Journal of Pediatric Gastroenterology and Nutrition Publish Ahead of Print

DOI: 10.1097/MPG.0000000000001736

Dietary fiber intake in children in remission or with mild inflammatory bowel disease.

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Funding and conflicts of interest: nothing to declare.

Figures: 1, **Tables:** 3, **Supplemental Content:** 1 Figure & 2 Tables

Manuscript: 2984 words

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML text of this article on the journal's Web site (www.jpgn.org).

Abstract

Objectives

The aim of the study was to estimate intake of total dietary fiber, and its soluble and insoluble fractions, by children with inflammatory bowel disease (IBD) in comparison to healthy controls.

Methods

This was a prospective controlled study on children with IBD. Food consumption data were collected by using the 3-day diet record. For intake of soluble and insoluble fibers author's questionnaire was used.

Results

The study included 50 children with IBD (80% in clinical remission) and 50 healthy controls. There were no statistically significant differences in age, weight, height and BMI percentiles between both groups. The mean disease duration was 3.5 ± 2.5 years. The daily median dietary fiber intake in patients was 15.3 ± 4.2 g whereas controls consumed about 14.1 ± 3.6 g/day; differences were not statistically significant. The median intake of soluble fiber in the study group was 5.0 g/day and in controls 4.7 g/day. Whereas the intake of insoluble fractions was 10.2 g/day *vs* 9.7 g/day, respectively. The total fiber intake significantly increased with age and it was higher among boys in each age group. The boys better achieved adequate intake (AI) recommendations ($p = 0.003$). Both, children with IBD and healthy controls, didn't meet the AI recommendations.

Conclusions

Intake of fiber in patients with IBD and healthy controls was comparable, however in both groups it was lower than recommended.

Key words: Crohn's disease; ulcerative colitis; soluble fiber; insoluble fiber; paediatric patients

What is known

- Majority of adult patients with inflammatory bowel disease (IBD) is avoiding high fiber foods in order to prevent disease recurrence and low-fiber diet is commonly reported in these patients, regardless of disease activity.
- There is a lack of information about dietary fiber intake in paediatric IBD patients.

What is new

- Intake of total dietary fiber in children and adolescents with no active to mild IBD was lower than Adequate Intake recommendations and it was comparable with results obtained in healthy controls.
- We obtained unique results about the intake of soluble and insoluble fiber in children with IBD.

Introduction

The role of specific components of diet in pathogenesis and treatment of inflammatory bowel disease (IBD) has been widely discussed [1]. Current evidence showed that the increased long-term consumption of dietary fiber, has been linked with a 40% reduction in risk of Crohn's disease (CD) but not with ulcerative colitis (UC) [2]. According to the results of few, small clinical trials, it seems that some types of dietary fiber can help during the course of the disease but it has not been well established yet.

In clinical practice, the symptoms of the disease have strong impact on quality of life. Majority of patients is avoiding certain foods in order to prevent disease recurrence [3,4] and low-fiber diet is reported regardless of disease activity [5].

According to existing dietary guidelines it is recommended to continue a regular diet during mild to moderately active disease both in UC and CD patients. The fiber restricted diet should always be used temporarily and only in a few cases which are acute relapse (with diarrhea, cramping), intestinal stenosis, small intestinal bacterial overgrowth and after some types of surgery e.g. colectomy [6].

It appears that especially soluble and/or fermentable fibers are beneficial for patients with IBD. Demonstrated effects were primarily associated with increased luminal production of short chain fatty acids (SCFA) which have immunomodulatory [7], healing and regeneration properties thereby modifying IBD-associated dysbiosis [8,9,10,11,12]. The newest study of Brotherton et al. [13] showed that in a 6-month period, patients with CD who did not avoid high-fiber foods were about 40% less likely to have a relapse compare to those patients who restricted their diet.

There is a lack of information about dietary fiber intake in paediatric IBD patients. Therefore, the aim of this paper was to estimate the intake of dietary fiber and its types among children and adolescents with no active to mild IBD in comparison to healthy controls. We believe that the results of our study make our diet advices, regarding fiber, more precisely and help us to plan fiber interventional study in children with IBD.

