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The Proportion and Type of Carbohydrates in the Diets of Children in Early Adolescence

Arzija Pasalic[1], Sabina Segalo[1], Suada Brankovic[1], Jasmina Mahmutovic[1], Hadzan Konjo[1]

Faculty of Health Studies, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Corresponding author:
Professor Arzija Pasalic, PhD. Faculty of Health Studies, University of Sarajevo, Stjepana Tomića 1, +387 61 102685. E-mail: arzija.pasalic@fzs.unsa.ba. ORCID ID: https://orcid.org/0000-0001-7819-5117.

ABSTRACT

Background: Carbohydrates are mainly substrates for energy metabolism and can affect satiety, blood glucose levels, insulin secretion, and fat metabolism. Their amount and type in the diet affect metabolic responses. High-carbohydrate diets, particularly high sugar consumption, are considered particularly harmful because of their specific characteristics related to postprandial metabolism, effects on hunger and satiety, and thus on caloric intake and energy balance. The European Food Safety Authority has suggested that the reference intake for carbohydrates should be between 45 and 60% of total energy requirements and less than 10% should be added sugars, especially for children. **Objective:** Investigate the proportion and type of carbohydrates in the diets of children in early adolescence in two territorially distinct areas, the continental and the Mediterranean. **Methods:** The study was conducted as part of a longitudinal cohort study. The survey was conducted in elementary schools in two regions: continental and Mediterranean. The School Physical Activity and Nutrition Survey was used for research purposes. Descriptive and inferential statistical tests were applied for data analysis. **Results:** A total of 1,411 respondents of both sexes aged 12-15 years, 729 boys and 678 girls, participated in the study. The intake of carbohydrates in the total sample is represented in the daily intake of 59%. The proportion of natural sugar in the diet of boys is statistically significantly higher in the continental compared to the Mediterranean region at the age of 12-13 years ($p = 0.002$), 13-14 years ($p = 0.049$), and 14-15 years ($p = 0.002$). Added sugars in total carbohydrate intake are statistically significantly higher in girls in the Mediterranean region compared to the continental region at ages 12-13 years ($p = 0.048$), 13-14 years ($p = 0.001$), and 14-15 years ($p = 0.001$). **Conclusion:** The high intake of added sugars in children in the Mediterranean region is of concern, although the intake in the continental area is well above current recommendations. Therefore, one of the public health goals is to promote proper nutrition as well as the availability of healthy foods in schools, especially during early adolescence when proper eating habits are adopted.

Keywords: carbohydrates, added sugars, early adolescence, Bosnia and Herzegovina.

1. BACKGROUND

Inappropriate dietary habits are currently a major health concern, contributing to obesity and increased risk of chronic non-communicable diseases such as diabetes or cardiovascular (CVD) and respiratory diseases (1). Carbohydrates (CHO) are mainly substrates for energy metabolism and can affect satiety, blood glucose levels, insulin secretion, and fat metabolism. They control intestinal functions through the fermentation process by maintaining the balance of commensal flora and colon epithelial cells' health. Also, they can act as immune modulators and influence calcium absorption. These properties have implications for overall health, contributing to the control of body weight, diabetes and CVD, aging, bone mineral density, colon cancer, constipation, and resistance to intestinal infections (2). The amount and type of CHO in the diet affect metabolic responses. A high-carbohydrate diet, especially high sugar consumption, is considered particularly harmful because of its specific properties related to postprandial metabolism, effects on hunger and satiety, and thus on caloric intake and energy balance (3).

