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Development and Validation of a Self-Administered Food Frequency Questionnaire to Assess Habitual Dietary Intake and Quality of Diet in Healthy Adults in the Republic of Croatia

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A B S T R A C T

Food frequency questionnaires (FFQ) are designed to assess habitual diet by asking about the frequency with which food items or specific food groups are consumed over a reference period. In this study, we have developed a FFQ to assess habitual dietary intake of healthy adults to estimate the quality of their nutrition and conducted a study to validate the developed FFQ against a three-day 24-hour recall. Second aim of the study is to establish the correlation between the FFQ to assess habitual dietary intake and a three-day 24-hour recall, in relation with participants' age and education level. FFQ used in our study was adapted from the Harvard Semiquantitative Food Frequency Questionnaire, consisted of 101 food items, divided into 9 groups. The 24-hour recalls were collected during one week (the same week when the FFQ was completed) and on each different day of the week (two weekdays and one weekend day). Both the FFQ and three day 24-hour recall were distributed to 100 healthy, employed subjects, 32 males (aged 39.73±14.02) and 36 females (aged 34.20±10.63). The results indicated that the developed FFQ is valid instrument to assess the habitual intake of energy and most of the nutrients in healthy adults in the Republic of Croatia, while men tended to have higher correlation coefficients than women and therefore a higher correlation of the FFQ with the three 24-hour recalls. Statistically significant correlations are not found between energy and nutrient intake based on the education level of the participants.

***Key words**: age, correlation, education level, gender, nutrition*

Introduction

Assessing habitual diet is important to gain the insight in overall health status of an individual. On the population level, it is important to adjust the estimations of habitual diet to certain population: this research is aimed to develop the preliminary version of an instrument for assessing habitual diet, adjusted for Croatian population.

In the past twenty years, food frequency questionnaires (FFQ) have become one of the key research tools in nutritional epidemiology[1] especially in studies and research relating to the effect of food consumption and chronic disorders[2].

Accurate estimates of habitual dietary intake still remain a challenge in diet-disease related studies, but it has been established that FFQs can assess long-term dietary intake, an important exposure fact for chronic diseases[3]. Although a quantitative assessment of dietary intake using a FFQ may be less accurate in comparison to a 24-hour recall or food weighing, FFQs are a method that can assess the habitual dietary intake of a larger population from a one-time administration[4] because it reflects the past diet and usual intake[5].

Food frequency questionnaires can be limited in their usefulness and therefore, once developed cannot be used for any population or research group without prior validation. A FFQ validation assesses the degree to which a questionnaire measures nutrients or food for which it has been developed. Without prior validation, a FFQ may produce incorrect information and therefore lead to false associations between dietary intake and diseases or state

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of the human organism[1]. Food frequency questionnaires are in most cases validated against other methods which assess dietary intake such as dietary records and dietary recalls but the reference method could also be influenced by factors which affect the validity of a FFQ such as memory and nutrient data[6].

It is expected that FFQs will not reflect current dietary intake, but will instead rank individuals by levels of their past nutrient intake[7]. To ensure an accurate estimation of dietary intake, food items during the development of a FFQ must be selected carefully, to assure a list of foods which will reflect the food consumption patterns and choices of the population under study[2] as well as the goal of the research for which a developed FFQ will be used.

Studies have shown that there is a significant difference in the FFQ results based on the education level of the participants[8]. Participants with low education have greater difficulty in answering the question thus providing more inaccurate results. Participants with a higher level of education show a tendency for better estimation of the nutrients[9], although the participants with less than a high school education do show a satisfactory performance on the FFQ[10].

Therefore, we developed a FFQ to assess habitual dietary intake of healthy adults to estimate the quality of their nutrition and conducted a study to validate the developed FFQ against a three-day 24-hour recall. The other aim of the study is to establish the correlation between the FFQ to assess habitual dietary intake and a three-day 24-hour recall with participants' age and education level.

Materials and Methods

Development of the FFQ

This FFQ to assess dietary intake in healthy adults was adapted from a questionnaire originally devised by Willet and colleagues (the Harvard Semiquantitative Food Frequency Questionnaire)[11].

The FFQ consists of four parts. The first part is a general questionnaire included to evaluate the possible determinants for food consumption habits and to register additional information about the subject (gender, age, education, possible food allergies, alcohol consumption, smoking history, physical activity level, number of meals per day, eating habits and food preparation habits).

