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Validation of a food-frequency questionnaire for Flemish and Italian-native subjects in Belgium: The IMMIDIET study

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A B S T R A C T

Objective: To validate an integrated food-frequency questionnaire (FFQ) developed to assess habitual food intake of Flemish and Italian-native subjects in Belgium as part of the European Collaborative Dietary Habit Profile in European Communities With Different Risk of Myocardial Infarction: the Impact of Migration as a Model of Gene/Environment Interaction (IMMIDIET Project).
Methods: The semiquantitative FFQ contained 322 items on food and food preparation. FFQs filled by a sample ($n = 70$) of the Flemish-Flemish and Flemish-Italian IMMIDIET subpopulations were randomly selected. Five 24-h recalls, administered over a period of 1 y by the same sample, served for validation. Energy and macronutrients were calculated using the Dutch NEVO and the Belgian NUBEL food composition tables. Intakes of energy and macronutrients estimated by the FFQ and repeated 24-h recall, respectively, were compared by means of correlation coefficients, classification into quartiles, and Bland-Altman plotting.
Results: The FFQ overestimated intake of energy and most macronutrients by 40–70%. This overestimation largely disappeared when values were expressed as energy percentage. Correlations ranked from 0.40 to 0.60 for energy and most macronutrients (median 0.53); correlations were lower (null to 0.41) for fat and higher (up to 0.90) for alcohol. Classification in quartiles of intake showed good agreement: 83% were classified in the same or adjacent quartile of energy, and 66–90% for macronutrients. Correlations and classification of macronutrient intake into quartiles remained similar when macronutrients were expressed as energy percentage. Stratification according to ethnic subgroup, age, body mass index, or social status showed no differences.
Conclusion: The IMMIDIET FFQ is a valuable tool for studies of the role of energy and macronutrients in disease etiology or outcome, but less suitable for estimating absolute intake levels.

Introduction

The occurrence of myocardial infarction and other cardiovascular diseases shows an unequal distribution over the countries in the European region. In the past, age-standardized incidence rates of myocardial infarction were markedly lower in Mediterranean than in Northern European countries for men and

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women. According to data from the World Health Organization multinational monitoring of trends and determinants in cardiovascular disease (MONICA) project, such rates were about three times higher in the United Kingdom and about two times higher in Belgium compared with the Italian population [1,2]. Traditionally, in preventive cardiology emphasis has been put on environmental risk factors, including nutritional habits.

European populations vary not only with regard to the occurrence of diseases but also with regard to their dietary habits. The relatively low rate of myocardial infarction in the Mediterranean regions of Europe has evoked interest in the potential protective role of the so-called Mediterranean diet [3–5]. "The dietary pattern of people living in Southern Italy in the 1960s" may be considered an operational definition of this Mediterranean diet, which used to be quite different from the dietary profile in northern parts of Europe.

To further investigate the role of diet, genetic determinants, and their mutual interactions, the Dietary Habit Profile in European Communities With Different Risk of Myocardial Infarction: the Impact of Migration as a Model of Gene/Environment Interaction (IMMIDIET Project) was conducted within the context of the European Commission's Fifth Framework Program (theme: quality of life and management of living resources; key action 1: health, food, and nutrition) [6,7]. The general aims of the IMMIDIET Project, a cross-sectional survey in which eight centers from five different countries participated, were to evaluate the present dietary habits and risk profiles of three European communities at different risk of myocardial infarction and to analyze the impact of migration on risk factors and metabolic risk profile for myocardial infarction.

The historical Italian migration to the Belgium coal-mining area and the subsequent integration of these immigrants through mixed marriage were applied as a model to evaluate gene-by-environment interaction. To realize the study objectives and to answer the related study questions, three different population samples of about 270 married native couples were recruited for data collection, i.e., from Italy (southern part: Abruzzo region), the United Kingdom (Southeast London: boroughs of Merton and Sutton), and Belgium (Flemish part: six former coal-mining municipalities). Recruitment was performed on a random base, by local general practitioners. In addition, a fourth population sample of mixed Belgian-Italian (BI) couples was recruited from the same region as the sample of native Belgian-Belgian (BB) couples. Survey data were collected by means of a general questionnaire (age, gender family history, socioeconomic status indicators, smoking, alcohol consumption, and various other risk factors), a food-frequency questionnaire (FFQ; habitual consumption of nutrients and food groups), anthropometry, and genetic polymorphisms. The food consumption part of the survey yielded valid data for 541, 556, 539, and 410 subjects from the four studied populations, respectively.

To measure food and nutrient intake in the Italian and British population samples of the IMMIDIET Project, existing semi-quantitative FFQs were used, which had been previously developed and validated as part of the European Prospective Investigation into Cancer and Nutrition (EPIC) study. Because no validated FFQ was available for the Flemish-speaking part of Belgium, and the Dutch EPIC FFQ was considered unsuitable because of insufficient coverage of Belgian dietary habits, we decided to develop and validate a new, integrated FFQ to cover the food habits of BB and mixed BI couples participating in the IMMIDIET Project. In the present report, we describe the comparative validity of this Belgian "multicultural" FFQ, using repeated 24-h recalls as the reference method.

