the BMI levels.

## CONCLUSION

Gluten-free diets used in the treatment of celiac disease have the potential to be unbalanced in terms of the relevant nutrient pattern if not planned correctly. Individual evaluations and planning of the diet by dietitians improve the nutritional status of children. In this study, it was shown that with diets that were specially planned and designed for children, the consumption of milk and milk products increased while the consumption of sugar and sugary foods decreased. Thus, the fat intake could be kept around the level of recommendations. In addition, it was observed that rapid growth was achieved in children who followed gluten-free diets.

## AUTHOR CONTRIBUTION

Idea/Concept: YEÖ, EK; Design: YEÖ, EK, ÖEG ; Data Collection and/ or Processing: YEÖ, EK, ÖEG; Analysis and/or Interpretation: YEÖ, EK; Writing the Article: YEÖ, EK; Critical Review: EK, ÖEG.

## CONFLICT OF INTEREST

Authors declare no conflict of interest.

## FINANCIAL DISCLOSURE

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## ETHICAL STATEMENT

Ethics approval of the study was obtained from Gazi University, Faculty of Medicine, Clinical Research Ethics Committee (Date: 22.01.2018, No: 24074710-8, Decision no: 42).

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