The second part of the FFQ was developed to include food items in order to assess the frequency of their consumption for assessing habitual dietary intake (the purpose of the FFQ). The FFQ was adapted to assess the dietary intake of all macronutrients (protein, carbohydrate and total fat), micronutrients for which the nutritional data in national food composition tables[12] is present (sodium, potassium, calcium, magnesium, iron, phosphorus, copper, zinc, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6, folate, vitamin C and retinol equivalent), fatty acids (saturated fatty acids, polyunsaturated fatty acids and monounsaturated fatty acids), cholesterol and total dietary fiber. The target population were healthy employed adults of both genders, with no current diagnosed chronic illnesses, women who are currently not pregnant, and individuals not taking any medication at the time of administration. When choosing foods which would be included in the FFQ, the usual diet of the population in Croatia was taken into account including commonly eaten foods in Croatia and national dishes. Only individual foods were included in the FFQ but are applicable for assessment when eaten in combination with other food. In order for the FFQ to assess an overall quality of usual diet, some food items where included in the FFQ multiple times but with different ways of preparation (ex. French fries, boiled potato, baked potato).

The third part of the FFQ was developed to assess any possible use of multivitamins or individual vitamin and/or mineral supplements (vitamin A, vitamin C, vitamin B_6, vitamin E, vitamin D, calcium, iron, magnesium and zinc) where the duration of supplement administration, weekly frequency and dosage was asked for each included supplement.

The fourth part of the FFQ was developed to assess the usual portion size of each food item included in the frequency assessment of the FFQ. Portion sizes included pictures of two to three different portion sizes for each food item, based on the type of the food item present in the FFQ and reflect the known consumption patterns in the population. For each food item subjects were also given the possibility to enter on a blank line their own estimation of their usual portion size.

Participants

Both the FFQ and three day 24-hour recall were distributed to 100 healthy, employed subjects between 20 and 67 years of age of both gender as according to present data and instructions, to correctly asses validity of a FFQ, a sample of 50–100 participants should be included[1]. Participants were excluded from the study if they were at the time of the study conduction taking medication for any illness, were pregnant or diagnosed with a chronic illness. All participants returned the questionnaires. Six participants returned an incomplete FFQ questionnaire, eight participants returned the questionnaires without completion of any 24-hour recalls and eighteen participants completed only one 24-recall and were therefore excluded from the statistical analysis. The total number of study subjects included in the statistical analysis was 68, healthy, employed adults of both genders (32 males and 36 females) in the city of Zagreb, Republic of Croatia, between 23 and 57 years of age (Table 1).

Data collection

Each subject included in the validity analysis completed one FFQ and three 24-day recalls (two referring to weekdays, and one referring to a day during the weekend). Food frequency questionnaires and 24-hour recalls were collected from the study subjects during autumn

2012, winter 2012 and spring 2013. The subjects were instructed how to complete both the FFQ and three 24--hour recalls with a written explanation at the beginning of each questionnaire.

Food frequency questionniare

The self-administered FFQ consists of 101 food items questions on dietary habits which contained two parts – assessment of consumption frequency and assessment of the usual portion size. The previous month was used as a reference period. The following consumption frequencies were available to consider by the subjects in the FFQ: never, once amonth, twice to three times a month, once a week, two to three times a week, four to six times a week and every day. The 101 food items were divided into 9 groups: cereals and grain products (fourteen items), vegetables (seventeen items), fruit (11 items), pulses and legumes (five items), meat, fish and eggs (seventeen items), milk and dairy products (fourteen items), fat (five items), sweets (four items) and beverages (fourteen items). For the assessment of the usual portion size, the subjects were given pictures of portion sizes with the written weight beneath the pictures which they could circularize or give their own estimation of the usual portion size.

Dietary intakes of energy, eighteen nutrients (protein, carbohydrates, total fat, sodium, potassium, calcium, magnesium, iron, zinc, copper, phosphorus, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6 folate, retinol equivalent and vitamin C), cholesterol, dietary fiber and three fatty acids (saturated fatty acids, polyunsaturated fatty acids and monounsaturated fatty acids) were calculated using national food composition tables[12].

Twenty four hour recall – the reference method

The 24-hour recalls were collected during one week (the same week when the FFQ was completed) and on each different day of the week (two weekdays and one weekend day).

When completing the 24-hour recalls, the subjects described in detail each food, method of preparation and the names of dishes including brand names if possible as well as the portion sizes using kitchenware (plate, tablespoon, teaspoon, cup, glass etc.).

Dietary intakes of energy, eighteen nutrients (protein, carbohydrates, total fat, sodium, potassium, calcium, magnesium, iron, zinc, copper, phosphorus, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6 folate, retinol equivalent and vitamin C), cholesterol, dietary fiber and three fatty acids (saturated fatty acids, polyunsaturated fatty acids and monounsaturated fatty acids) were calculated using national food composition tables[12] for food with no particular brand name or from brand packages for foods where brand name was written, in Microsoft Excel database especially conducted for the purpose of this study.