Methods

To check our hypothesis that the fiber intake in children with IBD is lower than in healthy controls we conducted this prospective controlled study. Patients were recruited from September to March inclusive, in years 2011 to 2014, taking into account local, seasonal consumption of fruit and vegetables in order to assess more usual dietary fiber intake in Poland. Patients were under outpatient care of Department of Paediatric Gastroenterology and Nutrition, Warsaw, Poland. The eligibility criteria for the study group were: diagnosis of IBD based on the revised Porto criteria [14], age from 4 to 18 years and confirmed clinical remission or mild disease activity. The severity of CD and UC was evaluated using the *Pediatric Crohn's Disease Activity Index* (PCDAI) [15] and the *Pediatric Ulcerative Colitis Activity Index* (PUCAI)[16]. A PCDAI score ≤ 10 for CD and a PUCAI score < 10 for UC were defined as remission. A PCDAI score 11-25 for CD and a PUCAI score 10-34 were defined as mild disease activity. The exclusion criteria were IBD unclassified, GI strictures, previous gastrointestinal surgery and moderate to severe disease activity.

The control group, which was recruited during the same period of time as study group, consisted of healthy preschool and school-aged children. Inclusion criteria were

age and gender matched to cases and no history of chronic diseases including allergies and food intolerances and other diseases resulting in dietary restrictions (assessed by health survey questionnaire).

For each enrolled subject, clinical and demographic characteristics including age, sex, place of residence, type of IBD, disease location according to Paris classification, medications, time to diagnosis and disease activity assessment were collected from the outpatient admission records. Healthy controls were asked the same questions regarding demographic characteristics.

Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Overweight was defined as a BMI $\geq 85^{th}$ percentile, and obesity as a BMI $\geq 95^{th}$ percentile. Percentiles were measured using the BMI-for-age and gender percentiles charts according to the World Health Organization [17].

Dietary intake was assessed using 3-day diet record (two consecutive weekdays and one weekend day) was used in combination with a photo album of foods [18] for more reliable data. Diet records where analyzed by registered dietitian working in the Department of Paediatric Gastroenterology and Nutrition, Warsaw, Poland.

Nutrient data on frequently consumed foods were supplemented if necessary with data obtained from local manufacturers of specific industrialized foods. Respondents were also asked to report a method of preparation of vegetables and fruits (ie. peeled/with skin, raw/cooked) to note the losses of insoluble dietary fiber components.

The nutrient content of dietary records was analysed using the *Diet* software version 5.0 (National Food and Nutrition Institute, Warsaw, Poland). Because the software did not contain data about soluble and insoluble fiber content in food, we have

created author's questionnaire in Microsoft Excel according to data provided in the appropriate literature [19,20,21,22] and we calculated again total fiber intake and the intake of its types. Data intakes from macronutrients were expressed as a percentage of total daily energy (%) and in grams per day.

The established Adequate Intake (AI) values for fiber were used to examine the adequacy of fiber intake. Adequate Intake is "*a recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate – used when a Recommended Dietary Allowance (RDA) cannot be determined"* [23,24].

To analyze the consumption of fiber according to origin, foods were classified as cereals and cereal products, fruits and fruit products, potatoes, and vegetables and vegetable products. Cereal products were bread, breakfast cereals, macaroni, snack foods, dry mixes, cakes and pastries. Fruit products included jams, marmalades, dried and canned fruits. Vegetable products included canned vegetables, sauerkraut, pickles and sauces. Beans and legumes, nuts and seeds were put as "others" because the consumption of each of them individually was small and not regarded as "main sources".

Data are presented as median. S_n statistic was computed as the measure of variability

(typical distance between two observations in group). Additionally, 1st (Q1) and 3rd (Q3) quartiles and minimal and maximal observations were reported. The Shapiro-Wilk test was used for the assessment of normality of obtained data. Baseline characteristics and nutrient intakes were compared by the nonparametric Mann–Whitney *U* test. Multivariate

regression model was used to analyse the results obtained by the software and by author's questionnaire if the results are equally precise. The Spearman correlation coefficient was used to describe the correlation variables. P value < 0.05 was considered statistically significant. All analyses were carried out in *Statistica* 10.0.

The study protocol was brought to the attention by the Ethics Committee in Research of the Medical University of Warsaw. All patients were informed about the study objectives.