Available representative surveys conducted in Belgium, France, Denmark, Hungary, Ireland, Italy, Norway, the Netherlands, Spain, and the United Kingdom confirm that intakes of total and added sugars are high, especially among children (4). Current data show that dietary sugar, as a source of excess calories, is associated with obesity and thus increased risk of diet-related diseases such as type 2 diabetes, CVD, nonalcoholic liver disease, and cancer (5). The average intake of CHO in children and adolescents in European countries varies between 43-58% of total energy (E) intake, of which added sugars account for 16-36%. The average intake of mono- and disaccharides in children and adolescents varies between 23-36%, with the highest intake in infants and polysaccharides ranging between 23 and 25%. The European Food Safety Authority (EFSA) has suggested that the reference intake for CHO should be between 45-60% of E requirements and added sugars should be less than 10%, especially in children. A proportion of CHO in total energy intake of 45-60% combined with a reduced intake of fats, especially saturated fats, is consistent with a lower risk of developing chronic diseases (6). The role of CHO in the diet cannot be adequately elucidated without considering all the nutritional properties of the foods themselves. Although fruits, vegetables, and whole grains are considered high-carbohydrate foods, their health benefits are often due to their low energy content and high micronutrient and phytochemical content (7). Recommendations for intake of added sugars are becoming more stringent. The Institute of Medicine has suggested a daily limit of 25% of calories from added sugars. More recent recommendations are lower, with the World Health Organization (WHO) issuing a guideline of < 10% of calories and a conditional recommendation for further reduction to < 5% (8).

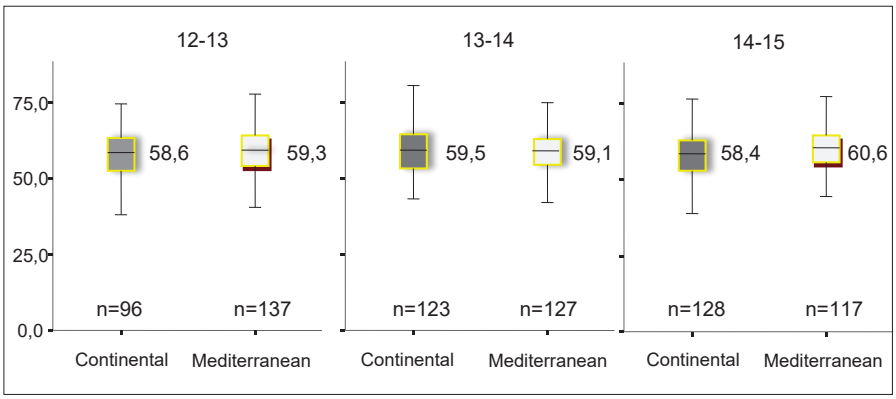

Figure 1. Percentage of carbohydrates in the diet of boys about age

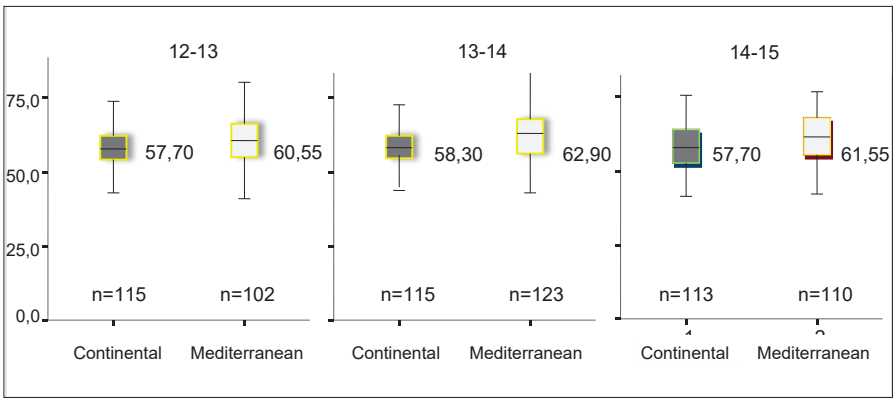

Figure 2. Percentage of carbohydrates in the diet of girls about age

2. OBJECTIVE

This study aims to examine the proportion and type of carbohydrates in the diets of children in early adolescence in two territorially distinct regions in Bosnia and Herzegovina (B&H), the continental and the Mediterranean.

3. MATERIAL AND METHODS

Study design

The study was conducted as part of a longitudinal cohort study over two years.

