

## Reproducibility and relative validity of a Food Frequency Questionnaire among French adults and adolescents.

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20 V Deschamps conceived the paper and led the design, interpretation and preparation of the  
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results and revision of the drafts. MA Charles and M Romon were involved in all aspects  
from study conception to manuscript writing.

## Abstract

**Objective:** Our aim was to evaluate the reproducibility of a food frequency questionnaire (FFQ) developed in a French population, and its validity against four 24-hour dietary recalls (24-HR).

5 **Methods:** 57 adults (aged 18 to 63), 17 adolescents (aged 14 to 18), and 20 children (aged 10 to 14) completed four 24-HRs (one per season) and two FFQs over a 1-year interval.

Reproducibility of the FFQ was estimated by intraclass correlation coefficients (ICCs). The validity of FFQ was assessed by comparison with the four 24-HRs.

10 **Results:** For most nutrients, the first FFQ measurements gave higher mean values than the second FFQ. The ICCs for nutrients ranged from 0.39 for total protein to 0.83 for alcohol. The ICCs were higher for food items consumed daily such as milk (0.80) or sugars and confectionery (0.65), and lower for rarely eaten food such as inner organs (0.11). Nutrient intakes as assessed by FFQs were higher than those from the 24-HRs, except for alcohol. The de-attenuated Pearson's correlation coefficient for nutrients varied from 0.25 (dietary fiber) to  
15 0.90 (alcohol), but the adjustment for energy did not improve these coefficients. When nutrient intakes were categorized into quintiles, FFQ and 24-HRs produced agreement rates (same or adjacent quintile) between 55% (for PUFA) and 95% (for alcohol), while misclassification to an extreme quintile was rare (<5%).

20 **Conclusion:** The FFQ developed for the FLVS II Study can be used to classify adults or adolescents according to their nutrients and food intakes over a one-year period.

Keywords: validation, food frequency questionnaire, adult, adolescent

## INTRODUCTION

The Fleurbaix Laventie Ville Santé Study II (FLVS II) is a longitudinal epidemiologic study, which started in 1999 with the aim of studying the determinants of weight and adiposity changes in children and adults in the general population. One specific aspect was to study the relationships between usual diet and the development of overweight among children, adolescents and adults. Among the various available instruments to evaluate food intake, food frequency questionnaires (FFQ) and dietary history are used to estimate individual perception of usual food intake over a defined period of time (Pietinen et al, 1988; Willett, 1998). To assess long-term usual food intake by 24-hour records or recalls (24-HR), multiple days must be collected and the number of days required increase with the day-to-day variability in the daily intake of the food components. For cost and feasibility reasons, when relative ranking of food and nutrient intake are sufficient for determination of relative risks, FFQs may be advantageous, even if they provide cruder information (Pietinen et al, 1988; Willett, 1998). There are few published French self-administered FFQs (Bonifacj *et al*, 1997; van Liere *et al*, 1997). The FFQ published by Bonifacj et al (Bonifacj *et al*, 1997) was developed in a specific population of Southern France, and the other was not validated for use in young children (van Liere *et al*, 1997). We developed a new FFQ for the French population with the specific aim of selecting food groups, which have a major contribution to energy and fat intake. The present report describes the reproducibility of this specific FFQ and its validity against four 24-HRs, in adults and adolescents as in children.

## METHODS

### Food-Frequency Questionnaire

The FFQ was developed according to the methodology proposed by Willett (Willett, 1998) and its construction is presented in the Appendix. The FFQ consists of 124 items: 106 single  
5 foods or mixed dishes and 18 soft or alcoholic beverages. They were classified in 24 groups: Inners organs, Processed pork meat products (“charcuterie” in French), Eggs, Meat, Cooked dishes (including a range of dishes from salted pies, pizzas to more complex dishes such as “cassoulet” “paella”), Fish, Cheese, Yogurt, Dairy desserts, Sugars and confectionery, Fats,  
10 Milk, Bread, Cereals/pasta/rice, Potatoes, Cakes/pastries/biscuits, Oleaginous fruits (e.g. peanuts), Fruit, Vegetables, Pulses, Sweet beverages and sodas, Water, Alcoholic beverages, Fat reduced foods.