Materials and methods

Study population and recruitment

The BB and BI participants of the IMMIDIET study population were recruited through a network of general practitioners as married couples from six former coal-mining municipalities in the Belgian province of Limburg. The study subjects were recruited by means of a two-stage sampling procedure. First, all general practitioners in the six ex–coal-mining municipalities were informed about the IMMIDIET Project. Second, those who showed interest and were willing to collaborate eventually were asked to invite a random selection of eligible couples to participate. In total 104 practices spread over the recruitment area were informed about the project. General practitioners of 61 of these practices contributed to the recruitment of the BB and mixed BI couples.

Inclusion criteria for the BB subpopulation of IMMIDIET were an age from 30 to 60 y, born and living in Limburg, married to a Belgian partner from Limburg, and all four grandparents born in the same region (Limburg). Inclusion criteria for the BI subpopulation of IMMIDIET were an age from 30 to 60 y; living in Limburg; the Italian partner born in Belgium from Italian parents, both of whom migrated from Southern Italy to Belgium, and belonging to the first or second generation after migration; and the Belgian partner with family living in Limburg for at least two generations. Subjects were excluded from IMMIDIET in case of specific cardiovascular antecedents (acute myocardial infarction, stable/unstable angina pectoris, stroke, transient ischemic attack, peripheral arterial disease), diabetes mellitus, familial hypercholesterolemia, malignancies, liver or renal failure, coagulation deficiency, hypo- or hyperthyroidism, and epilepsy. It was estimated beforehand that a sample of 70 subjects would be sufficient to allow the assessment of the validity of the new Belgian IMMIDIET FFQ with sufficient power. Therefore, a random subsample of 35 BB and 35 BI couples from the IMMIDIET participants were asked to participate in the present validation study. Because the study design of the IMMIDIET Project was based on selection of couples and not individuals, couples instead of individuals were invited. Participants who had already filled out the FFQ were invited by telephone to also participate in the present validation study.

Study design

The FFQ was distributed to the participants by the general practitioners during a visit scheduled as part of the IMMIDIET Project. The participants completed the FFQ at home. Within 1 wk, a home visit was scheduled by a trained dietitian to collect the FFQ; during this visit, the dietitian checked the FFQ for completeness and ambiguous answers.

Five 24-h dietary recalls served for validation. Because the FFQ was based on establishing habitual intake over the previous year, these five 24-h recalls were evenly spread over the year to cover every season. To achieve an even distribution of weekdays, each participant was visited five times on different weekdays (Monday through Friday). Visits on a Monday recalled a 48-h period.

Food-frequency questionnaire

Composition of FFQ

Because no published, well-documented, and validated FFQ for the Flemish part of Belgium was identified, and because none of the existing Dutch FFQs, developed for use in The Netherlands, was believed to sufficiently reflect the typically Flemish-Belgian food consumption habits, a new FFQ had to be developed from scratch. Initially a list of apparently relevant food items, organized by food group ($\approx$25 different categories), was designed by one of the members of the project team (D. L., a senior dietitian and lecturer in nutrition with profound knowledge of Belgian food-consumption patterns). Aided by the contents of existing Belgian food composition tables [8–10], the selection of the food items was primarily based on their contribution to (the variation in) the intake of energy and nutrients by the Belgian population. The original list of food items was refined through a number of consecutive steps including consensus meetings (D. L., M. v. D., N. W., W. A.). Eventually, the final draft version of the Belgian FFQ was subjected to a limited validation study: the questionnaire was filled out by 54 subjects who were representative of the IMMIDIET study population. The collected data were compared with the outcomes of a dietary history interview (including a cross-check), taken by a small team of experienced dietitians (C. D., W. A., M. C.), to verify the answers to the frequency part of the FFQ and especially to identify any missing food items. During a consensus meeting with the team of dietitians, all redundancies, irregularities, and difficulties observed in filling out the FFQ were reviewed, and several minor amendments to the draft FFQ were made.

The final FFQ was aimed at assessing the subjects' habitual intake over the previous year. Frequencies of consumption were recorded on a nine-level scale: never/rarely; 1–3 d/mo; and 1, 2, 3, 4, 5, 6, and 7 d/wk. For specific subcategories of foods (e.g., When you use milk, how often do you use full-cream milk?), five categories were recorded: (almost) never, sometimes, half the time, most times, and (almost) always. The 322-item FFQ comprised the following food groups (number of items per group): bread (17 items), bread spreads including butter/margarine on bread (23 items), cereals (3 items), dairy products (21 items), soup (2 items), meat/game/poultry (14 items), fish/shellfish/crustacean (9 items), vegetarian (5 items), cooked vegetables (21 items), raw vegetables (10 items), legumes (4 items), potatoes (6 items), rice/pasta/pasta dishes (14 items), cooking fat/oil (10 items), sauces (14 items), egg/egg dishes (5 items), fruit (fresh, tinned, dried) (32 items), nuts (5 items), coffee/tea (9 items), milk in coffee/tea (9 items), sugar/honey (10 items), alcoholic beverages (10 items), non-alcoholic beverages (12 items), miscellaneous (33 items), preparation (14 items), and food supplements (10 items). For both partners of the BI couples participating in the IMMIDIET Project, the FFQ was supplemented with 18 items covering the consumption of typically Italian oil, cheese, and vegetables.

