One-year follow-up of the nutritional status of celiac people on a gluten-free diet

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Research

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Abstract

Background

The gluten-free diet (GFD), the only effective treatment for celiac disease, is usually nutritionally imbalanced. The present work aimed to analyze the evolution of the nutritional status, dietary profile, and symptoms present among celiac people over one year on a GFD while receiving individualized dietary advice.

Methods

Twenty-seven adults and thirty-one celiac children/adolescents participated in the cohort study. They were followed by 3 visits, at diagnosis (vt0) and after 3 and 12 months (vt3;vt12). Participants filled out dietary and gastrointestinal symptoms questionnaires and received a personalized form from dietitians containing dietary advice and anthropometric and biochemical data evolution.

Results

Most patients presented normal BMI, fat and muscle mass, and biochemical parameters at diagnosis and vt12. By contrast, all participants consumed protein and lipids in excess and carbohydrates in defect, in both vt0 and vt12. Low intakes of cereals, fruits and vegetables and high of meat were observed, these also remaining unchanged after dietary counseling. Symptoms present decreased after vt3 but rebounded in vt12.

Conclusions

Few changes in dietary pattern and symptom elimination suggested that the intervention was not effective enough. More research is necessary to evaluate whether closer follow up and face-to-face dietary advice improve dietary habits of celiac people.

Trial registration:

Code PI2016069, Ethical Comitee of the Clinical Investigation of the Basque Country. Registered on 15 July 2016.

1. Background

A strict lifelong Gluten-Free Diet (GFD) is currently the only effective treatment for celiac disease (CD), consisting in the total elimination of all products containing gluten from the diet [1, 2]. Small amounts of gluten ingestion, which can cause important damage-causing disorders in the intestinal mucosa of celiac people, need to be avoided. In addition, other gluten-related disorders, such as Non-celiac Gluten Sensitivity (NCGS), have appeared in recent years. These also benefit from following this dietary restriction [3].

Apart from the absence of gluten, a GFD must guarantee nutritional balance and prevent deficiencies. However, when nutritional assessments of celiac people have been carried out, imbalanced proportions of macronutrients and lack of several vitamin and minerals have been observed in their diets [4–9]. In particular, these studies have confirmed that a GFD is usually characterized by a poor intake of carbohydrates, iron, calcium, folate, niacin, zinc and fiber, as well as of excessive saturated fats. Therefore, following a GFD could lead to increased risk of several pathologies related to dietary imbalances, such as higher probabilities of CV diseases [10], anemia, osteoporosis or constipation [11–13]. Indeed, clinical trials performed among celiac participants have observed altered biochemical parameters, which are related to the aforementioned associated pathologies [7, 14–17].

Therefore, and in view of this scenario, a nutritional intervention based on personalized nutritional advice and a close follow-up of celiac patients carried out by dietitian-nutritionists should be highly recommended in order to establish suitable dietary guidelines. In fact, authors working in this field have proposed a regular control of the dietary history, apart from measurements of serum antibodies, body composition and examination of nutritional deficiencies related symptoms, as a strategy for improving the nutritional status of celiac sufferers and for making GFD more balanced [18].

Nevertheless, dietitians/nutritionists working with this collective have to deal with a specific problem since they only can make approximations when evaluating a GFD. Dietary software available on the market does not include nutritional information about a large number of specific gluten-free products (GFP), which has been demonstrated to be different from those of their gluten-containing homologues [19, 20]. Thus, the diet of people with CD cannot be precisely designed and their nutrient intake is usually miscalculated. Moreover, most commercial softwares focus on dietary plan designs for healthy people and are not freely available. Only a small number of these programs are also useful for therapeutic dietary plans, including diseases such as diabetes, hypercholesterolemia, or hypertension and not CD.

It must be also taken into account that nutritional imbalances are not the only difficulty that people with CD have to deal with. Gluten elimination from the diet should lead to a total remission of symptoms. However, data in the literature indicate that approximately 20–30% of celiac people continue suffering from symptoms even though they follow a strict GFD [21–25]. One of the reasons attributed to these complications is involuntary ingestions
of small amounts of gluten, called gluten transgressions [23]. These can occur due to several factors, which may include a lack of knowledge about both gluten-containing and non-containing products, the high price of GFP, sharing the meal with non-CD diners [26], socialization problems of the collective or anxiety and depression [27–31]. Thus, ensuring adherence to GFD or a strict compliance have proved to be crucial not only for a faster improvement of intestinal lesion but also for the reduction of symptoms related to the CD and the normalization of body composition [32].

2. Methods

Taking into account all of the above, it is obvious that nutritional assessment, education and follow up is necessary among this collective. Thus, the aim of the present work was to analyze a 1 year evolution of the nutritional status, dietary habits and symptoms present in celiac people who were receiving individualized dietary counseling in order to improve their nutritional status.