The frequency of consumption inquired about usual food consumption during the previous year through a graded scale of 7 levels ranging in most cases from never to  $\geq 3$  times a day. For seasonal fruit and vegetables, subjects were asked to declare usual intake during seasons  
15 of maximal consumption.

For 45 food items, the subject was referred to a set of colored photographs, each showing three different portion sizes (low, medium, high) of a known weight (estimated from FLVS I Study data, (Lafay *et al*, 1997)) for the type of food illustrated. The same set of photographs could be used for related food (i.e. a photograph of roast beef for all types of red meat) and  
20 there were all together 12 sets of photographs. For the other 61 food items, an average portion size was estimated from the FLVS I Study data for children < 14 years and for adults or adolescents  $\geq 14$  years. Photographs of cups and glasses were proposed for each beverage.

### 24-hour dietary recalls

A dietician visited each subject four times to complete a 24-HR. The interviews were meal-  
25 sequence based and involved a detailed assessment and description of the food consumed.

Subjects had to describe all foods consumed during the previous day, qualitatively and quantitatively using household measures, to allow the dietician to estimate food and beverage intake.

### **Reproducibility and validity study**

5 *Protocol.* Volunteers were recruited in families of two small towns from the same region of Fleurbaix and Laventie who had participated in the FLVS I study (Lafay *et al*, 1997). They were visited at their homes by a dietician on the day they were due to begin their dietary assessment: the whole protocol was explained, the first FFQ delivered and height and weight in light clothes were measured. The dietician returned on day 2 to collect the first FFQ and to  
10 complete the first 24-HR. At month 4 and at month 8, the dietician visited each subject to complete respectively the second and the third 24-HR. At month 12, the dietician visited all subjects to give the second FFQ, and came back on the following day to collect the second FFQ and to complete the last 24-HR. Four 24-HRs, namely one per season, were therefore  
15 completed over a 1-year period for each subject. These four 24-HRs and the second FFQ inquired about diet over the same time-period.

*Subjects.* The data collection was carried out from December 1999 to December 2000. One hundred and twenty volunteers were contacted to participate in the FFQ validation study. Thirteen subjects refused because of the constraints of the protocol and 13 returned incomplete recalls. Ninety-four volunteers followed the complete protocol: 57 adults aged 18  
20 to 63 years (29 women and 28 men, mean BMI 24.2 kg/m<sup>2</sup>, range: 18.9-36.9), 17 adolescents aged 14 to 18 years (9 girls and 8 boys, mean BMI 19.4 kg/m<sup>2</sup>, range: 14.7-26.8) and 20 children aged 10 to 14 years (11 girls and 9 boys, mean BMI 19.6 kg/m<sup>2</sup>, range: 13.3-27.3). Because of the small sample of children and the difference in the analysis of validity in this group compared with adolescents and adults (*see result section*), most results are presented  
25 only for the adults and adolescents subgroup (n=74).

*Nutrient intake.* Estimation of energy and macronutrient intakes for the 24-HRs was obtained using the French REGAL food composition table (Feinberg et al, 1991; Paul & Southgate, 1978). For the FFQs, frequencies were converted into a number of servings per day and multiplied by the portion size. Daily nutrient intakes were obtained using the same food composition table as for 24-h recalls.

### **Statistical analysis**

*Reproducibility.* Means and standard deviations for food consumption and nutrient intake were calculated for both FFQs. Intraclass correlations were used to measure the reproducibility between the first and the second FFQ. A high value of this coefficient indicates a low within-person variation.