Results

In this study, 50 IBD patients were evaluated including 28 patients with CD and 22 patients with UC. The mean time to IBD diagnosis was 3.5 ± 2.5 years. All of patients with CD had non-penetrating, non-stricturing disease and majority (18/28) of them was diagnosed at the age of 10-17 years without growth delay (23/28). Majority (16/22) of patients with UC had pancolitis. Of the all IBD patients, 80% (40/50) were in clinical remission. All of the patients were on 5-ASA agents, 25/50 patients received immunomodulatory therapy, mainly (22/25) azathioprine. Only 2 patients were on biologic therapy (see Supplemental Table 1, Supplemental Digital Content, http://links.lww.com/MPG/B105). The control group consisted of 50 healthy children matched by age and gender to cases. In both groups, there was a predominance of males which amounted 60%. Majority of patients and controls came from the city: 76% and 86%, respectively.

There were no significant differences between both groups in body weight, height, and BMI percentiles. Basic characteristics of study participants are shown in table 1.

Daily intake of nutrients in the study and in the control group are showed in Table 2. The differences in macronutrient intakes between both groups were not statistically significant.

Also, we didn't observe differences between boys and girls in macronutrient intakes. Median intake was respectively, for: energy 1839 kcal *vs* 1672 kcal/d (p=0.053); protein 74 g *vs* 64 g/d (p=0.559); fat 61 g *vs* 50 g/d (p=0.687) and for total carbohydrates 267 g *vs* 243 g/d (p=0.460).

There were no differences between calculated daily intake of dietary fiber obtained by both methods (software *vs*. author's questionnaire) (see Supplemental Table 2 and Supplemental Figure 1, Supplemental Digital Content, http://links.lww.com/MPG/B105) therefore the results obtained by the author's questionnaire were used in subsequent fiber analysis. There was no statistically significant (p= 0.34) differences in daily median dietary fiber intake between the two groups, but we observed the trend of greater fiber consumption in the study group. The median daily intakes of each nutrients including total dietary fiber and soluble and insoluble fibers are described in Table 2.

Analysis of sources of fiber, expressed as percentage of total dietary fiber, revealed that they were similar for whole study participants (patients and controls). The main source of dietary fiber were cereals and cereal products (44.8±14.2% and 49.5±12.2%, respectively). In both groups, nearly 100% of respondents consumed refined cereals and cereal products based on wheat and rye flour (like bread, breakfast cereals, macaroni etc.) and white rice. Those who ate whole grain cereal products were few and

the consumption was in very small, not significant amounts so we put all cereal products as a main source of fiber.

Another source of dietary fiber included fresh vegetables and vegetable products (15.9 ± 7.4% *vs* 16.9 ± 5.9%, respectively). There was a wide variety of vegetable consumption so we couldn't indicate the main source of them but most of patients consumed cooked vegetables. Fresh fruit and fruit products (in total 14.7 ± 11.2% *vs* 14.3 ± 11.0%, respectively) included mainly bananas (approx. 50%) and apples (approx. 80%) but 60% of subjects consumed apples without skin. We reported two patients and seven healthy children who didn't consume fruit and fruit products at all. Potatoes were the last main source of fiber in both groups (12.2 ± 7.8% *vs* 14.1 ± 7.3%, respectively). The last, less important sources were "others" – for the study group 12.4±10.5% and for the control group 5.2±3.8%.

Regarding intake of fiber fractions, we found that intake of soluble fiber derived both from vegetables and fruits was higher in patients than in controls (0.9 g/day *vs* 0.8 g/day and 0.7 g/day *vs* 0.6 g/day, respectively). However, these differences were not statistically significant ($p = 0.50$) and were associated with culinary processing. Figure 1 presents the distribution of soluble and insoluble fiber sources.

There was no association between dietary fiber intake and nutritional status (based on the value of BMI percentiles) or place of residence. There was significant correlation between fiber intake and age ($p = 0.01$) and between gender ($p < 0.0001$) of respondents. Dietary fiber intake increased with age and it was higher among boys. The median intake of total dietary fiber among boys was 15.2 g/day whereas among girls it was 13.2 g/day. The median intake of soluble fiber among boys was 5.3 g/day and of insoluble fiber was

10.3 g/day. While among girls the median intake of both fractions was lower and amounted 4.4 g /day and 9.0 g/day, respectively.

Median fiber intake in the study group and in the control group did not meet AI recommendations in all age-groups. The percentage of children who consumed dietary fiber in quantities consistent with the standard AI was 32% (n = 16) in the study group and 24% (n = 12) in the control group. Table 3 presents implementation of adequate intake recommendation in our study subjects. We observed that the intake of fiber, expressed as a percentage of the AI, differed significantly only in terms of gender. Boys better achieved AI than girls (p = 0.003).