Processing of FFQ

Quantities of the FFQ items were recorded as absolute weights or as household measurements. A booklet with photographs was compiled and shown to the participants to estimate small, average, and large portions for spreads, bread spreads, and milk in coffee and tea. Household measurements were determined using Dutch [11] or Belgian [10] coding manuals, and dietary composition of all FFQ items (expressed per 100 g) was constructed. If questions contained multiple food products, an average value was used, e.g., the nutritional value of lean fish contained an average nutritional value of cod, pollack, plaice, sole, etc. Because of incompleteness (foods, nutrients) of the Flemish-Belgian NUBEL food composition table [9], the Dutch NEVO food composition table [8] was used for most FFQ items because the latter was considered the qualitatively best available table representative for Dutch-Belgian foods. Only for typically Belgian FFQ items ($n = 61$) was the Flemish-Belgian NUBEL food composition table [9] used instead. Energy and nutrient content of a single food was always taken from one food composition table.

24-h Dietary recall

The 24-h dietary recalls were executed in face-to-face interviews by predominantly one dietitian (W. A.). Home visits were planned at the convenience of the participants. Non-structured sheets were used by the dietitian to record the dietary data of the 24 h preceding the interview (or 48 h in case of a weekend recall). In addition, a checklist for several food groups was used to prompt the participants at the end of the interview. Dietary data were noted as detailed as possible, i.e., product name and brand, recipes, weight of portion eaten, and wastage. A scale was used to determine household measurements and weight of homemade foods. If necessary, the composition of processed and packed food items or meals was recorded.

The 24-h recalls were coded using the identical food composition tables [8,9] and coding manuals [10,11] as described for the FFQ. Nutritional values of specific brands were used if sufficient nutrient data were available (mostly obtained from food packets/containers or the Internet); if not, the composition of a comparable food product was taken. Standard recipes were used if the composition of mixed foods or meals was unspecified. All coding procedures were registered and standardized.

Statistical analysis

The FFQs were read by an optical mark reader and processed by the data entry service of Maastricht University (MEMIC Department; Maastricht, The Netherlands). Frequencies of the food items were coded as number of times per week; food items eaten less than once per month were coded as 0, and items eaten one to three times per month were coded as 0.5. Subsequently, the FFQ dataset and related food composition table were transferred to the Nutritional Epidemiology Unit of the Italian National Cancer Institute, Milan, Italy, and used to adapt the software package NAF (Nutrition Analysis of Food Frequency Questionnaires, National Cancer Institute, Milan, Italy), a generic tool previously developed to convert any FFQ data into frequencies of intake and average daily quantities of energy, nutrients, and food groups consumed. Statistical analysis of repeated 24-h dietary recall data was performed at Maastricht University (Department of Epidemiology). For each participant, the mean energy and nutrient intake of the five 24-h dietary recalls was calculated and used for further calculations. Population means ± standard deviations of intake of energy and macronutrients, based on the FFQ and the mean of five 24-h recalls, were calculated separately for men and women. To compare the FFQ and the mean of five 24-h recalls in terms of absolute intake and intake expressed as energy percent, intake ratios (FFQ/24-h recall) and Pearson's correlation coefficients were calculated. To compare classification by the FFQ and the mean of five 24-h dietary recalls, quartiles of intake were defined and the proportion of subjects classified in the same quartile, an adjacent quartile, and two and three quartiles apart by both methods were calculated. To compare the difference between FFQ and repeated 24-h recall as a function of intake, Bland-Altman analysis was performed for energy intake. For analyses by age group, median age (47 y) was used as a cutoff level for younger and older participants. $P < 0.05$ indicated statistical significance.

Results

Study participants

All subjects participating in the present validation study were also participants of the IMMIDIET Project. Table 1 presents some major characteristics of the study population of the validation study. Equal numbers of men and women participated in the study. The mean age was 46.9 y (range 25–74), and the mean body mass index (BMI) was 26.2 kg/m^2. Most study participants (61%) had received 6–12 y of formal education. Based on these characteristics, the subsample selected for the validation study was considered representative for the entire BB and BI IMMIDIET study populations (data not shown).

Intake levels measured by FFQ compared with repeated dietary recall

In men, mean energy intakes amounted to 3462 kcal based on the FFQ and 2495 kcal based on repeated dietary recall (ratio FFQ/dietary recall 1.42). In women, energy intakes were 2654 kcal based on the FFQ and 1756 kcal based on repeated dietary recall (ratio 1.55). Compared with repeated dietary recall, the FFQ overestimated intake of energy and most macronutrients, with intake ratios as measured by the FFQ compared with dietary recall ranging from 1.09 (men)/1.41 (women) for alcohol to 1.78/1.91 for saturated fat. For water, the intake ratio FFQ/recall was 1.39 (men)/1.50 (women).

When intake of macronutrients was expressed as a percentage of total energy intake, the overestimation by the FFQ compared with dietary recall generally disappeared (Table 2), with ratios from 0.77 (men)/0.93 (women) for alcohol to 1.24/1.20 for saturated fat. Similarly, when intake of specific types of fat (e.g., saturated) was expressed as a percentage of total fat intake (Table 3), intake FFQ/recall ratios were close to 1, indicating that the FFQ accurately estimated dietary fat composition.

Ranking of subjects

The median Pearson's correlation between absolute intake as measured by the FFQ and repeated dietary recall for energy and all macronutrients was 0.53. Except for fat, correlations between the two methods ranged from 0.34 (men)/0.42 (women) for

Table 1
Characteristics of study population ($n = 70$)*

Sex	
Male	35 (50%)
Female	35 (50%)
Age (y)	
Mean ± SD	46.9 ± 9.4
Range	25–74
Body mass index (kg/m^2)	
Mean ± SD	26.2 ± 3.8
≤25	24 (34%)
>25	46 (66%)
Duration of formal education (y)	
≤5	11 (16%)
6–12	43 (61%)
≥13	16 (23%)

* Values are presented as number of subjects (percentage) or mean ± SD.

