Dietary Intake of Macro- and Micronutrients in Slovenian Adolescents: Comparison with Reference Values

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Key Words

Adolescents • Nutrition • Diet • Food frequency questionnaire • Slovenia

Abstract

Background: Data on a nationally representative dietary intake in Central Europe is lacking. We investigated the diet of adolescents in Slovenia. **Methods:** Dietary habits were assessed using a food frequency questionnaire ($n = 2,661$), and present nutrition was assessed using a 3-day weighted dietary protocol ($n = 197$) for validation purposes. Dietary intake was calculated and compared with Central European [German (D), Austrian (A), and Swiss (CH); D-A-CH] recommendations and World Health Organization/Food and Agriculture Organization (WHO/FAO) recommendations. **Results:** Adolescents consumed exceeding reference intake values of free sugars (boys 16% of energy, girls 17%), saturated fatty acids (SFA; 13% of energy), and sodium (boys 203%, girls 210% of the WHO/FAO upper limit), but below-reference intake values of polyunsaturated fatty acids (PUFA; boys 5% of energy; girls 6%), water (boys 1,786 ml/day, girls 2,016 ml/day), and fiber density (only girls 2.8 g/MJ, $p < 0.001$). Among micronutrients, below-reference intakes (% of D-A-CH: boys and girls, respectively, $p < 0.05$) were reported for folate (64 and 69%), fluoride (28 and 31%), and calcium

(91 and 97%), as well as for vitamin D (20 and 20%). **Conclusions:** The dietary habits of Slovenian adolescents are less than optimal. They are characterized by exceeding reference intake values of free sugars, salt, and SFA, and a below-reference intake of PUFA, water, and several micronutrients.

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Introduction

Adolescence is a period of rapid growth, body changes, and re-establishment of behaviors, including eating habits. Many factors impact adolescents' eating behaviors, including society, parents' eating patterns, eating away from home, and physiological requirements [1]. Poor nutrient supply, as well as the establishment of unhealthy eating habits, can have a permanent impact on health status [2]. Assessment of their food intake is needed to learn about the nutritional status of adolescents, though their specific dietary habits, such as snacking, eating away from home, and skipping meals, make this assessment more difficult than in other age groups [3]. There has been no representative data on the nutrient intake of Slovenian adolescents until now.

This study is part of a cross-sectional study of goiter prevalence and food intake in Slovenian adolescents

[4, 5]. We investigated dietary habits and present diet by means of food frequency questionnaires (FFQ) and with 3-day weighted dietary protocols (3DP). We aimed to evaluate the dietary intake of Slovenian adolescents and compare it with relevant recommendations.

Materials and Methods

The investigation took place in 10 Slovenian regions during systematic medical examinations in health centers. All information gathered, procedures performed, and questionnaires were standardized. The study protocol was approved by the Ethics Committee of the Medical Faculty of the University of Ljubljana (No. 84/06/02). After an explanation of the study, written informed consent was obtained from the parents of the adolescents.

Subjects

A total of 2,813 Slovenian adolescents (10% of adolescents entering high school), aged 14–17 years, were recruited. In order to include adolescents from all socioeconomic groups, they were selected from various high school educational programs. The adolescents from each region were consecutively recruited during medical examinations until the specific number, proportional to the number of inhabitants of that region, was reached. Of those recruited, 95% agreed and completed an FFQ (2,661 = adolescents with FFQ) at regional health centers while waiting for their medical examination. Adolescents received oral instructions by trained nurses (a course was held prior to the study, at the University Children's Hospital in Ljubljana). Instructions were also written on the first page of the FFQ. The FFQ could be completed within 15 min. We excluded adolescents who: (a) had ≥ 4 invalid answers on the frequency of consumption (missing frequency, multiple marks for frequency) ($n = 96$; 4% of adolescents with FFQ); (b) were aged >16 years ($n = 80$; 3% of adolescents with FFQ) or <15 years ($n = 207$; 8% of adolescents with FFQ), or (c) reported an extremely high (more than 3 SD above the mean) or extremely low energy intake (boys <600 kcal/day; girls <500 kcal/day; $n = 54$; 2% of adolescents with FFQ), as it markedly deviated from the majority. Additionally, such extreme energy intakes could not represent an average energy intake during the whole year. Excluding these adolescents did not affect the conclusions of the study, as the mean values remained the same, but it did lower the SD. Thus 2,224 adolescents (83% of adolescents with FFQ; 1,010 boys and 1,214 girls) aged 15–16 years were included in the analysis.