2.1. Participants and procedure

A study group of celiac people was recruited between 2016 and 2018 in two hospitals of the Basque Country (Hospital Universitario de Cruces and Hospital Universitario de Donostia) and in the Celiac Association of Madrid (Asociación de Celiacos y Sensibles al Gluten de Madrid). All pediatric patients (n = 31) were referred to the clinics to confirm a CD diagnosis (intestinal biopsy and/or serological tests) over this time span (2016–2018) and were consecutively enrolled and followed for the first 12 months after diagnosis confirmation. In the case of adults, who were taken from Celiac Association of Madrid members, 10 participants were newly diagnosed and 17 had been on a GFD for less than 1 year. The number of recruited participants was defined by the capacity of recruitment of each center. They attended medical/dietitian offices on three occasions: at diagnosis (v0); after three months on a GFD (v3); and after 12 months on a GFD (v12). Twenty-seven adults (5 men, 22 women; mean age ± SD: 37.1 ± 9.1) and thirty-one celiac children and adolescents (mean age ± SD: 7.1 ± 3.9) took part in the study at v0; thirteen adults (3 men and 10 women) and twenty-two children and adolescents continued the study at v3 and four adults (0 men and 4 women) and sixteen children and adolescents at v12 (Fig. 1). Efforts to maintain subjects’ participation in the study were carried out, such as: telephone calls to encourage participants to continue in the study, controlling individually the data of each visit, giving personalized attention to each one, etc. All available data were used.

Exclusion criteria included a history of chronic diseases such as cardiovascular disease, diabetes, hyperthyroidism/hypothyroidism, hypercholesterolemia, hypertriglyceridemia or high blood pressure levels, other digestive pathologies that need specific dietary advice and as well as lack of motivation to participate in the study. Written informed consent was obtained from all participants, after receiving information about the survey. This study was approved by the Ethical Committee of The Basque Country (Comité Éticode Investigación Clínica de Euskadi, CEIC Code PI 2016069).

2.2. Anthropometric Measurements

Trained personnel collected anthropometric measurements. Body weight (± 10 g) was measured after using a digital integrating scale (SECA 760). Height was determined to the nearest 5 mm using a stadiometer (SECA 220). Body Mass Index (BMI) was calculated from weight and height (kg/m2). The BMI values of adult patients were categorized according to the World Health Organization (WHO) criteria as follows: Below 18.5 kg/m2 considered as underweight, 18.5–24.9 kg/m2 as normal weight, 25–29.9 kg/m2 as overweight and > 30 kg/m2 as obese (WHO). In case of children and adolescents, the criteria established by Sobradillo et al. [33] were used to categorize BMI values as follows: < percentile 3 was considered as underweight; between percentile 3 and 85 normal weight, between percentile 85 and 95 overweight and > percentile 95, obesity.

2.3. Body Composition and Energy Expenditure

Fat mass, muscle mass, water, protein and mineral body content were estimated by a direct segmental multiple-frequency bioelectrical impedance analysis method (Inbody 120; Microcaya, S.A., Bilbao). Two skin electrodes were placed on the feet and two on the hands. Following the standard procedure, whole-body resistance and reactance were measured. The guidelines of WHO [34, 35] and Moreno et al. [36, 37] were used as reference for body fat mass in adults and children respectively. Muscle mass values were compared to the limits described by Heymsfield et al (1990) and Ito et al (2001) [38, 39]. Protein, mineral and water content classified according to the limits established by InBody 120 for each participant.

Resting metabolic rate (RMR) and waist and hip circumferences (WHC) were also calculated by the bioelectrical impedance analysis method. In order to calculate energy expenditure, standard activity level value was applied to the RMR. The limits defined by the WHO were used to classify waist-height ratio data [40].

2.4. Biochemical data

Fasting glucose, total cholesterol, HDL-cholesterol (HDL-c), LDL-cholesterol (LDL-c), triglycerides, ferritin and transferrin levels were measured at each visit. Values were compared to the Basque Health System references.

2.5. Analysis of symptoms presence

For the systematic evaluation of current gastrointestinal symptoms, participants filled out a self-administered, structured Gastrointestinal Symptom Rating Scale (GSRS) questionnaire [4]. This is a validated questionnaire used widely in research on celiac disease and other gastrointestinal disorders [42–47]. The questionnaire measures five subdimensions of gastrointestinal symptoms: Indigestion, diarrhea, abdominal pain, reflux and constipation. It comprises 15 separate items altogether. Values for each of the five subdimension scores were calculated as a mean of the respective items and the total GSRS score as a mean of all 15 items. Scoring is based on a Likert scale from 1 to 7 points, where 1 point signifies minimal gastrointestinal
2.6. Dietary Assessment and Counseling

Dietary intake was assessed using 3-day 24-h food recalls (24 HR), two on weekdays and one at the weekend, in each visit to the medical/dietitian office (vt0, vt3 and vt12). Participants also filled out a food frequency questionnaire (FFQ) at the first and last visit (vt0 and vt12). Registered dieticians-nutritionists recorded the answers of participants. In order to avoid bias in the measurement of the diet, food portions and amounts were determined by using photographs of rations and sizes described in Rusolillo and Marques’ Photo Album [48]. Energy and nutrient intakes were calculated by GlutenFreeDiet software, a specific free software created by our team for GFD evaluation and analysis (http://www.ehu.eus/dieta-singluten/) that contains, apart from the nutritional composition of conventional products, the energy, macronutrient, cholesterol and fiber content of more than 700 specific GFP obtained from the food labels [49].