Discussion

In this observational study, we showed no differences in dietary fiber intake between children and adolescents with no active to mild IBD and healthy children (p = 0.34). However, surprisingly we observed the trend of greater fiber consumption in the study group. To our knowledge, this is the first study to estimate total, soluble and insoluble fiber intake in children and adolescents with IBD in remission or mild disease activity in comparison to healthy controls. The only study that assessed, among other diet components, fiber intake in children and adolescents with IBD compared with healthy controls, was Hartman et al study [25]and the authors found that total dietary fiber intake was significantly lower in IBD patients, 14.5 *vs* 31 g/day, respectively. However, the direct comparison between the two studies is difficult due to the fact that in Hartman et al study most patients had CD (57/68), only 38% of their patients were in remission, and

part of them (18/68) consumed nutritional supplements or were on exclusive enteral nutrition with no added fiber. Moreover, they didn't asses the intake of soluble and insoluble fiber and sources of dietary fiber.

Results of few studies conducted in adults with IBD were very inconsistent. In the three studies that compared fiber intake between IBD and healthy controls, the authors found no difference between the groups,[26] higher fiber intake in Crohn's patients [27] or higher fiber intake in controls [28].There are several factors that explain such different results obtained in these studies. Firstly, in these three studies only patients with CD were assessed whereas almost half of our patients were patients with UC. Secondly, the authors did not provide the data on disease activity of their study subjects. Thirdly, adults usually decide themselves what they eat. Children, especially younger and especially children with chronic diseases, are "sentenced" to eat meals prepared by parents or guardians.

In more recent studies, the intake of dietary fiber has been assessed without control groups and it was compared with recommendations. Although authors used different methodology in their studies, all of them obtained similar results. In these studies, fiber intake was lower in IBD patients when compared to recommendations [29 30 31 32]. To sum up briefly, it is impossible to compare the results, obtained in these five, above mentioned studies, with our own results, because of the main differences which are: the study group (adult IBD patients) and the divergence of the methods used. But undeniable fact is that, so far, published observational studies have shown that fiber intake by adults with IBD is lower than recommended which is similar to our result in pediatric patients with IBD.

In our study, we obtained unique results about the intake of soluble and insoluble fiber in children with IBD. In both groups, approx. 34% of total dietary fiber was a soluble fraction and approx. 66% was insoluble fraction. Because of the lack of data about the intake of dietary fiber in differentiation of soluble and insoluble fiber, we are not able to compare our result with other studies. The fractions of fiber are very important particularly in the management of gastrointestinal disorders.

Analyzing the consumption of fiber, according to the origin, showed that the main source of fiber in the study and in the control group were cereals and cereal products (approx. 45% *vs* 50%, respectively), followed by fresh vegetables and vegetable products (approx. 16% vs 17%, respectively). Kasper and Sommer [27], who conducted the only study that examines the main food sources of fiber in IBD patients reported, similar to our results, that the primary source of dietary fiber in the study and in the control group were cereals and cereal products (approx. 47% *vs* 44%). Potatoes and vegetables were included in one group and they accounted approx. 30% *vs* 31% of total fiber consumption.

In summary, our study is the first which estimated dietary fiber intake and its types in the pediatric IBD patients. A small number of controlled studies conducted in adult IBD patients due to the divergence of the methods used, and various obtained results makes it impossible to assess the real importance of the fiber in diet in IBD patients with no active to mild disease activity. Low intake of dietary fiber is a common phenomenon in developed countries and according to the FAO/WHO report, only 5% - 25% of the population complies with current guidelines for fiber consumption [33]. Proper diet and nutritional status play an important role in chronic diseases, including IBD,

especially in pediatric patients and one of the goals of the treatment is to achieve proper growth, which is directly associated with proper nutritional status. But unfortunately, it is commonly observed that patients with IBD reduce overall food intake because of the abdominal pain, nausea, vomiting, diarrhea or anorexia. Our study was conducted with a control group, which undoubtedly raises its value and enables the assessment of the general trends in the selection of products and meals in children with IBD and to compare if they are similar to those of healthy children. In our study, we estimated not only total dietary fiber intake but also its types and what is more, we analyzed the structure of dietary fiber from main dietary sources. The study was conducted using 3-day diet records and in practice, agreement between observed and reported intakes from this method made it the best choice among other dietary assessment methods [34]. The main limitation of our study is sample size and its observational character. Although in Poland fresh fruits and vegetables are available whole year, our study was conducted in months particularly rich in national fresh fruit and vegetables, so in fact we assessed seasonal, not yearly fiber intake.