Ethical approval

For each respondent included in the study, parents/guardians gave informed consent. This is by the Code of Ethics for Research on Children prepared by the Council for Children in B&H. The Ministry of Education, Science, and Youth of Sarajevo Canton, the Ministry of Education, Science, Culture and Sports of Herzegovina-Neretva Canton and West Herzegovina Canton gave consent to conduct the study in elementary schools.

Study population

The survey was conducted in elementary schools in two areas, the continental canton of Sarajevo and the Mediterranean cantons of Herzegovina-Neretva and West Herzegovina. A total of 1411 persons of both sexes, aged 12-15 years, participated in the survey. Among them, 729 were boys and 678 were girls. Of the respondents, 694 were from the continental area and 717 were from the Mediterranean area. Depending on their age, respondents were divided into three age groups: 12-13, 13-14, and 14-15.

Measurement tool

The School Physical Activity and Nutrition Survey (SPANS) was adapted to the model and domain of our research (9). Additional tests were conducted to evaluate the reproducibility and validity of the instrument. The research results showed that this questionnaire is a useful tool for epidemiological surveillance and assessment of required nutritional data (10). To analyze the representation of macronutrients and minerals in the study, the Serbian Food Composition Database was used, which was created within the European Food Information Resource Network (EuroFIR) project in 2005-2010 (11).

Statistical analysis

The SPSS for Windows software package (version 19.0, SPSS Inc, Chicago, Illinois, USA) and Microsoft Excell (version 11. Microsoft Corporation, Redmond, WA, USA) were

Age	Study area	N	Mean	SD	Min	Max	Percentile			p
							25th	Median	75th	
12-13	Continental	96	50.91	15.57	4.17	83.01	41.61	50.64	61.11	0.153
	Mediterranean	138	46.77	19.51	0.31	81.90	34.42	48.11	64.89	
13-14	Continental	123	52.01	17.23	0.37	99.17	39.82	55.55	63.37	0.082
	Mediterranean	127	48.42	19.34	0.48	95.30	35.91	50.68	60.43	
14-15	Continental	128	50.88	15.68	1.68	81.15	40.97	52.97	62.08	0.003
	Mediterranean	117	44.38	19.58	4.21	86.69	31.28	44.46	59.76	

Table 1. Percentage of polysaccharides in the total intake of carbohydrates in the diet of boys related to age and the areas studied

Age	Study area	N	Mean	SD	Min	Max	Percentile			p
							25th	Median	75th	
12-13	Continental	115	49.40	16.00	6.08	78.51	40.46	49.38	61.34	0.136
	Mediterranean	102	52.34	20.45	0.32	88.00	39.11	54.82	68.06	
13-14	Continental	115	52.2	16.49	9.55	88.88	42.49	53.13	62.72	0.072
	Mediterranean	123	46.67	20.72	1.13	85.13	32.64	50.05	62.04	
14-15	Continental	113	49.78	16.45	3.16	78.21	41.91	52.48	61.55	0.690
	Mediterranean	110	49.44	17.48	8.85	88.00	37.68	51.37	62.14	

Table 2. Percentage of polysaccharides in the total intake of carbohydrates in the diet of girls related to age and the areas studied

Age	Study area	N	Mean	SD	Min	Max	Percentile			p
							25th	Median	75th	
12-13	Continental	96	19.71	9.55	1.47	49.64	12.52	19.01	26.06	0.002
	Mediterranean	138	15.55	10.08	0.00	53.21	8.80	14.35	21.73	
13-14	Continental	123	18.10	9.9	0.00	53.47	12.53	18.14	24.17	0.049
	Mediterranean	127	15.88	9.82	0.00	47.33	8.43	15.50	22.22	
14-15	Continental	128	18.15	8.32	0.00	40.88	12.18	18.33	23.62	0.002
	Mediterranean	117	15.06	9.90	0.00	51.36	7.84	14.05	21.47	

Table 3. Percentage of natural sugars in the total intake of carbohydrates in the diet of boys related to age and the areas studied

used for statistical analysis of the data obtained. For the continuous variables in the study, the symmetry of their distribution was analyzed using the Kolmogorov-Smirnov or Shapiro Wilk test. The median and interquartile ranges were used to indicate the mean and the measure of dispersion, and the nonparametric Mann-Whitney U test was used to compare them. The limit of statistical significance is given as $p = 0.05$.