Anthropometrical and Food Intake Data

Anthropometrical measurements, height and weight, were taken by the medical personnel. A dietary history method was used for the evaluation of dietary habits during the previous year. We used the Harvard University FFQ developed by Willett [6] and also described by Thompson and Byers [7]. The FFQ was semi-quantitative, comprising 82 food items. The questions referred to the daily, weekly, and monthly consumption of various foodstuffs or groups of foodstuffs (9 frequency categories of consumption from never or $<\text{once/month}$ to a maximum of 6 or more times/

day). Foods and table salt were categorized into the following groups: (1) milk and milk products, (2) meat and meat products, (3) fish and fish products, (4) fats, (5) starch foods, (6) vegetables, (7) fruits and nuts, (8) beverages, and (9) salt [5].

The amounts of foodstuffs were estimated from the FFQ, based on portion sizes that were adjusted post hoc on the basis of calculated average portion sizes obtained from 3DP, separately for girls and boys. The 3DPs were carried out by a subgroup of 197 adolescents (adolescents with suspected goiter and their controls [4]). They received oral and written instructions on how to complete the 3DP. Of the 197 adolescents, 191 (97%) correctly completed the 3DP. Missing recordings of consumption for 1 or more days ($n = 6$; 3% of the completed 3DP) was an exclusion criterion. Portion sizes in the FFQ of foods without natural units (e.g. meat, rice, pasta, potatoes) were replaced with average portion sizes from the 3DP, while portion sizes for foods with natural units (e.g. 1 apple, 2 dl of milk) remained the same as in the original FFQ.

The FFQs were analyzed with nutrition software (Prodi 5.2 expert plus; Stuttgart, Germany) [8]. Values for the iodine content of table salts sold in Slovenia were added [5].

The absolute intake of energy and nutrients from foods, drinks, and table salt was calculated based on the frequency of consumption (from FFQ), portion size (from FFQ and 3DP), and energy and nutrient content of each food item. Energy was expressed as daily intake in kilocalories and megajoules. The nutrient intake was expressed in (micro)grams/day, while carbohydrate, protein, and fat intakes were also expressed as a percentage of the daily energy intakes. Free sugars were defined as all monosaccharides and disaccharides (e.g. glucose, fructose, sucrose) added to foods by the manufacturer, cook, or consumer, plus sugars naturally present in honey, syrups, and fruit juices [9].

Comparison with the Reference Intake

The dietary habits were compared with D-A-CH reference values [10], which are official in Slovenia [11]. Since the D-A-CH reference values do not define the maximum daily sodium and sugar intake [10], we compared the adolescents' intake with World Health Organization/Food and Agriculture Organization (WHO/FAO) recommendations (population nutrient intake goal for: sodium, <2 g/day, and free sugars, $<10\%$ of the daily energy intake) [9], which have also been adopted in Slovenia.

Statistical Analysis

The normality of the distribution was checked with the Shapiro-Wilk and Kolmogorov-Smirnov tests. The data (most of the variables) were log transformed. Nutrient intakes were adjusted for energy intake using the residual method [12]. We used statistical weighting to standardize the results [13]. The t test and Mann-Whitney U test were used to compare differences between genders. The Wilcoxon signed-rank test was used to compare nutrient intakes with the recommendations. To assess the correlations of energy and macronutrient intake to weight and BMI, Spearman's rank coefficients were calculated. Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS version 16.0; Chicago, Ill., USA). Results are presented as means $\pm$ SD. The two-tailed significance level was 0.05.