Statistical analysis

All consumed items, by frequency and quantity in both the FFQ and the three 24-hour recalls were coded and transformed to daily nutrient intakes with the use of a database, especially developed for the purpose of this FFQ. To assess the validity of the FFQ, we used Pearson correlation coefficients and compared them with the mean of the three 24-hour recalls. Unless reported differently, a P value od 0.05 was used as the threshold for significance. For most food groups, the food consumption was not normally distributed. Therefore, non-parametric methods (Spearman's correlation coefficient) were used to evaluate the validity of the FFQ against three day 24-hour recalls, as well as to determine the correlations between age and education level (expressed on the ordinal measuring scale). All analyses were conducted using STATISTICA statistical software.

Results

The characteristics of subjects enrolled in the study are displayed in Table 1. The dietary arm of the study included both women and men.

TABLE 1
CHARACTERISTICS OF STUDY PARTICIPANTS ENROLLED IN THE VALIDATION STUDY

	Male N=32	Female N=36
Age (years)	39.73±14.02	34.20±10.63
Weight (kg)	91.03±18.64	63.83±11.16
Height (cm)	183.31±6.50	169.14±6.63
Body Mass Index (kg/m^2)	27.04±4.93	22.30±3.55

Relative validity

Mean energy and nutrient intakes from the three 24-hour recalls and the administered FFQ are reported in Table 2.

Intakes of almost all nutrients were higher on the administered FFQ than the mean values of the three 24--hour recalls, whereas only the intake of vitamin B_3 and cholesterol was higher in the mean value of the three 24-hour recalls opposed to the administered FFQ. As expected, men have higher intakes of all nutrients, both on the administered FFQ and the 24-hour recalls.

When evaluating the intakes of all participants, the difference between estimated daily nutrient intakes from the administered FFQ and repeated 24-hour recalls is significant for all nutrients except cholesterol, sodium, vitamin B_2 and vitamin B_3. If we review only the female participants, the difference between their estimated daily nutrient intakes from the FFQ and repeated 24-hour recalls is significant for all nutrients except polyunsaturated fatty acids and cholesterol, whereas for male participants, the difference is significant for all nutrients except polyunsaturated fatty acids, sodium, cholesterol, vitamin B_2, vitamin B_3 and vitamin C. All statistically significant differences for estimates of daily nutrient intakes (for all participants, male participants and female

TABLE 2
MEAN ESTIMATES AND DIFFERENCES AMONG DAILY NUTRIENT INTAKES FROM THE ADMINISTERED FFQ AND THREE REPREATED 24-HOUR RECALLS

	Total			Males			Females		
	Repeated 24-hour recalls	FFQ	t-test	Repeated 24-hour recalls	FFQ	t-test	Repeated 24-hour recalls	FFQ	t-test
Total Energy (kcal)	1822.02±549.67	3054.24±2914.26	3.657**	1908.89±636.10	3576.45±3870.01	2.584**	1744.81±454.92	2590.05±1587.94	3.119**
Total protein (g)	79.92±24.94	146.45±76.36	–7.492**	85.97±23.96	136.35±68.26	–4.321**	74.54±24.87	155.52±82.79	–6.287**
Total carbohydrate (g)	207.29±76.46	282.07±140.90	4.965**	218.82±95.36	279.87±156.73	2.809**	197.05±53.92	284.04±127.42	4.150**
Total fat (g)	73.66±28.11	175.19±311.73	2.749**	75.11±30.84	230.46±425.73	2.114*	71.83±25.74	126.05±142.18	2.257*
Total saturated fat (g)	26.33±12.08	43.02±38.51	3.721**	28.94±14.54	51.64±49.78	2.641**	24.02±8.95	35.36±22.72	3.166**
Total monounsaturated fat (g)	25.50±12.83	67.04±115.20	3.075**	27.57±14.76	91.75±161.21	2.330**	23.65±10.71	45.07±36.49	3.578**
Total polyunsaturated fat (g)	14.66±13.14	56.40±163.82	2.107*	15.46±16.75	77.75±219.86	1.608	13.94±9.01	37.42±88.17	1.592
Cholesterol (mg)	298.31±197.57	260.82±166.09	–1.633	301.198±186.47	354.86±220.08	–1.676	224.92±138.55	248.04±162.17	–0.702
Dietary fiber (g)	16.85±7.55	34.60±17.36	8.544**	16.19±7.89	30.95±15.05	5.690**	17.44±7.297	37.84±18.79	6.491**
Calcium (mg)	686.37±304.15	1098.76±512.30	5.970**	715.37±324.08	1112.15±588.38	3.374**	660.598±287.42	1086.85±442.13	5.348**
Iron (mg)	11.31±4.55	20.27±9.49	7.320**	11.21±3.81	19.03±7.69	5.342**	11.396±5.17	21.38±10.83	5.208**
Magnesium (mg)	155.57±69.14	324.57±144.63	9.292**	153.01±66.98	309.03±142.89	5.643**	157.84±71.86	338.38±146.77	7.458**
Zinc (μg)	4.30±2.36	7.78±3.61	7.712**	4.13±2.26	7.76±3.73	5.403**	4.46±2.46	7.795±3.55	5.430**
Copper (mg)	1.06±1.51	2.20±1.38	5.333**	1.29±2.15	2.44±1.65	2.822**	0.85±0.42	1.98±1.06	6.136**
Phosphorus (mg)	1187.75±363.08	1857.21±745.47	7.919**	1247.17±371.66	1917.78±777.197	5.603**	1134.93±352.00	1803.37±722.82	5.539**
Sodium (mg)	1895.54±980.66	2136.42±920.73	1.894	2105.16±1118.89	2139.73±870.39	0.166	1709.22±810.09	2133.48±975.60	2.839**
Potassium (mg)	2469.491±708.88	4428.75±1811.17	8.654**	2454.14±626.58	4293.13±1691.84	5.756**	2483.14±783.45	4549.31±1926.797	6.402**
Retinol (îg)	560.69±424.57	1324.69±1579.49	4.066**	519.51±296.92	1703.12±2105.95	3.240**	597.296±513.86	988.31±774.76	3.288**
Vitamin B_1 (mg)	1.24±0.73	2.04±0.99	7.184**	1.36±0.89	2.09±0.95	4.534**	1.13±0.55	2.00±1.03	5.546**
Vitamin B_2 (mg)	1.72±3.39	2.48±1.18	1.917	2.17±4.92	2.52±1.22	0.414	1.31±0.56	2.45±1.15	6.626**
Vitamin B_3 (mg)	49.21±263.91	29.29±16.50	–0.638	86.69±384.36	30.48±15.38	–0.848	15.91±7.32	28.23±17.59	4.207**
Vitamin B_6 (mg)	1.30±0.80	3.59±1.88	11.456**	1.44±0.94	3.69±2.23	7.148**	1.17±0.64	3.49±1.54	9.020**
Vitamin C (mg)	127.59±176.68	227.36±130.54	4.046**	152.00±249.53	226.297±143.68	1.563	105.89±59.80	228.299±119.71	6.219**
Folic acid (μg)	124.79±69.83	345.17±186.90	10.214**	123.79±62.36	348.18±177.16	7.089**	125.68±76.73	342.49±97.61	7.253**