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Table 2
Intake of energy and macronutrients based on FFQ versus repeated 24-h dietary recall ($n = 70$)

Nutrient	Gender	FFQ		Repeated dietary recall		FFQ/recall ratio		Correlation of FFQ versus recall (Pearson's r)	
		Mean	SD	Mean	SD	Mean	SD	r	P
Energy (kcal)	male	3462	1076	2495	653	1.42	0.34	0.53	0.001
	female	2654	730	1755	402	1.55	0.42	0.47	0.005
Protein (g)	male	141	39	96	31	1.53	0.40	0.55	0.001
	female	109	27	71	17	1.59	0.41	0.42	0.013
Fat (g)	male	146	54	93	28	1.65	0.57	0.26	0.129
	female	116	44	70	21	1.75	0.73	0.29	0.093
Saturated fat (g)	male	56	22	33	9	1.78	0.63	0.21	0.232
	female	46	19	25	8	1.91	0.83	0.34	0.050
Monounsaturated fatty acids (g)	male	50	18	33	11	1.60	0.60	0.29	0.087
	female	39	14	24	7	1.71	0.69	0.34	0.046
Polyunsaturated fatty acids (g)	male	29	12	19	7	1.69	0.81	0.41	0.015
	female	22	10	14	6	1.81	1.00	0.04	0.821
Linoleic acid (g)	male	23	10	15	7	1.63	0.84	0.40	0.017
	female	17	7	11	5	1.73	0.99	−0.02	0.896
Cholesterol (mg)	male	446	209	259	81	1.84	0.81	0.29	0.089
	female	341	144	199	66	1.77	0.60	0.59	0.000
Carbohydrates (g)	male	367	132	283	91	1.32	0.31	0.76	0.000
	female	284	74	200	48	1.45	0.33	0.63	0.000
Mono- and disaccharides (g)	male	161	79	117	52	1.43	0.42	0.77	0.000
	female	124	41	86	26	1.50	0.43	0.60	0.000
Polysaccharides (g)	male	205	65	165	47	1.28	0.34	0.63	0.000
	female	159	45	114	29	1.43	0.44	0.52	0.000
Fiber (g)	male	35	11	22	7	1.62	0.39	0.76	0.000
	female	29	8	17	5	1.72	0.38	0.67	0.000
Alcohol (g)	male	17	19	20	24	1.09	0.90	0.90	0.000
	female	5	9	6	10	1.41	2.10	0.83	0.000
Water (g)	male	3311	821	2431	641	1.39	0.30	0.66	0.000
	female	3016	980	2117	715	1.50	0.49	0.58	0.000
Protein (en%)	male	16.6	2.9	15.5	3.4	1.09	0.18	0.61	0.000
	female	16.8	3.0	16.3	2.4	1.05	0.17	0.46	0.000
Fat (en%)	male	37.6	3.8	33.7	5.3	1.14	0.20	0.21	0.218
	female	38.7	5.5	35.7	4.6	1.10	0.19	0.23	0.185
Saturated fat (en%)	male	14.4	2.6	11.9	2.1	1.24	0.27	0.37	0.028
	female	15.2	3.2	13.0	2.3	1.20	0.26	0.41	0.014
Carbohydrates (en%)	male	42.0	5.0	45.3	7.3	0.94	0.14	0.49	0.003
	female	43.2	5.1	45.6	5.0	0.95	0.13	0.28	0.101
Alcohol (en%)	male	3.8	4.5	5.4	6.1	0.77	0.53	0.92	0.000
	female	1.4	2.1	2.4	3.8	0.93	1.36	0.84	0.000

FFQ, food-frequency questionnaire

energy to 0.90/0.83 for alcohol (Table 2), and most correlations were 0.40 to 0.60. For fat and saturated and unsaturated fatty acids, correlations were considerably lower, especially for polyunsaturated fatty acids and linoleic acid in women. When intake was expressed as energy percentage, correlations increased for protein and saturated fat; however, for total fat correlations remained similar, and for carbohydrate correlations showed a marked attenuation when expressed as energy percentage.

Table 4 presents the agreement between FFQ and repeated dietary recall in classifying energy and macronutrient intake into quartiles. For energy, in men and women, 83% of subjects were classified in the same or adjacent quartile of intake. For absolute intake of macronutrients, these figures ranged from 66% (men)/71% (women) for saturated fat to 80–90% for protein, carbohydrates, mono- and disaccharides, polysaccharides, fiber, and alcohol. The classification of macronutrient intake into quartiles remained similar when macronutrients were expressed as energy percentage.