Table 1. Intake of energy and macronutrients in Slovenian adolescents compared to the reference intake values [9, 10]

	Slovenian adolescents		Reference intake values ^{a, b}	
	boys (n = 1,010)	girls (n = 1,214)	boys	girls
Energy intake*, MJ/day	12.7 ± 6.9 [#]	9.7 ± 5.1 [#]	13.0 ^{a, c}	10.5 ^{a, c}
Energy intake*, kcal/day	3,043 ± 1,642 [#]	2,312 ± 1,220 [#]	3,100 ^{a, c}	2,500 ^{a, c}
Carbohydrates*, g/day	370 ± 55	379 ± 55	–	–
% E*	57 ± 9	58 ± 8	>50 ^a /55–75 ^b	>50 ^a /55–75 ^b
Total sugars*, g/day	170 ± 58	195 ± 65	–	–
% E*	26 ± 9	30 ± 10	–	–
Free sugars*, g/day	103 ± 56	110 ± 60	–	–
% E*	16 ± 9 [#]	17 ± 9 [#]	<10 ^b	<10 ^b
Starches*, g/day	193 ± 61	177 ± 59	–	–
% E*	30 ± 9	27 ± 9	–	–
Fiber*, g/day	28 ± 9 [#]	31 ± 11 [#]	>25 ^b	>25 ^b
g/MJ*	2.6 ± 0.8 [#]	2.8 ± 1.0 [#]	2.4 ^a	3.0 ^a
Fat, g/day	82 ± 21	82 ± 21	–	–
% E	28 ± 7	29 ± 7	30 ^a /15–30 ^b	30 ^a /15–30 ^b
SFA, g/day	36 ± 10	35 ± 9	–	–
% E	13 ± 3 [#]	13 ± 3 [#]	<10 ^{a, b}	<10 ^{a, b}
MUFA, g/day	30 ± 9	29 ± 10	–	–
% E	10 ± 3	10 ± 3	≥10 ^a	≥10 ^a
PUFA, g/day	16 ± 6	17 ± 7	–	–
% E	5 ± 2 [#]	6 ± 2 [#]	7–10 ^a /6–10 ^b	7–10 ^a /6–10 ^b
Cholesterol*, mg/day	268 ± 82 [#]	247 ± 77 [#]	<300 ^{a, b}	<300 ^{a, b}
Protein*, g/day	96 ± 18 [#]	86 ± 17 [#]	60 ^a	46 ^a
% E*	15 ± 3	13 ± 3	10–15 ^b	10–15 ^b
Protein, g/kg body weight/day	1.5 ± 0.4 [#]	1.5 ± 0.4 [#]	0.9 ^a	0.8 ^a
Water*, ml/day	1,786 ± 614 [#]	2,016 ± 711 [#]	2,450 ^a	2,450 ^a

Values are means ± SD. Total sugars (all monosaccharides and disaccharides) are free sugars plus sugars naturally present in foods (e.g. lactose in milk, fructose in fruits). Free sugars are all monosaccharides and disaccharides added to foods by the manufacturer, cook, or consumer, plus sugars naturally present in honey, syrups, and fruit juices [9]. Water refers to the total water from beverages and solid foods. % E = Percentage of total energy intake; – = no recommendation [9, 10].

* $p < 0.05$ between boys and girls; [#] $p < 0.05$ in comparison with the recommendations.

^a D-A-CH recommendations for the age group of 15 to <19 years; values for sexes are common or separated [10].

^b WHO/FAO recommendations [9].

^c Average daily energy requirements, calculated as (reference) the basal metabolic rate of individuals with a normal body weight multiplied by the physical activity level value 1.75 [10].