* difference is significant at the $p<0.05$ level (two tailed); ** difference is significant at the $p<0.01$ level (two tailed)

TABLE 3
CORRELATION COEFFICIENTS FOR ESTIMATE INTAKES OF ENERGY AND NUTRIENTS BETWEEN MEAN VALUES OF THE THREE 24–HOUR RECALLS AND THE ADMINISTERED FFQ

	Correlation coefficients				
	Total (adjusted to gender)	Total (unadjusted)	Males	Females	Z
Total Energy (kcal)	0.336**	0.409**	0.642**	0.059 (p)	2.76**
Total protein (g)	0.323** (p)	0.286* (p)	0.275 (p)	0.365* (p)	–0.39
Total carbohydrate (g)	0.420** (p)	0.477 ** (p)	0.620** (p)	0.242 (p)	1.88*
Total fat (g)	0.366**	0.398**	0.470**	0.314 (p)	0.73
Total saturated fat (g)	0.392**	0.412**	0.353*	0.329* (p)	0.11
Total monounsaturated fat (g)	0.390**	0.398**	0.471** (p)	0.336**	0.64
Total polyunsaturated fat (g)	0.174	0.293*	0.472**	0.048	1.83*
Cholesterol (mg)	0.447**	0.482**	0.614** (p)	0.143 (p)	2.24*
Dietary fiber (g)	0.244* (p)	0.248* (p)	0.309 (p)	0.186 (p)	0.52
Calcium (mg)	0.114 (p)	0.098 (p)	0.023 (p)	0.194 (p)	–0.68
Iron (mg)	0.096 (p)	0.101 (p)	0.086 (p)	0.105 (p)	–0.08
Magnesium (mg)	0.152 (p)	0.160 (p)	0.023	0.266 (p)	0.98
Zinc (μg)	0.282* (p)	0.281* (p)	0.274 (p)	0.289 (p)	–0.06
Copper (mg)	0.291*	0.321**	0.437*	0.242 (p)	0.87
Phosphorus (mg)	0.358** (p)	0.372 **(p)	0.491** (p)	0.240 (p)	1.15
Sodium (mg)	0.420** (p)	0.393** (p)	0.320 (p)	0.509** (p)	–0.90
Potassium (mg)	0.099 (p)	0.117 (p)	–0.005 (p)	0.191 (p)	–0.74
Retinol (μg)	0.251*	0.257*	0.298	0.446** (p)	–0.68
Vitamin B_1 (mg)	0.330**	0.343**	0.317	0.414* (p)	–0.44
Vitamin B_2 (mg)	0.471**	0.470**	0.484**	0.433** (p)	0.25
Vitamin B_3 (mg)	0.244*	0.394**	0.431*	0.210 (p)	0.97
Vitamin B_6 (mg)	0.407** (p)	0.239*	0.194	0.199 (p)	–0.02
Vitamin C (mg)	0.251*	0.320**	0.366*	0.277 (p)	0.39
Folic acid (μg)	0.292* (p)	0.312** (p)	0.145 (p)	0.421** (p)	–1.19

* correlation is significant at the 0.05 level (two tailed); **correlation is significant at the 0.01 level (two tailed); (p) Pearson's correlation coefficient; Z – difference among correlation coefficients

participants) where due to higher intakes of the nutrients according to the administered FFQ.