*Validity.* Intake in all nutrients was logarithmically transformed to achieve normal distributions, which was obtained for all of them, except alcohol. Means and standard deviations for nutrient and food intakes were determined for both FFQs on the one hand and for the average of the four 24-HRs on the other hand. We examined the correlation between estimated intakes for both FFQs and 24-HRs, assuming that the diet recalls represented actual intake. Within-person ( $S_w^2$ ) and between-person ( $S_b^2$ ) daily variances were computed for each nutrient and food item in 24-HRs. Pearson correlation coefficients were computed for nutrients and food items after log-transformation of the data and in further steps after de-attenuation (Rimm *et al*, 1992) and adjustment for energy intake. The second procedure was used because day-to-day within-person variance tends to attenuate the correlation between FFQ and 24-HRs. De-attenuated Pearson correlation coefficients were then obtained from crude coefficients after correction by the factor:  $\sqrt{1 + \{(S_w^2/S_b^2)/4\}}$ , as 24-HRs were repeated four times (Beaton *et al*, 1979). Nutrient and food intake data were adjusted for energy by using the residual method (Willett & Stampfer, 1986).

Study subjects were classified into quintile categories of energy, macronutrient and food intakes based on the distribution of data for both FFQs and the average of four 24-HRs. Proportions of subjects classified into the same or adjacent and extreme quintiles by the two methods were derived for crude variables.

- 5 Comparison of estimation of energy intake with minimal energy requirements was performed by calculation of the ratio Energy Intake / Basal Metabolic Rate (EI/BMR) for the FFQ and the 24-HRs by age group. Basal metabolic rate was calculated using weight (measured by the dietician, according to the equation of Schofield (Schofield, 1985).

Statistical analysis was performed by using SAS software (release 8.2; SAS Institute Inc,

- 10 Cary, NC).

## RESULTS

### Reproducibility

Daily intakes of each nutrient obtained using the different dietary assessment methods (two FFQs and four 24-HRs over a 1-y period) are presented in table 1 for adults and adolescents. The intraclass correlation coefficients for the two FFQs ranged from 0.40 to 0.60 for most nutrients and to 0.83 for alcohol.

Daily intakes of each food group obtained using the different dietary assessment methods are presented in table 2. The most noticeable differences ( $\geq \pm 25$  percent) between the first and the second FFQs were for inner organs and cheese, but these differences remained not significant. The intraclass correlation coefficients between FFQs ranged between 0.35 to 0.60 for most food items. The coefficients were lowest for rarely eaten foods such as inner organs (0.11).

### Validity

*Nutrients in adults and adolescents.* Nutrient intakes assessed by both FFQs were significantly higher than those from the 24-Hrs (Table 1). Pearson correlation coefficients were higher between the second FFQ and 24-HRs (that referred to the same 1-y period) than between the first FFQ and 24-HRs (Table 3). Between the second FFQ and 24-HRs, Pearson correlation coefficient for energy was 0.61, with a mean of 0.52 for all nutrients. The crude correlations were closely similar for protein, fats and total carbohydrates. For several nutrients, there was considerably more within-person than between-person variations as indicated by the variance ratio for 24-h dietary recalls data. As expected, de-attenuation improved the Pearson correlation coefficients for energy and nutrient intakes, especially for those with the highest variance ratio such as total carbohydrates and energy. De-attenuated Pearson correlation coefficients between the second FFQ and 24-HRs ranged from 0.45 to 0.70 for most nutrients. Energy adjustment did not improve the correlations. The



classification in quintiles (Table 4) gave similar results for both FFQs with on average 73% of subjects classified in the same or adjacent quintiles with FFQ1 and 71% with FFQ2. Misclassification in opposite extreme quintiles between FFQs and 24-HRs exceeded 5% only for PUFA in the second FFQ. On average, 1% of subjects were grossly misclassified into opposite extreme quintiles for nutrient intake in the first FFQ and 4% in the second FFQ.

*Influence of age.* If de-attenuated Pearson correlation coefficients for nutrients were in the adolescent subgroup closed to those found in the adult subgroup (Figure 1), except for protein (0.76 in adolescents vs. 0.42 in adults), de-attenuated Pearson correlation coefficients for nutrients were clearly lower in the children subgroup and they were below 0.40 for all nutrients except MUFA.