Results

Anthropometrical Data

The age and BMI of the adolescents (mean ± SD) was 15.6 ± 0.4 years and 21.4 ± 3.4, with no difference between boys and girls. Boys were on average 9.9 cm taller (boys vs. girls: 175.7 ± 7.0 vs. 165.8 ± 6.0 cm, $p < 0.001$) and 7.8 kg heavier than girls (boys vs. girls: 66.5 ± 11.9 vs. 58.7 ± 10.0 kg, $p < 0.001$).

Energy Intake

Both boys and girls reported energy intakes below the D-A-CH reference values (98 and 92% of D-A-CH, $p <$

0.05) (table 1). The Spearman rank coefficients between energy and BMI were –0.093 in girls ($p < 0.01$) and –0.049 in both genders ($p < 0.01$). The Spearman rank coefficients between energy and body weight were –0.080 in girls ($p < 0.01$) and 0.068 in both genders ($p < 0.01$).

Macronutrient Intake

The proportion between main macronutrients was adequate, with a slightly low intake of fat (28 and 29% in boys and girls, respectively).

Carbohydrates contributed 57 and 58% of the energy intake in boys and girls, respectively. Boys ingested a higher proportion of energy from starches than did girls

Fig. 1. Vitamins consumed by Slovenian adolescents compared to D-A-CH recommendations [10].

Fig. 2. Minerals and trace elements consumed by Slovenian adolescents compared to D-A-CH recommendations [10].

Fig. 3. Sodium and sugar consumed by Slovenian adolescents compared to the WHO/FAO upper recommended limit for intake [9].

(30 vs. 27%, $p < 0.05$). Both boys and girls had a high intake of free sugars (16 and 17% compared to the WHO/FAO recommendation of $<10\%$) ($p < 0.05$). The absolute intake of fiber was above the recommendations in both genders.

Fat contributed less than 30% of the energy for both genders ($p < 0.05$) but had an inappropriate composition: too high an intake of saturated fatty acids [SFA; 13% in both genders vs. the recommended $<10\%$] ($p < 0.05$), an appropriate intake of monounsaturated fatty acids (MUFA; 10% in both genders vs. the recommended $\geq 10\%$), and too low an intake of polyunsaturated fatty

acids [PUFA; 5% in boys and 6% in girls vs. the 7–10% recommended by D-A-CH and the 6–10% recommended by the WHO/FAO ($p < 0.05$)]. The Spearman rank coefficient between body weight and fat intake was -0.059 in girls ($p < 0.05$). Boys consumed more cholesterol than did girls ($p < 0.05$), although the intake in either gender did not exceed the upper limit of 300 mg/day.

Protein contributed 15% of the energy for boys and 13% for girls. Boys consumed significantly more protein (absolute amount and energy percentage) than did girls ($p < 0.05$). The Spearman rank coefficient between body weight and protein intake was 0.117 in both genders ($p < 0.01$).

Water intake from beverages (calculated from the frequencies and amounts of beverages consumed based on the FFQ) and solid foods (calculated from consumed foods from the FFQ and the nutrition software [8]) was too low in both genders ($p < 0.05$), with a higher water intake in girls ($p < 0.05$).

Micronutrient Intake

The daily intake of micronutrients (12 vitamins, 6 minerals, and 6 trace elements) and the recommendations are shown in table 2 and figure 1 and 2, and the intake of food groups is shown in table 3. Boys and girls consumed amounts below the reference intake values (% D-A-CH; boys and girls, respectively) of two vitamins (folate: 64 and 69%; vitamin D: 20 and 20%, $p < 0.05$; fig. 1), one mineral (calcium: 91 and 97%, $p < 0.05$; fig. 2), and one trace element (fluoride: 28 and 31%, $p < 0.05$; fig. 2), and too high an amount of sodium (203 and 210% of the WHO/FAO recommended upper limit, $p < 0.05$; fig. 3).