Correlation coefficients estimated from administration of the FFQ and mean values of the three 24-hour recalls are presented in Table 3. Correlation coefficients between the mean values of the three 24-hour recalls and the administered FFQ for energy and nutrients ranged from 0.10 (calcium) to 0.48 (cholesterol) when the intakes of all participants were reviewed (unadjusted), while the range for all participants when adjusted to gender, ranged from 0.10 (iron) to 0.47 (vitamin B_2). Within the male participants, correlation coefficients between the mean values of the three 24-hour recalls and the administered FFQ for energy and nutrients ranged from –0.01 (potassium) to 0.64 (total energy), while within the female participants, correlation coefficients ranged from 0.05 (total polyunsaturated fat) to 0.51 (sodium).

In all the analyses, all correlation coefficients are positive directed (with one exception, with zero-level correlation) which can support the arguments towards the validity of the questionnaire, even with some non-significant correlations. More statistically significant correlation coefficients are found within the male participants (12) than within the female participants (8). Within both genders, total saturated fat, total monounsaturated fat and vitamin B_2 showed significant positive correlations between the mean values of the three 24-hour recalls and the administered FFQ. Correlation coefficients between the mean values of the three 24-hour recalls and FFQ have similar values for all participants (unadjusted) and for all participants adjusted to gender, while only one correlation (total polyunsaturated fat) appears to become non-significant when participants are adjusted to gender. In other words, 19 out of possible 24 significant positive correlations are found for participants when adjusted to gender, while 20 out of possible 24 significant positive correlations are found for all participants (unadjusted to gender). In spite of different numbers of statistically significant correlations for male and female participants, when Fisher r-to-z transformation has been done, among all correlation coefficients (significant and non-signifi-

TABLE 4
CORRELATION COEFFICIENTS FOR ESTIMATE INTAKES OF ENERGY AND NUTRIENTS FROM THE ADMINISTERED FFQ WITH AGE AND EDUCATION LEVEL

Administered FFQ estimates	Total (adjusted to gender)		Males		Females	
	Age	Education	Age	Education	Age	Education
Total Energy (kcal)	–0.338*	0.033	–0.502**	–0.105	–0.320	0.158
Total protein (g)	–0.403**	0.065	–0.562**	–0.137	–0.289	0.295
Total carbohydrate (g)	–0.396**	–0.011	–0.495**	–0.041	–0.258	0.034
Total fat (g)	–0.302*	0.020	–0.434*	–0.118	–0.312	0.088
Total saturated fat (g)	–0.234	–0.023	–0.366*	–0.051	–0.176	–0.048
Total monounsaturated fat (g)	–0.326**	0.103	–0.411*	–0.144	–0.342*	0.233
Total polyunsaturated fat (g)	–0.340**	0.002	–0.396*	–0.187	–0.384*	0.096
Cholesterol (mg)	–0.146	0.078	–0.265	0.141	–0.028	0.064
Dietary fiber (g)	–0.239	0.068	–0.300	0.039	–0.264	0.095
Calcium (mg)	–0.109	0.121	0.091	0.241	0.044	0.065
Iron (mg)	–0.343**	0.010	–0.455**	–0.071	–0.328	0.111
Magnesium (mg)	–0.267*	–0.035	–0.271	0.010	–0.285	–0.059
Zinc (μg)	–0.213	0.045	–0.252	0.047	–0.200	0.060
Copper (mg)	–0.129	0.072	–0.071	0.110	–0.223	0.074
Phosphorus (mg)	–0.325**	0.057	–0.467**	0.049	–0.235	0.091
Sodium (mg)	–0.442**	0.147	–0.523**	0.021	–0.398*	0.321
Potassium (mg)	–0.169	0.131	–0.175	0.192	–0.204	0.111
Retinol (μg)	–0.062	0.132	0.022	0.319	–0.178	0.019
Vitamin B_1 (mg)	–0.557**	–0.013	–0.696**	–0.125	–0.404*	0.120
Vitamin B_2 (mg)	–0.337**	0.140	–0.413*	0.183	–0.247	0.147
Vitamin B_3 (mg)	–0.568**	–0.019	–0.723**	–0.111	–0.444**	0.082
Vitamin B_6 (mg)	–0.383**	0.023	–0.498**	–0.022	–0.347*	0.079
Vitamin C (mg)	–0.054	0.108	0.030	0.185	–0.120	0.042
Folic acid (μg)	–0.274*	0.097	–0.385*	0.154	–0.149	0.066

Legend: *correlation is significant at the 0.05 level (two tailed); **correlation is significant at the 0.01 level (two tailed)

cant), it appears that only four correlation coefficients are statistically significantly different for male and female participants. In all four cases, male participants showed higher correlations between the mean intakes from the three 24-hour recalls and the administered FFQ.