Conclusion

We demonstrated that there were no differences in dietary fiber intake between children with IBD and healthy controls. The fiber intake was lower than recommended in most of patients and controls. Randomized controlled trials are required to establish whether high fiber diet may have an important role in IBD therapy.

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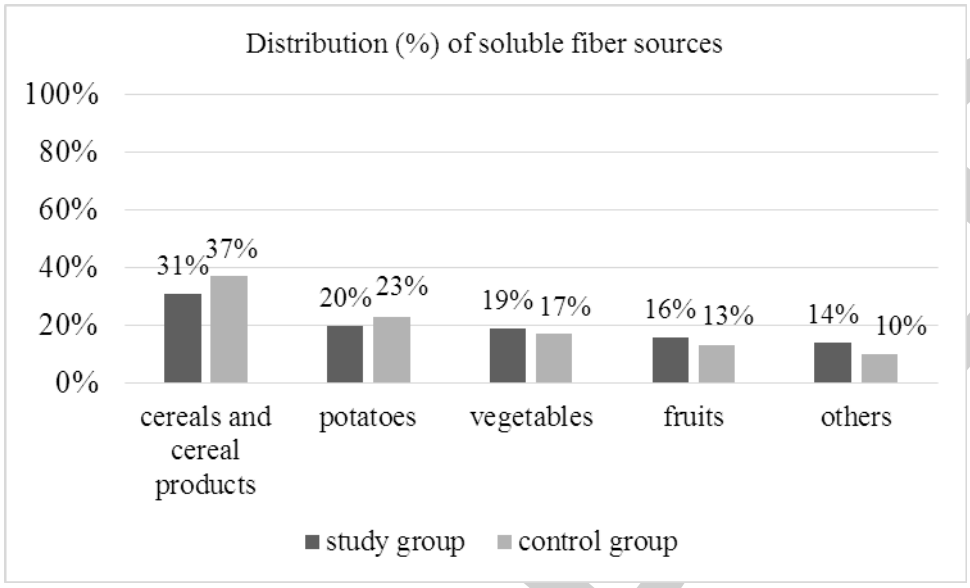

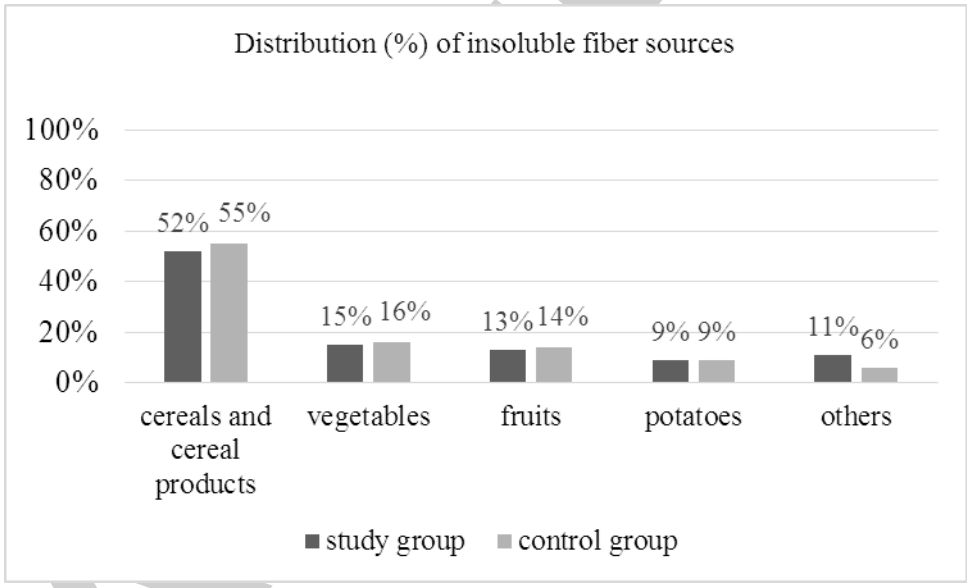

Figure 1. Distribution (%) of soluble and insoluble fiber main sources in the study and in the control group.