Table 2. Intake of selected vitamins, minerals, and trace elements by Slovenian adolescents compared to the reference intake values [10, 33, 41]

	Slovenian adolescents		Reference intake values ^{a-d}	
	boys (n = 1,010)	girls (n = 1,214)	boys	girls
<i>Vitamins</i>				
Biotin*, µg/day	48 ± 13	51 ± 14	30–60	30–60
Folate*, µg folate equivalent/day	255 ± 78 [#]	276 ± 90 [#]	400	400
Niacin*, mg niacin equivalent/day	33 ± 7 [#]	30 ± 6 [#]	17	13
Pantothenic acid, mg/day	6 ± 1	6 ± 1	6	6
Retinol equivalents, mg/day	1.2 ± 0.6	1.2 ± 0.7 [#]	1.1	0.9
Riboflavin, mg/day	1.8 ± 0.5 [#]	1.8 ± 0.5 [*]	1.5	1.2
Thiamine*, mg/day	1.4 ± 0.3 [#]	1.3 ± 0.3 [#]	1.3	1.0
Vitamin B ₁₂ *, µg/day	6.7 ± 3.3 [#]	5.9 ± 3.1 [#]	3.0	3.0
Vitamin B ₆ , mg/day	2.0 ± 0.5 [#]	2.0 ± 0.5 [#]	1.6	1.2
Vitamin C*, mg/day	177 ± 95 [#]	230 ± 140 [#]	100	100
Vitamin D, µg/day	4 ± 4 [#]	4 ± 3 [#]	20 ^b	20 ^b
Vitamin E*, mg/day	13 ± 5	15 ± 6 [#]	15	12
<i>Minerals</i>				
Calcium*, mg/day	1,094 ± 387 [#]	1,167 ± 398 [#]	1,200	1,200
Magnesium*, mg/day	407 ± 96	421 ± 103 [#]	400	350
Phosphorus*, mg/day	1,484 ± 307 [#]	1,448 ± 317 [#]	1,250	1,250
Potassium*, mg/day	3,494 ± 810 [#]	3,770 ± 959 [#]	2,000	2,000
Sodium, mg/day	4,059 ± 1,452 [#]	4,191 ± 1,684 [#]	550 ^c	550 ^c
	[#]	[#]	2,000 ^d	2,000 ^d
Chloride, mg/day	6,125 ± 1,939 [#]	6,212 ± 1,152 [#]	830 ^c	830 ^c
<i>Trace elements</i>				
Iron, mg/day	16 ± 3 [#]	16 ± 3 [#]	12	15
Copper*, mg/day	2.2 ± 0.4 [#]	2.4 ± 0.5 [#]	1.0–1.5	1.0–1.5
Fluoride*, mg/day	0.9 ± 0.3 [#]	0.9 ± 0.4 [#]	3.2	2.9
Iodine*, µg/day	181 ± 74 [#]	205 ± 82 [#]	150	150
Manganese, mg/day	4.8 ± 1.7	4.8 ± 1.7	2.0–5.0	2.0–5.0
Zinc, mg/day*	13.5 ± 2.7 [#]	12.4 ± 2.5 [#]	10.0	7.0

Values are means ± SDs. * $p < 0.01$ between boys and girls; [#] $p < 0.05$ in comparison with the recommendations.

^a D-A-CH recommendations for the age group of 15 to <19 years; values for sexes are common or separated [10].

^b New reference value for vitamin D [33].

^c Lower recommended amount according to D-A-CH recommendations [10].

^d Upper allowed amount according to WHO/FAO recommendations; corresponds to <5 g NaCl/day, NaCl (g) = Na (g) × 2.54 [41].

Discussion

This is the first study on the dietary habits of Slovenian adolescents. In this secondary data analysis, we used data obtained in the survey of goiter prevalence and the food intake of Slovenian adolescents [4, 5]. We calculated the dietary intake using the FFQ in a representative sample of adolescents and determined portion sizes using the 3DP in a subgroup. The dietary habits of Slovenian adolescents are less than optimal. They consume an inappropriate composition of fat, excessive amounts of free sug-

ars, especially in liquid form, and sodium, and below-reference intake values of some vitamins and minerals.