In Table 4, the correlation coefficients between daily nutrient intakes of the administered FFQ with age and education level are presented. The first observation lead to the conclusion that there are no statistically significant correlations between education level and the administered FFQ for any of the nutrients, for all participants as well as separately for male and for female participants. On the other hand, almost all (even non-significant) correlations between the administered FFQ with age have a negative direction. Correlation coefficients between the administered FFQ for energy and nutrients and age have a range from –0.05 (vitamin C) to –0.58 (vitamin B_3) for all participants, between 0.09 (calcium) to –0.72 (vitamin B_3) for male participants and between 0.04 (calcium) to –0.44 (vitamin B_3) for female participants.

More statistically significant correlation coefficients with age are found for male participants (15) than for female participants (6). For both genders, six nutrients showed significant negative correlations between age and the administered FFQ: total monounsaturated fat, total polyunsaturated fat, sodium, vitamin B_1 and vitamin B_6. Correlation coefficients between the administered FFQ for energy and nutrients and age showed 19 out of possible 24 significant negative correlations for all participants when adjusted to gender.

In Table 5, correlation coefficients for energy and nutrients between estimates of mean daily nutrient intakes from the repeated 24-hour recalls with age and education level are presented. As in Table 4, there are no statistically significant correlations between education level and the mean values of the three 24-hour recalls for any of the nutrients, for all participants or stratified by gender. On the other hand, almost all (even non-significant) correlations between the mean values of the three 24-hour recalls with age have a negative direction. Correlation coefficients between the mean values of the three 24-hour recalls for energy and nutrients and age are ranged from

TABLE 5
CORRELATION COEFFICIENTS FOR ESTIMATES OF DAILY ENERGY AND NUTRIENT INTAKE BETWEEN THE THREE 24-HOUR RECALLS ADJUSTED TO AGE AND EDUCATION LEVEL

Three 24-hour recalls	Total (adjusted to gender)		Males		Females	
	Age	Education	Age	Education	Age	Education
Total Energy (kcal)	–0.289*	–0.103	–0.425*	–0.098	–0.152	–0.150
Total protein (g)	–0.239	–0.003	–0.331	0.100	–0.225	–0.115
Total carbohydrate (g)	–0.427**	–0.087	–0.587**	–0.125	–0.232	–0.106
Total fat (g)	–0.110	–0.065	–0.182	–0.015	–0.045	–0.118
Total saturated fat (g)	–0.078	–0.115	–0.163	–0.110	0.018	–0.182
Total monounsaturated fat (g)	–0.092	–0.106	–0.071	–0.047	–0.111	–0.213
Total polyunsaturated fat (g)	–0.149	–0.120	–0.210	–0.071	–0.139	–0.166
Cholesterol (mg)	–0.098	–0.051	–0.078	0.024	–0.115	–0.111
Dietary fiber (g)	–0.100	0.018	–0.192	0.322	–0.090	–0.238
Calcium (mg)	–0.272*	–0.015	–0.281	0.117	–0.343*	–0.041
Iron (mg)	–0.080	–0.014	–0.054	0.104	–0.131	–0.134
Magnesium (mg)	–0.157	–0.036	–0.189	0.094	–0.147	–0.167
Zinc (μg)	–0.257*	0.049	–0.234	0.177	–0.332	–0.061
Copper (mg)	–0.225	0.035	–0.475**	0.040	–0.169	0.097
Phosphorus (mg)	–0.441**	–0.096	–0.495**	–0.053	–0.335	–0.142
Sodium (mg)	–0.225	0.035	–0.493**	–0.154	–0.372*	–0.024
Potassium (mg)	–0.223	–0.010	–0.309	0.109	–0.168	–0.128
Retinol (μg)	–0.309**	–0.002	–0.242	–0.031	–0.435**	0.045
Vitamin B_1 (mg)	–0.412**	0.003	–0.386*	0.074	–0.420**	–0.071
Vitamin B_2 (mg)	–0.448**	–0.091	–0.495**	–0.016	–0.480**	–0.126
Vitamin B_3 (mg)	–0.274	–0.099	–0.471**	0.123	–0.307	–0.207
Vitamin B_6 (mg)	–0.405**	–0.081	–0.496**	0.061	–0.350*	–0.203
Vitamin C (mg)	–0.175	–0.078	–0.281	0.117	–0.253	–0.086
Folic acid (μg)	–0.121	–0.025	–0.108	0.114	–0.181	–0.185

* correlation is significant at the 0.05 level (two tailed); **correlation is significant at the 0.01 level (two tailed)

–0.08 (iron) to –0.45 (vitamin B_3) for all participants, between –0.05 (iron) to –0.50 (vitamin B_6) for male participants and between 0.02 (total saturated fat) to –0.48 (vitamin B_2) for female participants.