Dietary reference intakes (DRI) for Spanish population issued by the Spanish Societies of Nutrition, Feeding and Dietetics (FESNAD) in 2010 were taken as references for the interpretation of the 24 HR [50]. In the case of FFQ, Spanish Society of Community Nutrition (SENC) recommendations were used for the correct interpretation of the results [51].

All patients received a personalized form by email, after each visit to the medical/dietitians office (after vt0, vt3 and vt12). These reports detailed their nutritional status diagnosis and the quality of their diet, such as their consumption of macronutrients, food groups, their micronutrient deficiencies and possible associated risks, etc. Moreover, specific dietary guidelines were provided to each patient to correct particular imbalances detected. Despite patients having the option of requesting personalized consultations concerning their results, most of them did not use this service.

2.7. Statistical analysis

Statistical analyses of results were performed by using the IBM SPSS statistical program, version 23 (IBM Inc., Armonk, NY, USA). Normality in the distribution was assessed by the Kolmogorov-Smirnov test, and homogeneity by Levene's test. Follow-up was addressed by indicating the number of participants in each visit. Statistical analyses were performed in order to calculate differences between measurements performed with Wilcoxon test (vt0 vs vt3 and vt0 vs vt12). Correlation between variables was calculated with Pearson’s correlation coefficient test. p values < 0.05 were accepted as statistically significant.

3. Results

3.1. Evolution of anthropometric and biochemical parameters over 1 year of GFD in adults, children and adolescents with CD

Table 1 and Table 2 show the evolution of anthropometric and biochemical data among adult participants and children and adolescents during one year on GFD. As may be observed, with regard to BMI, fat mass and muscle mass these were normal at diagnosis except for men’s values, which were worse than those of other participants. Going on a GFD for 3 and 12 months did not change any of the anthropometric parameters measured except in the case of children’s weight, height, Resting Metabolic Rate and Energy Expenditure which increased in all cases due to growth. Nevertheless, BMI of the majority of these participants remained in the normal range. Likewise, all biochemical parameters were under normal values at diagnosis, except in the case of men’s total cholesterol, which was above 200 mg/ml. Unfortunately, there were no more data collected in men. Women’s biochemical data remained unchanged after 3 and 12 months on GFD. In the case of children and adolescents, even though fasting glucose values increased from vt0 to vt3 and to vt12, they remained within normal values. No changes were observed in the rest of the parameters in the infant population.
## Table 1

### Anthropometric and biochemical data of celiac adults.

|                  | Men |          |          |          | Women |          |          |          |
|------------------|-----|----------|----------|----------|-------|----------|----------|----------|
|                  | vt0 | vt3      | vt12     | p value  | vt0   | vt3      | vt12     | p value  |
| N                | 5   | 3        | 0        |          | 22    | 10       | 4        |          |
| **Anthropometric measurements** |      |          |          |          |       |          |          |          |
| Weight (kg)      |      |          |          |          |       |          |          |          |
|                  | v0  |          |          |          |       |          |          |          |
| BMI (kg/m²)      |      |          |          |          |       |          |          |          |
| low              | <18.5 |          |          |          |       |          |          |          |
|                  | 24.5±2.2 |          |          |          |       |          |          |          |
| normal           | 18.5–24.9 |          |          |          |       |          |          |          |
|                  | 60   |          |          |          |       |          |          |          |
| overweight       | >30.0 |          |          |          |       |          |          |          |
|                  | 40   |          |          |          |       |          |          |          |
| Obesity          |      |          |          |          |       |          |          |          |
|                  | 0    |          |          |          |       |          |          |          |
| WHR              |      |          |          |          |       |          |          |          |
| low risk         |      |          |          |          |       |          |          |          |
|                  | 0    |          |          |          |       |          |          |          |
| high risk        |      |          |          |          |       |          |          |          |
|                  | 0    |          |          |          |       |          |          |          |
| Fat mass (kg)    |      |          |          |          |       |          |          |          |
| low              | <8.9/12.9% of BW |          |          |          |       |          |          |          |
|                  | 20.3±3.2 |          |          |          |       |          |          |          |
| normal           | 40% of BW |          |          |          |       |          |          |          |
|                  | 20   |          |          |          |       |          |          |          |
| high             | >40.1% of BW |          |          |          |       |          |          |          |
|                  | 40   |          |          |          |       |          |          |          |
| Muscle mass (kg) |      |          |          |          |       |          |          |          |
| low              | <39.9% of BW |          |          |          |       |          |          |          |
|                  | 34.7±4.2 |          |          |          |       |          |          |          |
| normal           | 40% of BW |          |          |          |       |          |          |          |
|                  | 80   |          |          |          |       |          |          |          |
| high             | >40.1% of BW |          |          |          |       |          |          |          |
|                  | 20   |          |          |          |       |          |          |          |
| Protein content (kg) | 12.1±1.3 | 13.1±2.1 |          |          | 8.1±0.8 | 8.0±1.0 | 6.8±2.7 |          |
| low              |      |          |          |          |       |          |          |          |
| normal           |      |          |          |          |       |          |          |          |
| high             |      |          |          |          |       |          |          |          |
| Mineral content (kg) | 4.2±0.5 | 4.5±0.9 |          |          | 2.9±0.3 | 2.9±0.3 | 2.9±0.4 |          |
| low              |      |          |          |          |       |          |          |          |
| normal           |      |          |          |          |       |          |          |          |
| high             |      |          |          |          |       |          |          |          |
| Water content (L) |      |          |          |          |       |          |          |          |
| low              |      |          |          |          |       |          |          |          |
| normal           |      |          |          |          |       |          |          |          |
| high             |      |          |          |          |       |          |          |          |