4. RESULTS

Figure 1 presents the percentage of CHO in the diet of boys concerning age. It is highest in boys aged 13-14 years in the continental region (59.5%) and in boys aged 14-15 years in the Mediterranean region (60.6%). The percentage of CHO in the diet of boys aged 12-13 and 13-14 years in two territorially different areas is not significant, while statistical significance (p=0.026) was found in boys aged 14-15 years.

The percentage of CHO in the diet of girls in territorially different areas is statistically significantly different at age 12-13 years ($p = 0.01$), age 13-14 years ($p = 0.0001$), and age 14-15 years ($p = 0.004$), with higher intake in girls from the Mediterranean area (Figure 2).

Boys aged 12-13 and 13-14 years consume approximately the same amount of polysaccharides (PS) in both areas, while boys aged 14-15 years consume statistically significantly more PS in the Mediterranean area compared to the continental area, $p = 0.003$.

There was no statistically significant difference in the intake of PS in the diets of girls in the two areas studied.

The proportion of natural sugars in the diet of boys is statistically significantly higher in the continental compared to the Mediterranean region at the age of 12-13 years ($p = 0.002$), 13-14 years ($p = 0.049$), and 14-15 years ($p = 0.002$).

The proportion of natural sugars in total CHO intake is statistically significantly higher in girls in the continental area than in the Mediterranean area at ages 12-13 ($p = 0.005$), 13-14 years ($p = 0.011$), and 14-15 years ($p = 0.001$).

Consumption of added sugars is significantly higher in boys in the Mediterranean than on the continent, and there

Age	Study area	N	Mean	SD	Min	Max	Percentile			p
							25th	Median	75th	
12-13	Continental	115	18.18	8.88	0.00	42.21	12.35	17.10	24.30	0.005
	Mediterranean	102	14.85	10.06	0.00	48.59	7.45	14.31	21.00	
13-14	Continental	115	18.12	9.14	0.00	45.79	11.18	17.70	23.27	0.011
	Mediterranean	123	15.62	10.69	0.00	57.08	8.65	14.61	20.80	
14-15	Continental	113	18.92	10.51	0.57	67.99	11.76	19.80	25.07	0.001
	Mediterranean	110	12.67	10.65	0.00	65.88	2.36	11.39	19.27	

Table 4. Percentage of natural sugars in the total intake of carbohydrates in the diet of girls related to age and the areas studied

Age	Study area	N	Mean	SD	Min	Max	Percentile			p
							25th	Median	75th	
12-13	Continental	115	18.18	8.88	0.00	42.21	12.35	17.10	24.30	0.005
	Mediterranean	102	14.85	10.06	0.00	48.59	7.45	14.31	21.00	
13-14	Continental	115	18.12	9.14	0.00	45.79	11.18	17.70	23.27	0.013
	Mediterranean	123	15.62	10.69	0.00	57.08	8.65	14.61	20.80	
14-15	Continental	113	18.92	10.51	0.57	67.99	11.76	19.80	25.07	0.001
	Mediterranean	110	12.67	10.65	0.00	65.88	2.36	11.39	19.27	

Table 5. Percentage of added sugars in the total intake of carbohydrates in the diets of boys related to age and the areas studied

Age	Study area	N	Mean	SD	Min	Max	Percentile			p
							25th	Median	75th	
12-13	Continental	115	33.45	18.86	4.13	42.64	21.50	31.97	41.59	0.048
	Mediterranean	102	39.45	38.94	3.17	52.86	20.13	34.40	45.58	
13-14	Continental	115	29.80	15.69	1.93	51.33	17.89	30.19	37.69	0.001
	Mediterranean	123	39.26	22.29	1.18	60.71	23.53	35.69	50.77	
14-15	Continental	113	31.78	14.29	1.63	52.60	21.57	30.96	39.13	0.001
	Mediterranean	110	40.22	24.43	2.39	63.38	26.52	37.88	49.15	

Table 6. Percentage of added sugars in the total intake of carbohydrates in the diets of girls related to age and the areas studied

is statistical significance at ages 12-13 years (p = 0.001), 13-14 years (p = 0.013), and 14-15 years (p = 0.001).