More statistically significant correlation coefficients for age are found for male participants (9) than for female participants (6). For both genders, four nutrients showed significant negative correlations between age and 24-hour recalls: sodium, vitamin B_1, vitamin B_2 and vitamin B_6. Correlation coefficients between 24-hour recalls for energy and nutrients and age showed 9 out of possible 24 significant negative correlations for all participants when adjusted to education.

When comparing the results from Table 4 and Table 5, the number of statistically significant correlations of the daily nutrient intake estimates from the administered FFQ and mean values of the three 24-hour recalls with age is different. More statistically significant correlation coefficients with age are found for the administered FFQ especially for male participants but also for all participants, while the number of significant correlations remains the same for female participants.

Discussion

Assessment of dietary intake is an important part of the scope of work of a nutritionist/dietitian. Therefore, an appropriate questionnaire must be used for assessing dietary intake, based on the fact what the nutritionist/dietitian wants to assess in the subjects diet. Since (to our knowledge) there isn't a questionnaire to assess habitual dietary intake and quality of diet specifically in the Republic of Croatia, we developed a questionnaire and decided to validate it against mean values of three repeated 24-hour recalls in healthy adults in the Republic of Croatia.

The paper describes the validity of a developed FFQ to assess habitual dietary intake of energy and nutrients by healthy adults in the Republic of Croatia in order to estimate the quality of their diet. Validity was assessed by comparing estimate daily intakes obtained from the administered FFQ with those from three 24-hour recalls in both genders in the general population. The FFQ performed well in comparing energy and nutrient intakes for energy, total protein, total carbohydrate, total fat,

saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, dietary fiber, zinc, copper, phosphorus, sodium, retinol, vitamin B_1, vitamin B_2, vitamin B_3, vitamin C and folate estimated from mean values from three 24-hour recalls with assessments by correlations.

Validity studies of FFQs which are developed to measure habitual intake of energy and nutrients are in most cases based on repeated 24-hour recalls or weighed or household records as reference methods[13]. The correlation coefficients for intakes of all participants ranged between 0.10 and 0.47 which is insignificantly lower as observed in other validation studies[14–18] or similar[19–21]. Evaluation of energy and nutrient intakes confirmed moderate relative validity. The FFQ underperformed for calcium, iron, magnesium and potassium.

The results were adjusted according to gender but did not improve the correlation coefficients except for protein, calcium, sodium and vitamin B_6 insignificantly. When adjusted to gender, the FFQ performed well for energy, total protein, total carbohydrate, total fat, saturated fat, monounsaturated fat, cholesterol, dietary fiber, zinc, copper, sodium, retinol, vitamin B_1, vitamin B_2, vitamin B_3, vitamin C and folate.

In the study, men tended to have higher correlation coefficients overall than women and therefore a higher correlation with the mean values of the three 24-hour recalls. Similar observations were found in other validation studies and studies for food group intake[22, 23]. In general, absolute intake estimates of nutrients were higher for almost all nutrients (except vitamin B_3 and cholesterol) from the administered FFQ when compared to the mean values of the three 24-hour recalls. This could be due to the fact that on the days when the repeated 24-hour recalls were performed, some food items from the administered FFQ where not consumed[15]. Nevertheless, in most validity studies, FFQs do report a higher intake of nutrients than the reference methods[24–27].

When the results of the administered FFQ and mean values of the three 24-hour recalls were correlated with the education level, they showed that there is no significant correlation between energy and nutrient intake based on the level of education of the participants and therefore can be used to assess the habitual intake of energy and nutrients of healthy adults without taking into account their education level. Other studies evaluation the level of education on energy and nutrient intake have shown a different trend where higher education was most consistently associated with more desirable levels of nutrient intakes, lower percentage of dietary fat and higher levels of vitamin C, calcium and potassium[28].