*Denotes calculation of InBody 120 values.*
|                          | Men                           | Women                          |
|--------------------------|-------------------------------|--------------------------------|
| Basal Metabolic Rate (kcal) | 1688.4±147.5 1793.3±232.0 NS - | 1260.5±84.9 1264.8±118.2 1260.0±145.1 NS NS |
| Energy expenditure (kcal) | 2802.2±196.8 2873.3±309.7 NS - | 2042.2±140.0 2032.1±129.9 2025.0±168.4 NS NS |
| **Biochemical data**     |                               |                                |
| Glucose (mg/dl)           | 76–110 95±2.8 DNC - -         | 89.1±11.0 83.1±7.05 DNC NS - |
| Total cholesterol (mg/dl) | <200 234.5±12.0 DNC - -       | 164.0±26.0 168.7±19.2 DNC NS - |
| HDL (mg/dl)               | >40 DNC DNC - -               | 50.2±10.9 59.4±16.0 DNC NS - |
| LDL (mg/dl)               | <130 DNC DNC - -              | 99.4±24.5 91.8±28.1 DNC NS - |
| TG (mg/dl)                | <150 143±17.0 DNC - -         | 135.6±270.4 70±30.0 DNC NS - |
| Ferritin (ng/ml)          | 20–200 DNC DNC - -            | 28.7±30.0 18.9±14.3 DNC NS - |
| Transferrin (mg/dl)       | 200–374 DNC DNC - -           | 273.7±21.1 310.5±159.1 DNC NS - |
Table 2
Anthropometric and biochemical data of celiac children and adolescents.

| Children and adolescents | vt0  | vt3  | vt12 | p value     |
|--------------------------|------|------|------|-------------|
| n                        | 31   | 22   | 16   |             |

| Anthropometric measurements | Reference values* |
|-----------------------------|--------------------|
| Weight (kg)                 | 29.7 ± 12.1        |
| Height (m)                  | 1.28 ± 0.2         |
| BMI (kg/m$^2$)              |                   |
| % low                       | <P3                |
| P3-P85                      | 16.5 ± 1.8         |
| % normal                    | P85-P95            |
| 7.4                         |
| % overweight                | >P95               |
| 3.7                         |
| % obese                     |                   |
| 3.7                         |
| NS                          |
| WHR                         |                   |
| very low risk               | <P5                |
| P5-P95                      | 0.7 ± 0.1          |
| low risk                    | P95                |
| 19                           |
| high risk                   |                   |
| 4                            |
| Fat mass (kg)               |                   |
| <P5                         | 17.1 ± 6.2         |
| % low                       | P5-P95             |
| 20                           |
| % normal                    | >P95               |
| 60                           |
| % high                      |                   |
| 20                           |
| Fat mass (kg)               |                   |
| <P5                         | 17.1 ± 6.2         |
| % low                       | P5-P95             |
| 20                           |
| % normal                    | >P95               |
| 60                           |
| % high                      |                   |
| 20                           |
| Muscle mass (kg)            |                   |
| < 41.9% of BW               | 12.1 ± 4.8         |
| % low                       | 42–47% of BW       |
| 38.5                        |
| % normal                    | >47.1% of BW       |
| 61.5                        |
| % high                      |                   |
| 0                            |
| Protein content (kg)        | 4.8 ± 1.7          |
| % low                       | Personalized calculation of InBody 120 |
| 24                           |
| % normal                    | 76                   |
| 90                           |
| % high                      | 0                    |
| Mineral content (kg)        | 1.7 ± 0.6          |
| % low                       | Personalized calculation of InBody 120 |
| 8                            |
| % normal                    | 92                   |
| 95                           |
| % high                      | 0                    |
| Water content (L)           | 17.9 ± 6.2         |

*Reference values: BMI: Sobradillo et al., 2004 [33] established limits; WHR and Fat Mass: Moreno et al. 1998 [36]and Moreno et al. 1999 [37]established limits; Muscle Mass: Heymsfield et al. 1990 [38]and Ito et al. 2001[39] established limits; Protein, Mineral and Water content: limits established by InBody 120 for each participant; Biochemical data: Basque Health System established values.
3.2. Evolution of energy, macronutrient, fibre and cholesterol intake of adults, children and adolescents with CD during 1 year of GFD