Bland-Altman analysis

To check for individual differences in over-reporting, we made scatterplots of individual values of the difference between FFQ and repeated dietary recall, expressed as a function of absolute intake level (i.e., mean of FFQ and repeated dietary recall). This Bland-Altman analysis for energy intake is shown in Figure 1. Compared with the dietary recall, the FFQ tended to over-report energy intake by 933 kcal, with a range of ±1500 kcal between subjects. The observed limits of agreement are quite strongly influenced by a few outliers. Although the Bland-Altman analysis suggested that the degree of over-reporting was positively related to absolute energy intake (regression line: $y = -391.37 + 0.51$ x (set tight to 0.51) [95% confidence interval of regression coefficient: 0.29–0.74]), this relation disappeared

Table 3
Composition of dietary fat estimated by FFQ versus repeated 24-h dietary recall

Subjects	Fat (%)	FFQ		24-h recall		FFQ/24-h recall ratio	
		Mean	SD	Mean	SD	Mean	SD
Men ($n = 35$)	saturated	38.1	4.8	35.3	4.0	1.08	0.13
	monounsaturated	34.4	3.4	35.6	3.8	0.97	0.12
	polyunsaturated	20.0	3.5	20.1	3.4	1.02	0.19
	total	92.5	1.0	91.0	2.2	1.02	0.03
Women ($n = 35$)	saturated	39.3	5.1	36.3	4.7	1.09	0.17
	monounsaturated	34.1	2.9	34.7	3.6	0.99	0.13
	polyunsaturated	19.0	4.5	19.5	4.5	1.02	0.30
	total	92.5	0.7	90.6	2.5	1.02	0.03

FFQ, food-frequency questionnaire

Table 4
Percentage of subjects classified into quartiles of nutrient intake: comparison of food-frequency questionnaire versus repeated 24-h dietary recall ($n = 70$)

Nutrient	Gender	In same quartile	In adjacent quartile	In same or adjacent quartile	2 quartiles apart	3 quartiles apart
Energy (kcal)	male	46	37	83	14	3
	female	43	40	83	17	0
Protein (g)	male	34	46	80	20	0
	female	34	46	80	20	0
Fat (g)	male	40	34	74	20	6
	female	34	37	71	20	9
Saturated fat (g)	male	37	29	66	29	6
	female	26	45	71	23	6
Monounsaturated fatty acids (g)	male	34	40	74	20	6
	female	40	34	74	20	6
Polyunsaturated fatty acids (g)	male	37	46	83	11	6
	female	31	38	69	23	9
Linoleic acid (g)	male	46	34	80	14	6
	female	26	43	69	23	9
Cholesterol (mg)	male	17	46	63	26	11
	female	37	52	89	11	0
Carbohydrates (g)	male	54	35	89	9	3
	female	46	48	94	6	0
Mono- and disaccharides (g)	male	54	34	89	6	6
	female	51	40	91	9	0
Polysaccharides (g)	male	40	46	86	14	0
	female	51	38	89	9	3
Fiber (g)	male	57	32	89	9	3
	female	54	35	89	11	0
Alcohol (g)	male	63	34	97	9	0
	female	51	49	100	0	0
Water (g)	male	51	32	83	14	3
	female	40	43	83	14	3
Protein (en%)	male	46	37	83	11	6
	female	37	43	80	14	6
Fat (en%)	male	23	48	71	23	6
	female	37	20	57	37	6
Saturated fat (en%)	male	51	32	83	9	9
	female	43	37	80	14	6
Carbohydrates (en%)	male	40	34	74	17	9
	female	29	45	74	17	9
Alcohol (en%)	male	63	34	97	0	3
	female	46	48	94	6	0

when the difference between FFQ and repeated dietary recall was plotted as a function of dietary recall (instead of the mean of FFQ + recall; regression line: $y = 1062.37 - 0.06$ x (set tight to 0.06) [95% confidence interval of regression coefficient: −0.35 to 0.23]). This indicates that the apparent relation was mainly due to strong overestimation of intake on the FFQ by some subjects (Figs. 1 and 2).

FFQ performance after stratification for ethnic background, age, BMI, and social status

Ethnic background

Separate analyses of intake levels for men and women, stratified by ethnic background (subjects from BB versus mixed BI couples), showed that the overestimation of intake by the FFQ compared with repeated dietary recall was similar in BB and BI subjects for most nutrients, except for an ≈15–25% larger overestimation in BI women for energy and most nutrients except mono- and disaccharides; when expressed as energy percentage, these differences generally disappeared. Correlations between nutrient intake, as estimated by the FFQ and dietary recall, were similar in BB versus BI participants for most nutrients, except for lower correlations (from −0.19 to 0.30, in contrast to correlations >0.40 for other subgroups) in BB women for protein (grams), in BI women for protein (energy percentage) and linoleic acid, and in BB and BI women for fat (grams and energy percentage), saturated fat (grams and energy percentage), monounsaturated fatty acid (grams), and polyunsaturated fatty acid (grams). Classification of subjects into quartiles according to intake (i.e., subjects in the same or adjacent quartile) showed similar values in BB and BI subjects, except for lower values in BB women for fat expressed as energy percentage (47% in same or adjacent quartile versus ≈65% in other three strata).

Age

Stratified analyses of intake levels by age (>48 versus ≤47 y) showed no systematic differences in intake levels except a tendency for larger overestimation (by ≈10–20%) for total fat (grams), polyunsaturated fatty acid (grams), linoleic acid (grams), cholesterol (grams), and carbohydrates (grams) in women ≤47 y and for water (grams) and alcohol (grams; 70% versus −10% to 30%) in women >48 y. Correlations by age group (≤47 versus >48 y) showed no differences except for low correlations in older men for fat (grams), saturated fat (grams), and monounsaturated fatty acid (grams) and in BB women for fat (energy percentage). Stratified analysis of quartiles (same or adjacent quartile) by age showed no effect of age.