Table 1. Basic characteristics of the study (A) and control group (B)

Variables	Group	Median	S_n	Q1	Q3	Range (min-max)	p
Age (years)	**A**	13.6	2.6	11.8	15.2	4.7 -17.1	0.86
	B	14.0	2.4	11.8	15.4	4.8- 17.7	
Weight (kg)	**A**	47.5	15.3	35.7	58.0	14.5-85.2	0.26
	B	54.0	14.3	39.6	63.5	18.6 – 80.6	
Height (m)	**A**	1.6	0.1	1.5	1.7	1.0-1.9	0.36
	B	1.6	0.1	1.5	1.7	1.1-1.8	
BMI (percentiles WHO)	**A**	50	25	25	75	5-99	0.47
	B	75	22	50	85	3-97	

S_n – measure of variability;

Min., Max. – minimum, maximum;

Q1, Q3 – First Quartile and Third Quartile

Table 2. **Daily intake of nutrients in the** study (A) and in the control group (B)

Nutrient	**Group**	**Median**	**S_n**	**Q1**	**Q3**	**Range (min-max)**	**P**
Energy (kcal/day)	**A**	1839	353.6	1493	2075	921.4- 3310	0.71
	B	1762	393.4	1526	2058	872.5-3133	
Total protein (g/day)	**A**	70.3	16.1	61.2	85.5	31.3-145.6	0.27
	B	65.8	17.8	55.2	84.9	36,6-128	
Animal protein (g/day)	**A**	46.5	14.0	37.0	56.1	17.3-133.7	0.39
	B	42.1	11.6	35.0	56.7	22.4-87.8	
Animal protein *(% of total protein)*	**A**	65.3	8.3	59.4	71.3	39.5-91.9	
	B	64.3	7.1	59.0	69.3	40.5-83.0	
Plant protein (g/day)	**A**	23.1	6.6	19.3	28.4	5.7-52.5	0.95
	B	23.1	5.6	19.3	29.1	11.8-42.8	
Plant protein *(% of total protein)*	**A**	33.8	7.5	27.4	40.3	8.2-55.4	
	B	35.7	7.6	30.5	41.0	17.0-59.5	
Fat (g/day)	**A**	58.4	19.9	41.3	68.5	22.0-125.9	0.63
	B	62.3	20.1	44.2	72.4	26.5-132.7	
Total carbohydrates (g/day)	**A**	257.3	63.7	214.1	308.9	120.9-479.7	0.74
	B	255.0	44.7	223.4	285.4	122.0-439.6	
Sucrose (g/day)	**A**	55.9	19.4	44.3	75.4	7.1-136.6	0.75
	B	54.3	24.1	43.2	79.2	13.7-151.7	
Sucrose *(% of total carbohydrates)*	**A**	23.6	6.8	17.6	30.0	5.0-37.6	
	B	22.2	7.0	16.9	28.0	6.4-40.5	
Total fiber *Diet 5.0* **(g/day)**	**A**	16.2	4.3	12.9	18.7	6.9-27.2	0.31
	B	14.5	3.7	12.1	18.0	7.7-31.0	
Total fiber *quest.* **(g/day)**	**A**	15.3	4.2	12.1	18.3	6.5-28.8	0.69
	B	14.1	3.6	11.9	18.5	5.6-31.3	

Total fiber ***(% of total carbohydrates)***	**A**	6.0	1.4	4.9	6.9	4.0-11.4	
	B	6.0	1.2	5.2	7.1	3.8-14.3	
Soluble fiber (g/day)	**A**	5.0	1.4	4.4	6.3	2.4-10.6	0.39
	B	4.7	1.3	3.9	5.9	1.4-9.9	
Soluble fiber *(% of total fiber)*	**A**	34.4	3.3	31.6	37.1	25.8-42.8	
	B	33.4	3.6	30.4	35.6	24.7-43.6	
Insoluble fiber (g/day)	**A**	10.2	2.9	7.8	12.0	4.1-18.2	0.91
	B	9.7	2.8	7.6	12.4	4.2-22.5	
Insoluble fiber *(% of total fiber)*	**A**	65.9	3.5	63.2	68.4	57.0-76.0	
	B	66.6	3.6	64.3	69.6	55.3-75.3	

S_n – measure of variability;

Min., Max. – minimum, maximum;

Q1, Q3 – First Quartile and Third Quartile

Table 3. Implementation (%) of Adequate Intake recommendation

	Group	Median	S_n	Q1	Q3	Range (min-max)
Adequate intake	A	80.3	18.5	68.1	96.3	34.1-151.5
	B	75.1	17.5	64.7	92.0	29.7-164.7

S_n – measure of variability;

Min., Max. – minimum, maximum;

Q1, Q3 – First Quartile and Third Quartile