*Food items in adults and adolescents.* Among 24 food groups, one was underestimated by both FFQs compared with 24-HRs (Cakes/pastries/biscuits) and 13 food groups were overestimated by both FFQs (Table 2). The most noticeable differences (FFQ/24-HR ratio  $\geq \pm 50$  percent) between both FFQs and 24-HRs were meat, cooked dishes, cereals, potatoes, fruits and fat-reduced foods. Pearson correlation coefficients for food items were quite similar between the second FFQ and 24-HRs (that referred to the same 1-y period) and between the first FFQ and 24-HRs (Table 5). Between the second FFQ and 24-HRs, Pearson correlation coefficient for foods ranged from 0.02 for eggs to 0.77 for alcoholic beverages, with a mean of 0.37. De-attenuation to correct for intra-individual variability improved the Pearson correlation coefficient and led to the greatest changes for intakes in fats (0.37 to 0.54), cakes/pastries/biscuits (0.56 to 0.73) and inner organs (0.38 to 0.53). Inner organs, cooked dishes, fish, fats and cereals/pasta/rice presented the highest variance ratios. Energy adjustment did not improve the correlations for food items. The classification in quintiles (Table 6) gave similar results for both FFQs with on average 66 % of subjects classified in the

same or adjacent quintiles. On average, 3 percent of subjects were grossly misclassified into opposite extreme quintiles for food intake in both FFQs.

### **Underestimation**

Mean of EI/BMR ratios (Figure 2) reached higher level for both FFQs than for 24-HRs.

## DISCUSSION

The aim of this study was to estimate the reproducibility and relative validity of the FFQ designed for the FLVS II Study. This FFQ was developed to study the relationship between diet and the development of overweight among children, adolescents and adults.

### 5 FFQ structure

The number of food items listed in food frequency questionnaires tends to vary widely. A review (Cade *et al*, 2002) found that the number of food items on a questionnaire ranged from 5 to 350. Willett (Willett, 1998), suggested that there is a rapidly decreasing marginal gain in information obtained with increasingly detailed questionnaires. Our FFQ, which was  
10 composed of a list of 124 food items, appears therefore to have an optimal length.

### Reproducibility

Reproducibility of food frequency questionnaires has been assessed using two measurements with varying time intervals, from 15 days (Vereecken & Maes, 2003) to several years (Shu *et al*, 2004) but for most studies with two or more measurements over a 1-y period (Gnardellis *et al*, 1995; Kelemen *et al*, 2003; Malekshah *et al*, 2006; Ocke *et al*, 1997; Ocke *et al*, 1997; Pietinen *et al*, 1988; Pietinen *et al*, 1988; van Liere *et al*, 1997). In these previous studies, the  
15 intraclass correlation coefficients were generally similar to our results and ranged from 0.4 to 0.8 for nutrients intake and from 0.3 to 0.8 for food groups. Overall, the reproducibility of our instrument was slightly lower than the French Dietary History Questionnaire (van Liere *et al*,  
20 1997), except in terms of alcohol consumption, which was well detailed in our questionnaire. Reproducibility tests are based on the assumption that diet does not change between two questionnaires, so reproducibility may ideally be assessed by two closely administered questionnaires, but in that case subjects would likely remember and repeat their responses (Willett, 1998). Our time interval was long (one year), the observed reproducibility may be

lower than the true value as differences in responses may reflect true changes in dietary habits as well as variation in response.

### **Validity**

*Reference method.* A major component of the validation process is the selection of the appropriate reference method against which to assess the test measurement. There is no gold standard for the measure of dietary intake. However, it is crucial that the errors of both methods be as independent as possible. The major sources of errors in FFQs are memory, interpretation of questions, perception of serving sizes and the restriction imposed by a fixed list of food. Diet records, with their open-ended form and their independency towards memory, are then likely to have the least correlated errors with FFQs (Willett, 1998). Nevertheless, keeping a diet record represents a substantial burden on subjects and it commonly changes respondents' diet (Block *et al*, 1986; Margetts & Nelson, 1997). Collection of multiple 24-hour recalls is then often considered as an alternative to the use of diet records (Willett, 1998). In a recent review about validation of FFQs, authors showed that 75% of studies validated FFQs against repeated 24-HRs (Cade *et al*, 2002).