Body mass index

Stratified analysis of intake levels by BMI (overweight, i.e., >25 kg/m^2, versus normal, i.e., ≤25 kg/m^2) showed no systematic differences between overweight and normal-weight subjects,

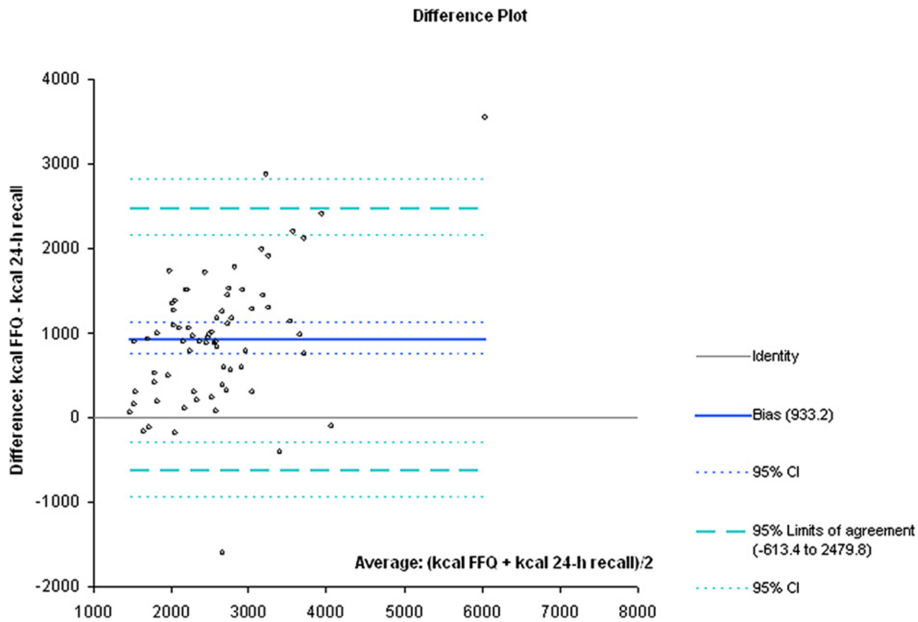

Fig. 1. Bland-Altman analysis comparing energy intake based on the FFQ with repeated 24-h dietary recall ($n = 70$). Values show the difference (FFQ − recall) in energy intake as a function of mean energy intake ([FFQ + recall]/2). CI, confidence interval; FFQ, food-frequency questionnaire.

except for, in overweight women, a somewhat larger overestimation (by ≈10%) of fat, saturated fat, and polyunsaturated fatty acid intakes and a strong overestimation for alcohol (+130% versus −30% as the mean for the other three strata). Correlations in overweight and normal-weight subjects were similar except for a low correlation ($r = -0.08$) for cholesterol in normal-weight men. Stratified analysis of quartiles by BMI showed similar values in overweight versus normal-weight subjects, except for a lower agreement between the FFQ and 24-h recall for cholesterol in men with a BMI ≤25 kg/m^2 (44% in same or adjacent quartile versus ≈75% in other three strata).

Social status

Stratified analysis of intake levels and correlations by social status showed no major differences, except for a low correlation ($r = -0.34$) for cholesterol in subjects of low social status. Stratified analysis of quartiles by social status also showed similar values in subjects with high and low social status, except for lower agreement in women of high social status for fat (energy percentage: 45% in same or adjacent quartile versus ≈75% in other three strata).

Discussion

In this study, the validity of a new multicultural FFQ, covering food habits of BB and mixed BI couples participating in the IMMIDIET Project, was compared with mean intake from five repeated 24-hour recalls as the reference. The underlying principle of the FFQ approach is that an average long-term diet is the conceptually important exposure rather than intake on a few specific days [12]. Therefore, precise intake measurements obtainable during 1 d or a few days are sacrificed for more crude information relating to an extended period. The FFQ typically uses generic memory, a concept supported by cognitive research, and consists of a list of food items and a response section for frequencies and eaten portions [12].

Results of the validation study showed that the IMMIDIET FFQ overestimated absolute energy intake by 42% compared with repeated dietary recall; for macronutrients, overestimation ranged from 9% (for alcohol in men) to 91% (for saturated fat in women). The large overestimation (9–91%) of absolute intake levels of energy and macronutrients by the IMMIDIET FFQ is a well-known phenomenon [12], which may increase with increasing length of the FFQ. Results stratified for ethnic background showed that women from mixed BI couples were characterized by a ≈15–25% larger overestimation of intake compared with BB couples for energy and most macronutrients. No systematic effect of age, BMI, or social status on the degree of over-reporting was observed.

When intake was expressed as energy percentage, there was good agreement in intake levels between the FFQ and 24-h recall, corroborating the notion that FFQs generally perform better if macronutrient intake is expressed as energy percentage [2].