Table 3 and Table 4 show the energy intake, macronutrient distribution and fibre and cholesterol consumption of adults and children, respectively. Energy intake was according to the energy expenditure in most cases, with the exception of adult men in vt3, which was lower than ±20% of their energy waste. All participants showed a bad distribution of macronutrients in their diets, which was characterized by an excess of protein and lipids and a low consumption of carbohydrates. Saturated fatty acids intake was high among adults (except for men in vt3), whereas children’s intake was nearer to the recommended amount. By contrast, consumption of sugars was adequate in all participants. Data obtained after 3 and 12 months on GFD did not indicate a modification of this dietary profile, except for protein consumption among women, which increased significantly after 3 months on GFD.
Table 3
Energy and macronutrient intake of celiac adults.

|                        | Men | Women | p value | Men | Women | p value |
|------------------------|-----|-------|---------|-----|-------|---------|
| **N**                  | 5   | 3     | 0       | vt0 vs vt3 | vt0 vs vt12 | vt0 vs vt3 | vt0 vs vt12 |
| **Energy intake (kcal)** | ± 20% of EE | 2412.4 ± 831.0 | 1698.0 ± 606.0 | NS | - | 1867.5 ± 517.4 | 2194.2 ± 393.5 | 1944.0 ± 97.7 | NS | NS |
| **Protein (%)**        | 12.5 | 16.4 ± 3.4 | 17.3 ± 3.5 | NS | - | 16.3 ± 3.7 | 20.3 ± 3.5 | 19.8 ± 2.0 | < 0.05 | NS |
| **Lipids (%)**         | 32.5 | 40.1 ± 10.4 | 38.7 ± 4.2 | NS | - | 41.3 ± 7.4 | 36.0 ± 7.3 | 40.6 ± 4.6 | NS | NS |
| **Saturated fatty acids (%)** | < 10 | 16.4 ± 13.8 | 10.0 ± 1.3 | NS | - | 12.0 ± 4.3 | 12.8 ± 2.9 | 14.5 ± 2.6 | NS | NS |
| **Carbohydrates (%)**  | 55  | 41.9 ± 9.5 | 42.0 ± 1.7 | NS | - | 40.2 ± 8.3 | 42.7 ± 8.0 | 36.3 ± 7.1 | NS | NS |
| **Simple sugars (%)**  | < 10 | 3.1 ± 2.1 | 3.4 ± 1.6 | NS | - | 4.6 ± 2.3 | 3.8 ± 1.1 | 4.1 ± 0.1 | NS | NS |
| **Fibre (g)**          | 14 g/1000 kcal | 32.0 ± 11.7 | 20.9 ± 20.6 | NS | - | 19.2 ± 10.0 | 25.9 ± 9.3 | 25.3 ± 7.1 | 0.059 | NS |
| **Cholesterol (mg)**   | < 300 | 309.5 ± 110.9 | 223.2 ± 62.9 | NS | - | 296.3 ± 138.9 | 326.5 ± 65.5 | 378.3 ± 125.2 | NS | NS |

Abbreviations: Vt0 = visit at time 0, at diagnosis; vt3 = visit after 3 months on a gluten-free diet; vt12 = visit after 12 months on a gluten-free diet NS = Not Significant; EE = Energy Expenditure.

*Recommended contribution in a balanced diet proposed by the Federation of Spanish Societies of Nutrition and Dietetics (FESNAD) and Spanish Society for Community Nutrition (SENC) [50, 51].

Table 4
Energy and macronutrient intake of celiac children and adolescents.

|                        | Children and adolescents | p value | Men | Women | p value |
|------------------------|--------------------------|---------|-----|-------|---------|
| **N**                  | 31                       | 22      | 16  | vt0 vs vt3 | vt0 vs vt12 |
| **Diet**               |                          |         |     |         |         |
| **Energy intake (kcal)** | ± 20% of EE            | 2055.6 ± 497.1 | 2142.5 ± 6.3 | 1982.8 ± 231.3 | NS | NS |
| **Protein (%)**        | 12.5                     | 15.3 ± 2.7 | 15.2 ± 2.72 | 15.6 ± 2.5 | NS | NS |
| **Lipids (%)**         | 32.5                     | 38.6 ± 7.6 | 39.9 ± 6.2 | 38.8 ± 7.7 | NS | NS |
| **Saturated fatty acids (%)** | < 10 | 11.5 ± 4.2 | 10.2 ± 2.6 | 9.4 ± 3.9 | NS | NS |
| **Carbohydrates (%)**  | 55                       | 44.9 ± 7.3 | 43.1 ± 5.5 | 44.8 ± 8.0 | NS | NS |
| **Simple sugars (%)**  | < 10                     | 3.9 ± 3.2 | 2.9 ± 2.3 | 3.0 ± 0.6 | NS | NS |
| **Fibre (g)**          | 10-13g/1000kcal         | 17.9 ± 6.7 | 18.1 ± 8.6 | 20.1 ± 6.9 | 0.079 | NS |
| **Cholesterol (mg)**   | < 200                    | 274.3 ± 120.0 | 312.4 ± 114.6 | 317.1 ± 79.3 | NS | NS |

Abbreviations: NS = Not Significant; EE = Energy Expenditure.

*Recommended contribution in a balanced diet proposed by the Federation of Spanish Societies of Nutrition and Dietetics (FESNAD) and Spanish Society for Community Nutrition (SENC) [50, 51].