The strength of our study is the large number of participants (10% of adolescents entering high school) from all geographic regions of Slovenia and all sociodemographic backgrounds. An additional strength is the high participation rate (95% of those invited), which was achieved firstly by inviting adolescents at the most appropriate time, while waiting for a medical examination, and secondly due to the invitation and high motivation for participation on the part of specially trained nurses, and

Table 3. Intake of food groups of Slovenian adolescents aged 15–16 years (n = 2,224) compared to the optimized mixed diet (adolescents aged 15–18 years) [29] (adapted from Kobe et al. [5])

Food amounts, g/day	Diet of Slovenian adolescents				Optimized mixed diet	
	boys (n = 1,010)		girls (n = 1,214)		boys	girls
	mean	SEM	mean	SEM		
Beverages and plant foods						
Beverages	1,549	29	1,750*	28	1,500	1,400
Vegetables	179*	5	163*	4	350	300
Fruits	321*	9	489*	12	350	300
Bread/cereals ^a	271*	4	226*	4	350	280
Potatoes/rice/pasta	212*	4	163*	3	280	230
Animal foods						
Milk/milk products ^b	513	10	479	9	500	450
Meat/meat products	126*	3	85	2	85	75
Eggs	5 ^c		8 ^c		20 ^d	20 ^d
Fish/fish products	46*	2	41*	1	30 ^e	30 ^e
High-fat, high-sugar foods						
Oils/fats	14*	0	16*	0	45	40
Tolerated food groups	85*	2	98	2	105 ^f	85 ^f

Food intakes are adjusted for energy intake. * $p < 0.001$ mean values were significantly different from the optimized mixed diet (Wilcoxon's signed-rank test).

^a Cooked cereals including millet and wheat; legumes.

^b Milk equivalents: 100 ml milk corresponds to 15 g hard cheese or 30 g soft cheese.

^c Data obtained from the 3DP, does not include eggs in other foods (e.g. pasta, pastry).

^d Corresponds to 2–3 eggs/week.

^e Fish only (i.e. without fish products), corresponds to 1 portion (100–200 g)/week.

^f E.g. sugar, sweets, jam, chocolate, cake.

thirdly because the FFQ could be completed within 15 min. Nevertheless, our results need to be interpreted with caution. We used a semi-quantitative method to assess dietary habits during the last year, so some degree of misestimation cannot be excluded. Since there is no representative database on food composition in Slovenia, we used a German database, which is the most widely used in Slovenia.

Based on the FFQ, the estimated energy intake of boys and girls (mean 3,043 and 2,312 kcal/day) was below the D-A-CH reference values (3,100 and 2,500 kcal/day for moderate physical activity) [10]. Slovenian adolescents probably do not, on average, achieve this activity level. In view of normal BMI, some degree of underreporting cannot be excluded. The D-A-CH reference values for energy intake (i.e. guiding values) are set at the level of the average energy requirement without a safety margin to avoid the risk of inadequate energy intake. This was chosen due to the fact that the problem of overweight in Germany, Austria, and Switzerland is higher than an insufficient

energy intake [10]. The same concept was also adopted for Slovenia [11].

In boys there were no significant correlations between body weight or BMI and intakes of energy and macronutrients. A very weak negative correlation existed between body weight as well as BMI and energy intake in girls.

Observing adolescents according to 4 categories of BMI (underweight, healthful weight, overweight, and obese), underweight adolescents reported a lower energy intake than overweight and obese adolescents. However, some misreporting has to be considered: 34% of boys and 27% of girls underreported their energy intake, whereas 10% of boys and 11% of girls overreported their energy intake. Among underreporters, there were the lowest proportions of underweight and normal-weight adolescents but the highest proportions of overweight and obese adolescents. We investigated the misreporting of energy intake in adolescents. Excluding the misreporters (under- and overreporters) would cause a loss of subjects but would not affect the mean energy values. Additionally,

the exclusion would not be based on actual physical activity, since we did not investigate it [14]. To minimize the effect of misreporting of energy intake, we used statistical weighting to standardize the results and the residual method to adjust the nutrient intake for energy intake.