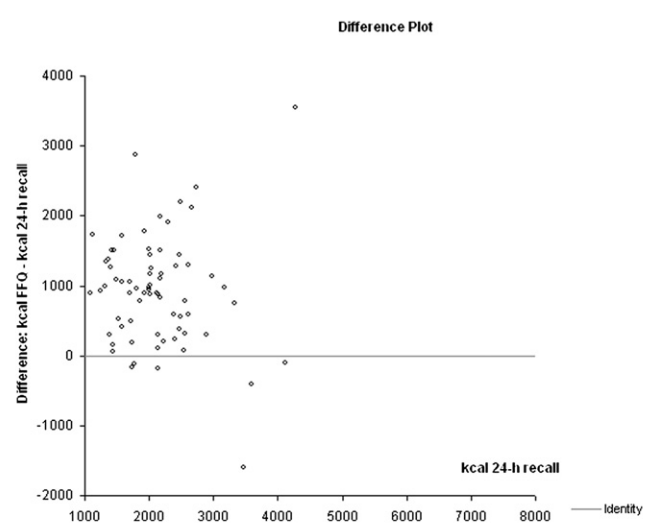

Fig. 2. Analysis comparing energy intake based on the FFQ with repeated 24-h dietary recall ($n = 70$). Values show the difference (FFQ − recall) in energy intake as a function of energy intake according to the reference method (recall). FFQ, food-frequency questionnaire.

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Similarly, our FFQ was able to accurately estimate dietary fat composition when intake of subtypes of fat (e.g., saturated) was expressed as percentage of total fat intake.

Correlations of intake of energy and macronutrients as assessed by the FFQ and dietary recall were moderate for energy (0.34 men/0.42 women) and for macronutrients (0.40–0.60), with a median correlation for energy and macronutrients of 0.53 between the two methods. Relatively low correlations (−0.02 to 0.41) were found for total fat and subtypes of fat. These findings were hard to explain and can be considered a serious limitation. Relatively high correlations (up to 0.90) were found for alcohol. Correlations between FFQs and reference methods of dietary assessment have been reported to improve when adjusted for energy intake, similar to absolute intake levels [2,13]. However, in our study, this de-attenuation of correlations was only confirmed for protein and saturated fat, but not for total fat or carbohydrates. Theoretically, the relatively low correlations could partly be due to limitations of our reference method, because Molag et al. [14] showed that correlations were higher for studies comparing FFQs with a reference method of 8–14 dietary recall/record days compared with 1–7 d. Subar et al. [2] performed an extensive validation study including the 126-item Willett FFQ [15], the 106-item Block [16], and a new diet history questionnaire developed by the National Cancer Institute. These investigators, using four dietary recalls over a 1-y period as a reference, found unadjusted correlations of 0.25 (men)/0.30 (women) for the Willett FFQ compared with correlations of 0.53/0.53 for the Block FFQ and 0.52/0.55 for the diet history questionnaire. Energy adjustment improved all correlations to 0.55–0.65, an observation not confirmed in our study. This would suggest that our low correlations of energy-adjusted fat intake are probably not, or at least not only, due to a limited number of days of the dietary recall.

It may be noted that, for the application of a FFQ in etiologic or prognostic epidemiologic studies, correct classification of subjects in quantiles is far more relevant than the absolute values of correlations [17]. Classification by quartiles of intake in our study showed good to excellent agreement between the IMMIDIET FFQ and repeated dietary recall: for energy, 83% of the subjects were classified in the same or adjacent quartile, and for macronutrients, 66–90%. This agreement remained when subjects were stratified according to ethnic background, age, BMI, or social status. Of note, the FFQ performed slightly better in classifying subjects into quartiles for absolute fat and carbohydrate intake than when expressed as energy percentage.

To our knowledge, the Belgian IMMIDIET FFQ is the first in Europe aiming to cover the dietary habits of different ethnic groups within a single FFQ. George et al. [18] validated a FFQ for young adult college women and low-income women (i.e., mixed population of white non-Hispanics, Hispanics, and African Americans) in the southwestern United States. Results showed de-attenuated mean Pearson's correlations of 0.42 in college women and 0.45 in low-income women; 76% and 79% of subjects, respectively, were classified into the correct quartile.

Our study has several limitations. Due to time constraints in the collaborative European IMMIDIET Project, there was no opportunity to obtain an initial dietary recall/record dataset as a basis for item reduction. This resulted in a relatively long FFQ (322 items), which may have contributed to the overestimation of absolute intake levels [12]. Although a longer FFQ could have contributed to non-response, Subar et al. [19] reported that response rates and percentage of missing or uninterpretable responses were comparable in longer and shorter FFQ versions and concluded that clarity and ease of administration may compensate for questionnaire length. In our case, response of the FFQ was excellent, showing good feasibility.

Other limitations of our study are the relatively small validation sample ($n = 70$) and the limited span of 5 d for the repeated dietary recall. Molag et al. [14] reported that correlations generally increase with increasing number of days of recalling/recording dietary intake (8–14 d better than 1–7 d). Cade et al. [17] reviewed the validation and use of FFQs for different study designs. They concluded that 14–28 d are required to properly describe an individual's diet and that the validity of the reference method, and thereby the apparent validity of the FFQ, is increased by a longer period of the reference dietary recall/record. A thorough comparative analysis of dietary assessment methods is presented elsewhere [20].

We were also limited with regard to food composition data, because the Belgian NUBEL food composition table [9] is incomplete with regard to a number of foods and nutrients. For this reason, we used the Dutch NEVO food composition table [8] for the large majority of foods. For the purpose of the present validation study, the identical food database was used for intake calculations of the FFQ and dietary recalls. However, if the nutrient composition of the used food database is less representative for Belgian foods, this could be a limitation in studies in which diet is linked to disease etiology or prognosis. For this reason, we used the Belgian NUBEL food composition table [9] for typically Belgian foods. A final limitation of the present study is that the IMMIDIET FFQ has not been validated for micronutrients, because this was not within the scope of the IMMIDIET Project.