Fibre intake was high enough in men but low in women and children at vt0. However, both groups, adult women and children and adolescents, increased their fibre consumption after 3 and 12 months on a GFD even though this change only reached a tendency to increase after three months. Women complied with fibre recommendations in vt3 and vt12 and children only in vt12.

Cholesterol intake was only sufficient among men in vt3 and among women in vt0. The cholesterol intake reported in the rest of the visits of adult participants and among children was above recommendations.
3.3. Food frequency consumption and its evolution

The daily consumption of vegetables, fruits, oils and especially that of cereals was low at vt0 in all participants (Table 5 and Table 6). Men did not fulfil the recommendation for dairy products either. Meat consumption was extremely high in all subjects exceeding the recommended intake 2 fold in the case of women and children.

| Table 5 | Food group consumption frequency of adult participants. |
|---------|------------------------------------------------------|
|         | Men | Women | Recommended intake* | vt0 | vt12 | p value | vt0 | vt12 | p value |
| N       |      |       |                     |     |      |         |     |      |         |
| Daily consumption | Dairy | 2–4 | 1.7 ± 0.8 | - | 2.7 ± 1.5 | 3.2 ± 0.3 | NS | vt0 vs vt12 |
|         | Cereals | 4–6 | 1.4 ± 0.2 | - | 2.9 ± 1.4 | 2.7 ± 0.8 | NS | vt0 vs vt12 |
|         | Vegetables | 2 | 0.7 ± 0.3 | - | 1.5 ± 1.5 | 2.0 ± 1.3 | NS | vt0 vs vt12 |
|         | Fruits | 3 | 2.2 ± 0.7 | - | 2.5 ± 1.7 | 2.2 ± 1.5 | NS | vt0 vs vt12 |
|         | Oils | 3–6 | 2.0 ± 1.0 | - | 2.5 ± 1.3 | 2.7 ± 2.3 | NS | vt0 vs vt12 |
| Weekly consumption | Meat | 3–4 | 4.8 ± 2.0 | - | 6.7 ± 2.5 | 4.5 ± 1.3 | NS | vt0 vs vt12 |
|         | Fish | 3–4 | 2.3 ± 1.4 | - | 3.7 ± 2.3 | 4.3 ± 1.4 | NS | vt0 vs vt12 |
|         | Eggs | 3–4 | 2.2 ± 1.1 | - | 3.1 ± 2.7 | 3.0 ± 0.1 | NS | vt0 vs vt12 |
|         | Legumes | 2–4 | 2.3 ± 1.5 | - | 1.8 ± 1.4 | 1.7 ± 1.2 | NS | vt0 vs vt12 |
|         | Nuts | 3–7 | 3.5 ± 2.7 | - | 1.9 ± 2.0 | 2.2 ± 1.4 | NS | vt0 vs vt12 |
|         | Pastries | Occasional | 0.6 ± 0.4 | - | 0.8 ± 1.0 | 0.3 ± 0.3 | NS | vt0 vs vt12 |

Abbreviations: NS: Not significant

*Recommended intake according to the Spanish Society of Community Nutrition (SENC) [51].

| Table 6 | Food group consumption frequency of children and adolescents. |
|---------|---------------------------------------------------------------|
|         | Children and adolescents | Recommended intake* | vt0 | vt12 | p value |
| n       | 31 | 16 | vt0 vs vt12 |
| Daily consumption | Dairy | 2–4 | 2.7 ± 1.3 | 2.5 ± 0.6 | NS | vt0 vs vt12 |
|         | Cereals | 4–6 | 3.8 ± 1.9 | 2.7 ± 1.5 | 0.098 | vt0 vs vt12 |
|         | Vegetables | 2 | 0.8 ± 0.5 | 0.9 ± 0.6 | NS | vt0 vs vt12 |
|         | Fruits | 3 | 1.7 ± 1.3 | 2.0 ± 1.1 | NS | vt0 vs vt12 |
|         | Oils | 3–6 | 2.1 ± 1.4 | 2.4 ± 1.3 | NS | vt0 vs vt12 |
| Weekly consumption | Meat | 3–4 | 7.2 ± 3.5 | 6.5 ± 1.4 | < 0.01 | vt0 vs vt12 |
|         | Fish | 3–4 | 3.1 ± 1.6 | 3.4 ± 1.6 | NS | vt0 vs vt12 |
|         | Eggs | 3–4 | 2.7 ± 1.2 | 2.8 ± 0.6 | NS | vt0 vs vt12 |
|         | Legumes | 2–4 | 2.6 ± 1.2 | 2.5 ± 0.9 | NS | vt0 vs vt12 |
|         | Nuts | 3–7 | 1.3 ± 2.1 | 1.1 ± 1.2 | NS | vt0 vs vt12 |
|         | Pastries | Occasional | 1.8 ± 2.2 | 1.3 ± 1.7 | NS | vt0 vs vt12 |

Abbreviations: NS: Not significant

*Recommended intake according to the Spanish Society of Community Nutrition (SENC) [51].
A year on a GFD with dietary advice reduced the frequency of meat consumption in women and children, reaching statistical significance in the latter group. However, the decrease observed was not enough to fulfill recommendations. The intake of the rest of food groups remained unchanged after the intervention. Moreover, cereal consumption among children showed a tendency toward decreased values \((p = 0.098)\) after 12 months on a GFD.