Studies on the dietary intake of adolescents of the same age in other countries similarly reported a low energy intake, i.e. 2,754 and 2,024 kcal/day for boys and girls, respectively, in Switzerland [15], 2,565 and 1,979 kcal/day in Spain [16], and 1,964 and 1,804 kcal/day in Turkey [17], although these comparisons should be made with caution due to different survey methods. SD for the total energy intake estimated from FFQs were found to be greater than those from dietary records [6].

Slovenian adolescents consumed a low percentage of energy from fat (28 and 29%) but a high percentage from carbohydrates (57 and 58%). A low percentage of energy from fat (30–33%) was also found in Portuguese adolescents [18]. The proportions of energy from SFA, MUFA, and PUFA in the nutrition of Slovenian adolescents were: 13, 10, and 5% (in boys), and 6% (in girls), showing that they consumed too much SFA, mainly of animal origin (milk and milk products, meat and meat products), and too little PUFA, which are mainly found in plant oils and sea fish. A further indicator of an inappropriate fat composition was a low polyunsaturated/saturated fat ratio, which was 0.48. A low polyunsaturated/saturated fat ratio was also found among adolescents from Western European countries [19] and among Turkish adolescents [17]. Several authors [20–22] have reported that Spanish adolescents have a high fat intake (39–45% of energy), while the percentage of energy from MUFA is also high (18–19%), mainly due to a high consumption of olive oil.

The high contribution of carbohydrates to energy intake in Slovenian adolescents was due to the high intake of free sugars, which exceeded the WHO/FAO upper recommended limit [9] by 60% in boys and by 70% in girls (equal to 16 and 17% of the daily energy intake). Sugar-sweetened beverages (i.e. fruit nectars, syrup beverages, sweetened tea, ice tea, and sweetened carbonated beverages) contributed 9 and 10% to the daily energy intake of Slovenian adolescent boys and girls [5]. In a recent WHO report, Slovenian 15-year-old adolescents were at the top of 39 countries from Europe and North America in terms of the frequency of adolescents reporting drinking sugared soft drinks on at least a daily basis. This is a risk factor for increased energy intake, weight gain, overweight and obesity, metabolic syndrome, and diabetes type 2 [23]. Different definitions of sugars have been used in different studies. German children and adolescents consumed 13%

of energy from added sugars, which were defined as all refined sugars eaten separately at the table or used as ingredients in processed or prepared foods [24]. In our study, added sugar intake, according to this definition, was 11% of the energy. In one survey in Spain, added sugars contributed 16% of the energy in adolescents [18]. Adolescents should reduce their intake of industrially prepared foods that are rich in sugar, especially sugar-sweetened beverages and confectionary. A high-sugar content was found to contribute significantly to the total caloric intake, but it does not satisfy nutrient requirements [24, 25]. Sugar-sweetened beverages are a significant contributor to energy intake. Water should be promoted as the main source of fluids. Limiting the supply of rapidly absorbed carbohydrates and simple sugars should be promoted, with a preferential intake of slowly absorbed carbohydrates [26].

The boys in our study had a sufficient fiber intake, while the girls' absolute intake was adequate but had too low a fiber density. A low dietary fiber intake was also reported among adolescents in Germany [27] and Denmark [28].

Slovenian adolescents consumed too low amounts of folate. Folate is mainly found in vegetables, whole grains, beans, and breakfast cereals [8], all of which are consumed in too low quantities by Slovenian adolescents (table 3). As noted previously, only 11% of Slovenian adolescent boys and 10% of girls in our study consumed the recommended amount of vegetables (boys on average 179 g/day vs. recommended 350 g/day [29]; girls on average 163 g/day vs. recommended 300 g/day [29]). The consumption of too low amounts of folate was also reported for Spanish and Turkish adolescents [16, 17]. Inadequate folate intake in childhood and adolescence has been correlated with elevated plasma levels of homocysteine, which may be a risk factor for cardiovascular diseases later in life [30]. A study in Germany demonstrated that folic and pantothenic acid supplements help to achieve a higher proportion of recommendations in some age groups and especially in girls [31].