The proportion of added sugars in total CHO intake is statistically significantly higher in girls in the Mediterranean region compared to the continental region at ages 12-13 years (p = 0.048), 13-14 years (p = 0.001), and 14-15 years (p = 0.001).

5. DISCUSSION

Carbohydrates are the main source of energy and should be included in the total daily intake at 45-65% according to the recommendations of WHO for adolescents, while the EFSA Council suggests that the intake should be in the range of 45-60%. Our study showed that CHO intake in the total sample was 59% of daily intake, which is in line with the recommendations. A study conducted by Fidler Mis et al. showed that adolescents in Slovenia consume approximately the same amount (12). Our findings on the lower percentage of CHO in the diet in the continental region (58.3%) compared to the Mediterranean region (60.4%) are in contrast to the studies conducted in Europe. For comparison, a study conducted in Spain (ENCAT), which included 114 adolescents aged 10-17 years, found that the percentage of CHO is very low, 43.4% (13), while in Central European countries it is 51.4–54% (14). In terms of sex, CHO intake is higher in girls than in boys. Boys in continental and Mediterranean areas have almost the same proportion of CHO in their diet, corresponding to the average intake in European countries, which ranges from 43-58% (15).

Our research has shown that boys consume more CHO compared to certain European countries. The highest intake in Europe is in Norway with 55 ± 7% (6), followed by Poland with 53.9 ± 8% (14), which is less than our respondents. Boys aged 14-15 years have the highest percentage of CHO in our study, and only among them, there is a statistically significant difference (p = 0.026), while the intake is lowest in sixth grade with 58.5 ± 7.9%, which is the exact opposite of boys in Germany, whose CHO intake decreases from sixth to eighth grade (16). The percentage of CHO in boys aged 12-13 years in the continental region is 58.6% (52.6-63.55)

of total daily intake at the median, which is less than the percentage in boys of the same age in the Mediterranean region (59.3%). A similar study conducted in Germany on approximately the same number of boys (n=114) showed a much lower median CHO intake of 51.6% (16).

In girls, there is a statistically significant difference in the percentage of CHO in all classes, and the intake is significantly higher in the Mediterranean area than in the continental part. Compared to other studies, the intake is significantly higher in girls. Among European countries, CHO intake in girls of the same age is highest in Norway, 55 ± 6% (17), and Poland, 54 ± 7.7% (18). A study conducted in Turkey on 940 female respondents aged 12-17 years showed that the proportion of CHO was 53.7% (19).

A study conducted in Oman among adolescents found that the intake of CHO was 54%, higher than that of Flemish boys (49%) (20). The highest percentage of carbohydrate intake is in Mediterranean girls aged 13-14 years, 62.3 ± 8.7%, which is higher than the EFSA Council recommendation but still in line with the recommendations of WHO. The ANIBES study conducted in Spain in 2013, which included 87 girls aged 9-12 years and 74 girls aged 13-17 years, showed a very low CHO intake, which was 44.4% for the first age group and 45.2% for the other, which is significantly lower than our Mediterranean (21). Prospective studies show that the increase in CHO intake is mainly due to higher consumption of pastries/cakes and sweets, without an associated increase in fiber intake.

Although the percentage of CHO is by the recommendations of WHO, the quality in the diet of adolescents is not satisfactory. Of the total intake of CHO, our respondents consume the most PS 49% (28.9% E), then added sugars 35% (23.8% E), and the least mono- and disaccharides 16% (18.2% E). The Dortmund Nutritional and Anthropometric Longitudinally Designed Study, which analyzed the changes in the quality of carbohydrates in the diet of German adolescents between 1988 and 2007, evaluated this trend as unfavorable (22).