When the results of the administered FFQ and mean values of the three 24-hour recalls were correlated with age, they showed that there is significant negative correlation between age and energy and nutrient intake. Results show that older adults (results for both genders adjusted to gender) have lower intake of energy, total protein, total carbohydrate, total fat, monounsaturated fatty acids, polyunsaturated fatty acids, iron, magnesium, phosphorus, sodium, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6 and folate. Older female participants have lower intake of monounsaturated fatty acids, polyunsaturated fatty acids, sodium, vitamin B_1, vitamin B_3 and vitamin B_6, while older male participants have lower intakes of energy, total protein, total carbohydrate, total fat, saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, iron, phosphorus, sodium, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6 and folate. A similar study has shown a different trend where for example there is no difference in energy intake within age groups, but an age-related decline was observed for calcium intake in male participants and for dietary fiber, magnesium, iron, vitamin C and vitamin B_1 for female participants[29].

The statistically significant difference is found in the estimated daily intake for almost all nutrients (except cholesterol, sodium, vitamin B_2 and vitamin B_3) between the administered FFQ and the mean values of the three repeated 24-hour recalls. The reason for numerous statistically significant differences in estimated daily intake between the two methods is most likely a systematic error, when estimating the intake of food. Consistently lower intakes of food from the 24-hour recalls in this case should not reflect the validity of the developed FFQ, since most correlations between the estimated daily intakes are positive, statistically significant and low to middle high values.

There is no perfect measurement tool[30, 31] for assessing dietary intake, but the FFQ presents an easy, low-cost and simple tool, although with limitations, but enough validity to assess the general dietary intake both in large epidemiological studies as well as for individual habitual dietary intake. The developed FFQ validated in this study has the disadvantage of being too long (30 pages) and therefore is time consuming for the participant, but based on the validity results from this study, shows that can estimate habitual intake of all macronutrients and almost all micronutrients and therefore is an excellent tool for one time administration in epidemiological and observational studies to assess the quality of diet based on habitual intake.

Conclusion

The study indicated that the developed FFQ is valid to assess the habitual intake of energy and the following nutrients in healthy adults in the Republic of Croatia: total protein, total carbohydrate, total fat, total monounsaturated fat, total polyunsaturated fat, total saturated fat, cholesterol, dietary protein, zinc, copper, phosphorus, sodium, retinol, vitamin B_1, vitamin B_2, vitamin B_3, vitamin B_6, vitamin C and folate. The FFQ is not valid to assess the habitual intake of calcium, iron, magnesium and potassium.

Since it is valid for all macronutrients and energy, the FFQ can be used in epidemiological and observational studies to assess the habitual intake of healthy adults in

the Republic of Croatia as well as to assess individual habitual intake and quality of diet of a healthy individual in the Republic of Croatia.

Further research should be targeted towards the validation of the FFQ in specific population groups (adolescents, children, elderly people) as well as population groups with specific diseases in order to make the FFQ more usable.

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RAZVOJ I VALIDACIJA UPITNIKA UČESTALOSTI KONZUMIRANJA PREHRAMBENIH NAMIRNICA ZA PROCJENU UOBIČAJENOG UNOSA I KVALITETE PREHRANE KOD ZDRAVIH ODRASLIH OSOBA U REPUBLICI HRVATSKOJ

SAŽETAK

Upitnici učestalosti namirnica (FFQ) se dizajniraju za procjenu uobičajene prehrane, ispitujući učestalost prehrambenih proizvoda ili određene skupine hrane koja se konzumira tijekom referentnog razdoblja. U ovoj studiji, razvili smo FFQ za procjenu uobičajenog unosa za procjenu kvalitete prehrane zdravih odraslih ispitanika. Proveli smo istraživanje kako bi utvrdili mogućnost razvijanja FFQ u odnosu na trodnevno 24-satno prisjećanje. Drugi cilj istraživanja bio je utvrditi povezanost između FFQ za procjenu uobičajenog unosa i trodnevnog 24-satnog prisjećanja, povezano s dobi sudionika i razinom njihova obrazovanja. FFQ korišten u našoj studiji je prilagođen na temelju upitnika Harvardske semikvantitativne frekvencije prehrane, te se sastojao od 101 prehrambenog artikla, podijeljenih u 9 skupina. Podaci o 24-satnim prisjećanjima prikupljeni su tijekom jednog tjedna (istog tjedna kad je ispunjen i FFQ),i to svakog drugog dana u tjednu (dva radnim danom i jedan dan vikenda). Oba prikupljanja podataka (FFQ i trodnevna 24-satna pri-

sjećanja su provedena na 68 zdravih zaposlenih ispitanika, 32 muškarca (u dobi od 39,73±14,02) i 36 žena (u dobi od 34,20±10,63). Rezultati su pokazali da je razvijeni FFQ valjan instrument za procjenu uobičajenog unosa energije i većine hranjivih tvari u zdravih odraslih osoba u Republici Hrvatskoj, dok su kod muškaraca pronađene više vrijednosti koeficijenata korelacije u odnosu na žene i stoga višu povezanost FFQ sa 24-satnim prisjećanjima. Statistički značajne korelacije nisu pronađene između unosa energije i hrane, ovisno o razini obrazovanja sudionika.