Slovenian adolescents had a dietary intake of vitamin D of 4 µg, which is similar to that of adolescents in Germany [32]. In the absence of endogenous synthesis, this quantity is insufficient to reach the estimated value of adequate vitamin D intake that ensures the desired 25(OH) D serum concentration of at least 50 nmol/l. The difference between dietary vitamin D intake through habitual diet and the reference intake value much be covered by endogenous synthesis and/or an additional intake of vitamin D [33]. Too low amounts of vitamin D and cal-

cium, which were also reported for adolescents in Austria, indicate a high risk of the development of bone metabolism disorders [34]. Especially in girls, an inadequate intake of calcium during the years of achieving peak bone mass may lead to osteoporosis later in life [35].

The fluoride intake in Slovenian adolescents was also considerably below the recommendations (1.0 and 0.9 mg/day for boys and girls, respectively). Even lower levels were found in German children (0.1–0.3 mg/day) [36].

The WHO/FAO recommendation is <2 g sodium intake per day [9]. Slovenian adolescents had a sodium intake that was 107% above the upper limit (i.e. 207% of the WHO/FAO recommendation), which shows that the salt intake was markedly too high.

The dietary habits of Slovenian adolescents show patterns with potential risks of cardiovascular diseases, in terms of several indicators. Firstly, too high an intake of SFA increases the level of LDL cholesterol in plasma [37]. Secondly, a high intake of mono- and disaccharides is thought to reduce the level of plasma HDL cholesterol [38]. This causes a raised LDL/HDL ratio, which plays an important role as a risk factor for coronary heart diseases [39]. Furthermore, the high intake of sodium found among adolescents in our study clearly indicates an excessive salt intake, which is related to high blood pressure [40]. Multiple observational studies have shown a clear association of sodium consumption with cardiovascular disease, as well as gastric cancer, osteoporosis, cataracts, kidney stones, and diabetes [41]. Cardiovascular diseases are the leading cause of death in Slovenia (40% of all deaths) [42].

A major limitation of our study is that we had no resources for designing and validating a questionnaire *de novo*. We used an existing, evaluated semiquantitative questionnaire, as purposed by Willett [6]. The Harvard University FFQ is the most widely used FFQ in epidemiological studies. It covers all of the main foods eaten also in Slovenia. Some traditional Slovenian foods represent only a very minor intake in most Slovenian adolescents. Since the questionnaire was semiquantitative, developed for the US population, and, prior to the study, not evaluated in Slovenian adolescents, the results must be interpreted with caution. Willett [6] reported that the portion size specification for foods without natural units was sometimes ignored by participants who complete the FFQ. The marked frequency of consumption in the FFQ would therefore have been the same even if the portion size was different. In order to check this, we compared the portion sizes from the FFQ to those calculated from the 3DP, separately for boys and girls, in a subgroup ($n = 180$) [those that completed both the FFQ ($n = 2,224$) and the

3DP ($n = 191$) correctly]. We found that the portion size specification for foods without natural units was ignored by adolescents. For evaluation of the FFQ, therefore, we used the average portion sizes of foods without natural units obtained from the 3DP for boys and girls separately. Ideally, the subgroup of adolescents with 3DP would be even larger. A further limitation of our study is that we did not provide standard digital scales to adolescents to weigh their food intake. Some degree of misreporting, including underreporting, cannot therefore be excluded.

In conclusion, as in other countries, our first national study on the dietary intake of Slovenian adolescents also indicates their less-than-optimal dietary habits. Since nutrition that provides an adequate nutrient intake in adolescence is of crucial importance for health later in life, action should be taken to improve the nutrition of adolescents.

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