### 3.4. Gastrointestinal symptoms presence evolution during 1 year of GFD

Symptoms presence evolution indicated that in both adults and children, symptoms presence decreased after 3 and 12 months on a GFD (Fig. 2a and 2b) because the amount of participants that presented 0 symptoms increased after 3 and 12 months on a GFD. Similarly, 3 months on a GFD led to a reduction in the amount of patients with more than 6 symptoms at vt0 \((p = 0.059)\) in the case of children. However, the number of patients with more than 6 symptoms again increased between vt3 and vt12 in both populations (adults and children).

### 4. Discussion

It is known that CD is a common form of malabsorption [52–54]. For the time being, lifelong rigorous GFD is the only available treatment effective in remitting the symptoms of CD [1, 2]. Nevertheless, symptoms can sometimes remain even though patients go on a GFD. Moreover, this dietary pattern can bring as a result an imbalanced proportion of macro and micronutrient ingestion in both minors and adults with CD [4, 55, 56]. Several reasons have been proposed to justify these results, such as the scarce nutritional education of this collective or the lack of a strict compliance to the diet [6, 32]. Thus, nutritional counseling and a regular follow up by RDN to celiac and gluten sensitive people have been proposed as key strategies for achieving successful results in both symptom deletion and dietary balance [6, 18] and, as a consequence, in the nutritional status and quality of life of this collective. In this regard, the present work is a pilot study, an initial approach, to design a specific nutritional intervention suitable for the coeliac community.

Studies in the literature usually show that celiac people at diagnosis commonly present lower BMI values than does the general population, apart from lower fat and muscle mass, and that these parameters are normalized on average, after commencement, over the next two years [57–59]. However, recently published works have observed that, in the last 30 years a changing pattern in the clinical presentation of celiac people has occurred, mainly in paediatric patients, and that weight loss, for example, is not as common a symptom as it was [60]. Thus, recent research has also reported normal body weight and BMI values at diagnosis of CD [9, 61–65]. In the present work, most participants, adults and children, showed normal BMI, fat and muscle mass values at diagnosis indicating that their nutritional status was appropriate. Moreover, this remained unchanged 3 and 12 months after GFD commencement. This lack of changes after dietary treatment in celiac subjects with normal BMI values has also been described by other authors. Indeed, it has been proposed that following a GFD may have a beneficial effect on weight and body composition in patients whose BMI is out of its normal parameters [62–64, 66].

Biochemical parameters are also important when assessing the nutritional status of the celiac and gluten-sensitive collective. In the present study, all paediatric patients had normal biochemical parameters at the beginning of the study and all remained under normal ranges after 3 and 12 months on a GFD. These data are in accordance with the maintenance of normal body weight and composition observed for these subjects over the whole intervention. Only a fluctuation in fasting glucose was observed after 12 months among celiac children. These changes were also reflected in a recent study by Forchielli et al. [64], where authors described not only an increasing fasting glucose among celiac infants but also incremented HDL-c and decreased LDL-c values. However, it must be pointed out that the concentration of these parameters was maintained under normal ranges in both studies, and so no repercussion on celiac children’s health can be concluded. Among adult participants, celiac men had exceeded total cholesterol values at diagnosis, which is not borne out by the literature because, in general, celiac adults show lower total cholesterol values than the normal population at diagnosis [67, 68]. Moreover, this parameter was maintained unchanged after GFD treatment [69]. Unfortunately, the small sample size of adult males in the present study and the lack of biochemical data collected in this group in vt3 and vt12 render this work not comparable with the other studies mentioned.

The dietary pattern of celiac people on GFD in published works indicate that even though energy consumption can adjust to energy waste, macronutrient distribution is not balanced. Protein and lipids (especially saturated ones) are usually consumed in excess among people following a GFD, and by contrast, carbohydrate consumption is low [5, 6, 70, 71]. It has to be considered that GFP have partly been blamed for this imbalance, for several reasons: the high price of GFP (source of carbohydrates) that make celiac sufferers avoid them [72]; cereals used in GFP manufacturing that are poorer in proteins and usually not whole grains [19, 73]; the use of fats and gums in their production in order to improve palatability [19], etc. In fact, our previous studies indicated these nutritional composition differences between GFP and their gluten-containing counterparts [19]. Nevertheless, in the present study, all participants presented an imbalanced distribution of macronutrient at diagnosis, when GFP had not been consumed yet, and this was generally maintained until vt12. This fact would suggest that, apart from GFP consumption, there were other dietary factors that altered energy distribution, such as the dietary habits of the subjects.