Our study showed the difference in intake between genders. Boys consume 2.9% more CHO than girls, while the intake is fairly even across classes. A study conducted in the Netherlands came to similar conclusions. There, the prevalence of PS is slightly higher in boys than in girls, while the difference by age is insignificant (17). However, a study conducted among Belgian adolescents found no difference between the sexes, as PS intake was consistent (22). The proportion of PS in the total daily energy intake of boys in both areas studied and in all classes is higher compared to available data from other studies in European countries, where this intake is 23-25% E (6).

Natural sugars in the form of mono- and disaccharides are found in fruits, vegetables, and milk, and it is desirable to have as much of them as possible in the diet, especially for adolescents, as this ensures adequate intake of micronutrients. The proportion of natural sugars in the diet of our respondents varies by region, adolescents in the continental region have a significantly higher intake and it is 18.5% CHO or 10.7% E, while in the Mediterranean region this intake is significantly lower, 12, 8% CHO or 7.7% E. There is also an obvious difference by gender, with a higher prevalence of natural sugars in boys than in girls, which is why we differ from research in 33 countries, where in general girls consume more fruits and vegetables than boys (23). The consumption of natural sugars is highest at the age of 12-13 years and then decreases so that it is lowest at the age of 14-15 years, which means that the consumption of fruits and vegetables among our respondents decreases with age. This is consistent with the findings of studies conducted in 33 countries that fruit and vegetables are most commonly consumed by children aged 11 years and least commonly consumed by adolescents aged 15 years (23).

According to available data from studies conducted in European countries, the average intake of added sugars in school children and adolescents is between 11-25% E, which is consistent with our research (23). By gender, there is no difference in the intake of added sugars between boys and girls. It is already approximately the same, which is not the case in German adolescents, where the negative trend in CHO quality is more pronounced in boys (24). However, there was also no difference in the intake of added sugars between the sexes in the third National Health and Nutrition Examination Survey conducted in the USA. There, the intake of added sugars was 20.1% E for both girls and boys (24). According to all other available data, girls in Estonia, Sweden, Portugal, Poland, the Netherlands, and Hungary have higher intakes of added sugars than boys (6). In terms of age, the intake of added sugars is highest in the 14-15-year-old group, at 21.2% E, while it is about the same in the 12-14-year-old group. A 2015 study in Spain found that younger subjects aged 9-12 years had a higher proportion of added sugars in their total daily intake of 18.8% E than older adolescents aged 13-17 years, for whom intake was 17.7% E (21). In the case of boys, it is worth highlighting that there is a statistically significant difference in the intake of added sugar in all grades in the two areas studied, as boys in the Mediterranean area consume more added sugar than boys in the continental area, which is in contrast to the studies conducted in European countries. For example, the intake of added sugar is lower among boys in Spain, a Mediterranean country, than among boys in Poland (14). Boys aged 10-14 years in Portugal have the highest intake of added sugars of all European countries, 24.2% E (25).

The consumption of added sugars is higher in girls in Portugal than in our country, amounting to 25.4% E (25). In the United States, the consumption of added sugars was high from 1994 to 1996, exceeding 20% E (26). Later it decreased and in 2005-2008 it was 17.5% E in boys and 16.6% E in girls (27). After the interventions were implemented, the consumption of added sugars decreased to 14.6% E in 2007-08, according to the latest report (28). The high prevalence of added sugars in total carbohydrate intake and total energy intake requires appropriate intervention since excessive sugar consumption is associated with the occurrence of metabolic disorders as well as deficiencies in essential nutrients (29).

6. CONCLUSION

The proportion of carbohydrates in the diet of adolescents of both sexes is by recommendations. The high intake of added sugars in children in the Mediterranean region

is of concern, even if the intake in the continental area is well above the current recommendations. One of the public health objectives, therefore, is to promote proper nutrition and the availability of healthy foods in schools, especially during the period of early adolescence, when proper eating habits are adopted.

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