Conclusion

The IMMIDIET FFQ is a useful instrument to assess dietary habits in the Flemish part of Belgium. Based on the good performance of this FFQ in attributing subjects to their quartile of intake of energy and macronutrients, this FFQ is valuable for studies of the role of energy and macronutrients in disease etiology or outcome. However, as a commonly reported limitation of FFQs, the IMMIDIET FFQ is less suitable for estimating individual intake levels due to the inherent overestimation of absolute intake levels.

References

[1] Tunstall-Pedoe H, Kuulasmaa K, Mahonen M, Tolonen H, Ruokokoski E, Amouyel P. Contribution of trends in survival and coronary-event rates to changes in coronary heart disease mortality: 10-year results from 37 WHO MONICA project populations. Monitoring trends and determinants in cardiovascular disease. Lancet 1999;353:1547–57.

[2] Subar AF, Thompson FE, Kipnis V, Midthune D, Hurwitz P, McNutt S, et al. Comparative validation of the Block, Willett, and National Cancer Institute food frequency questionnaires: the Eating at America's Table Study. Am J Epidemiol 2001;154:1089–99.

[3] Trichopoulou A. Mediterranean diet: the past and the present. Nutr Metab Cardiovasc Dis 2001;11:1–4.

[4] Kushi LH, Lenart EB, Willett WC. Health implications of Mediterranean diets in light of contemporary knowledge. 1. Plant foods and dairy products. Am J Clin Nutr 1995;61. 1407S–15.

[5] Kushi LH, Lenart EB, Willett WC. Health implications of Mediterranean diets in light of contemporary knowledge. 2. Meat, wine, fats, and oils. Am J Clin Nutr 1995;61. 1416S–27.

[6] Anonymous. Dietary habit profile in European communities with different risk of myocardial infarction: the impact of migration as a model of gene–environment interaction. The IMMIDIET Study. Research proposal (QLRT-2000–00100). European Collaborative Group of the IMMIDIET Project. Santa Maria Imbaro, Chieti, Abruzzo, Italy: Consorzio Mario Negri Sud, Angela Valenti Laboratory of Genetic and Environmental Risk Factors for Thrombotic Disease; 2000.

[7] Iacoviello L, Arnout J, Buntinx F, Cappuccio FP, Dagnelie PC, de Lorgeril M, et al. Dietary habit profile in European communities with different risk of

myocardial infarction: the impact of migration as a model of gene–environment interaction. The IMMIDIET Study. Nutr Metab Cardiovasc Dis 2001;11:122–6.
[8] Stichting NEVO. NEVO-tabel: Nederlands Voedingsstoffenbestand 2001 (NEVO: Dutch food database 2001). Den Haag: Voedingscentrum; 2001.
[9] Seeuws C, et al. Belgische Voedingsmiddelentabel (Belgian food composition table) (ed 3). Brussels: NUBEL v.z.w. (Nutriënten België); 1999.
[10] Bellemans M, De Maeijer M. Maten en gewichten. Handleiding voor gestandaardiseerde kwantificering van voedingsmiddelen in België (Measures and weights. Manual for standardised quantification of foods in Belgium) (ed 3). Brussels: Hoge Gezondheidsraad; 2001.
[11] Donders-Engelen MR, Van der Heijden L, Hulshof KFAM. Maten, gewichten en codenummers 1997 (Measures, weights and coding numbers 1997). Wageningen, The Netherlands: Department of Human Nutrition and Epidemiology, Wageningen University; 1997.
[12] Willett W, Food-frequency methods. Nutritional epidemiology (ed 2). New York: Oxford University Press; 1998. p. 74–100.
[13] Willett W. Invited commentary: a further look at dietary questionnaire validation. Am J Epidemiol 2001;154:1100–2.
[14] Molag ML, de Vries JH, Ocké MC, Dagnelie PC, van den Brandt PA, Jansen MC, et al. Design characteristics of food frequency questionnaires in relation to their validity. Am J Epidemiol 2007;166:1468–78.
[15] Willett WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J, et al. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol 1985;122:51–65.
[16] Block G, Thompson FE, Hartman AM, Larkin FA, Guire KE. Comparison of two dietary questionnaires validated against multiple dietary records collected during a 1-year period. J Am Diet Assoc 1992;92:686–93.
[17] Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires—a review. Public Health Nutr 2002;5:567–87.
[18] George G, Milani T, Hanss-Nuss H, Kim M, Freeland-Graves J. Development and validation of a semi-quantitative food frequency questionnaire for young adult women in the southwestern United States. Nutr Res 2004;24:29–43.
[19] Subar AF, Ziegler RG, Thompson FE, Johnson CC, Weissfeld JL, Reding D, et al. Is shorter always better? Relative importance of questionnaire length and cognitive ease on response rates and data quality for two dietary questionnaires. Am J Epidemiol 2001;15(153):404–9.
[20] Bingham SA, Gill C, Welch A, Cassidy A, Runswick SA, Oakes S, et al. Validation of dietary assessment methods in the UK arm of EPIC using weighed records, and 24-hour urinary nitrogen and potassium and serum vitamin C and carotenoids as biomarkers. Int J Epidemiol 1997;26 (suppl 1):S137–51.

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