By contrast, fiber intake among adult men at diagnosis and at vt3 was appropriate. Women and children consumed low amounts of this nutrient at diagnosis, but the GFP made women and children increase fiber consumption by vt3, and it was maintained in vt12. This could be due to the fact that fiber content does not differ between GFP and their homologues as much as macronutrient content does. In fact, it has been recently described that specially glutenfree breads can contain even more fibre than those containing gluten, suggesting that the food industry is making efforts to raise the content of this nutrient in GFP [74–76].
All these dietary imbalances observed among participants were linked to their dietary habits. In fact, imbalances remained unchanged across the whole study. According to the literature [4, 9, 55, 56, 65, 77], poor consumption of cereal, fruits, vegetables and oils was observed in all groups of participants. By contrast, meat was consumed in excess, which could be linked to the greater contribution of saturated fats in the diet at diagnosis. In fact, a positive correlation between both parameters was observed among celiac children at diagnosis (p = 0.02). Likewise, this nutrient consumption decreased slightly among children at vt3 and vt12, as did meat consumption. In the light of the above, giving dietary advice after vt0 and the followup in vt3 and vt12 did not change participants’ dietary pattern in our study. Thus, it can be stated that, in general, the dietary advice received by participants had little impact on their dietary profile improvement.

Even though dietary imbalances are observed frequently among people following a GFD, just as they are among the general population [4, 55], the introduction of a GFD is recommended for the partial or total elimination of symptoms [1, 78, 79]. Nevertheless, the period required for symptom remission varies between individuals [80, 81] and there is a small proportion of patients that continues suffering from symptoms even though they follow a GFD [81, 82]. In the present study, an amelioration of gastrointestinal symptoms in the first three months was observed among children, which was probably due to the motivation of starting the intervention and thus to a complete initial adherence to the diet. However, after this period a return of symptoms was observed in vt12, which indicated the probable relaxation of this collective in strictly following the GFD. In fact, dietitians suspected a lower dietary adherence at vt12 on face-to-face interviews among child participants. The literature also indicates that dietary adherence to GFD can decrease with the duration of treatments [83, 84] and the higher the adherence, the more effective the GFD is in resolving symptoms [85, 86]. Symptoms reported by adult participants did not change during the intervention indicating that concern about both the diet and symptom presence was not as important for children as it was for adults. Unfortunately, dietary adherence among the participants was not collected in the present study. In this respect, Silvester et al. have shown that almost all patients with CD only manage to maintain a diet which is reduced in gluten but not totally gluten-free [87]. Thus, these data suggest that a continuous follow up of patients is necessary for ensuring the total adherence to the diet and for obtaining its beneficial results in symptom absence not only in the short term, but also in the long term.

Considering all the above mentioned it is clear that correct personalized dietary counseling, nutritional education and a continuous follow-up of celiac and gluten sensitive patients performed by RDN is crucial for obtaining positive results. The lack of changes viewed in the present study indicates that the intervention may not have been the most appropriate. In an attempt to find a simple form of counseling, which is not too stressful for the patient and is feasible for healthcare personnel, patients were given personalized dietary advice through individualized reports by e-mail, which probably resulted in a lack of complete adherence, disinformation or failing to grasp the guidelines. It also appears that reports did not capture the interest of the participants. Although they had the option of requesting personalized consultations, most of them did not. Furthermore, the loss of participants in the study was substantial. For successful results, a continuous and more frequent monitoring as well as patient nutrition education should be carried out while applying a more effective methodology, namely: face-to-face intervention, regular phone calls, WhatsApp and mail attention, Internet forums, workshops and other educational tools for patient empowerment. Bearing this in mind, this study represents a pilot experience devoted to a second improved intervention study, which will start in the near future in order to achieve better outcomes.

The main limitation of the present study was the high number of participants that failed to continue with the study during the follow up and the consequent lack of data at vt3 and vt12. Thus, a second improved study, as well as any further interventions aimed to improve GFD in celiac people, must overcome this limitation. Moreover, it would be interesting to analyse vitamin and mineral consumption and to detect the main difficulties in following a safe and balanced GFD. However, it is worth highlighting the long period in which participants were monitored in the present study, as well as the amount of data collected about the evolution of their nutritional status and dietary habits. It is also noteworthy that this study provides relevant information about decisive aspects that future interventions should address.

5. Conclusions

It is clear that people with CD need both personalized and continuous nutritional assessment and advice by RDN in order to achieve improvements in their dietary habits, leading to a positive effect on their nutritional status and as a consequence on their quality of life. Whilst general nutrition education together with the provision of individualized information may serve as an encouragement for patients, simple intervention carried out by monitoring via email has not been effective enough; therefore, closer face-to-face and continuous counseling is required.

Abbreviations

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Declarations

**Ethics approval and consent to participate:** The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of Clinical Research of Basque Government (PI2016069). Written informed consent to participate was obtained from all participants.

**Consent for publication:** Written informed consent was obtained from the patients to publish this paper.
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Figures

![Figure 1](image_url)

**Figure 1**

Patients included in the study. Vt0: visit at time 0, at diagnosis; vt3: visit after 3 months on a gluten-free diet; vt12: visit after 12 months on a gluten-free diet.
Figure 2

Percentage of adult (a) and children and adolescent (b) participants presenting 0, 1-5 or more than 6 symptoms. Vt0: visit at time 0, at diagnosis; vt3: visit after 3 months on a gluten-free diet; vt12: visit after 12 months on a gluten-free diet.

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