*Number of recalls.* To estimate long-term usual intake, collection of 3 to 4 days of recalls in each of four seasons of the year is considered as ideal (Willett, 1998). However, several studies enhanced the possibility of using only a small number of replicate measures for the reference method combined with a statistical adjustment to remove the effects of within-person variation. The greatest statistical efficiency is obtained with only two, and at the most five, replicates per subjects (Carroll *et al*, 1997; Rosner & Willett, 1988; Stram *et al*, 1995). In that context, to validate our FFQ against four 24-hour recalls appeared as adequate.

*Number of subjects.* Despite the demonstrated validity of our FFQ, one limitation of our study is the size of the population. The recommended number of cases in validation studies is at least 100 cases, and that number should be enhanced when the age range is large and when

the number of replicates per subjects is limited (Cade *et al*, 2002). Unfortunately, our time and financial resources did not allow us to contact more than 120 individuals, and among them 19% did not fully complete the study. This problem of sample size was crucial among children (n=20) who could not be pooled with adolescents and adults and had to be excluded from our analyses.

*Comparison with other studies.* The higher correlation between the second FFQ and 24-HRs, which covered the same time period, than between the first FFQ and 24-HRs was previously underlined in similar studies (Pietinen *et al*, 1988; Shu *et al*, 2004; Willett, 1998). Pearson correlation coefficients between FFQ and four 24-hour dietary recalls in our study were moderate when compared to other validation studies conducted among adults (Bingham *et al*, 2001; Chen *et al*, 2004; Kelemen *et al*, 2003; Malekshah *et al*, 2006; McNaughton *et al*, 2005; Rodriguez *et al*, 2002; Shu *et al*, 2004; Verkleij-Hagoort *et al*, 2006) or adolescents (Lietz *et al*, 2002; Rockett *et al*, 1995; Vereecken & Maes, 2003). Except for PUFA, our de-attenuated correlation coefficients, ranging mainly from 0.45 to 0.70 for nutrients, compared favorably with those reported for two French questionnaires, as presented in table 7 (Bonifacj *et al*, 1997; van Liere *et al*, 1997) or for questionnaires developed in European countries (Bingham *et al*, 1994; Decarli *et al*, 1996; Gnardellis *et al*, 1995; Martin-Moreno *et al*, 1993; Ocke *et al*, 1997; Ocke *et al*, 1997; Pietinen *et al*, 1988; Pietinen *et al*, 1988; Vereecken & Maes, 2003). In our study, adjustment for energy led to a decrease in correlation coefficients for most nutrients, which according to Willet (Willett & Stampfer, 1986) happens when variability is more related to systematic errors of under/overestimation than to energy intake. It could also be a consequence of the FFQ development which focused on food items that contributed substantially to energy intake. This specificity of our FFQ may explain its rather good performance for the assessment of energy and macronutrients compared to others questionnaires. It may also explain its limitations for the assessment of nutrients that

contribute little to energy such as PUFA. Indeed, PUFA intake comes mainly from intake of fatty fish, nuts and some oils. In our questionnaire questions on fish consumption were based on preparation (canned fish in oil, breaded fish, smoked or salted fish..) which influences energy intake rather than on the type of fish, which would be important for a more accurate assessment of PUFA intake.

Despite some difference in estimation of both nutrients and foods, agreement in classification was good. More than 70% of subjects were classified in the same or adjacent quintile for energy and macronutrient intakes by both methods, that is quite similar to other French questionnaires (Bonifacj et al, 1997; van Liere et al, 1997). Misclassification was higher for dietary fibers and PUFA (5% and 7% classified in opposite extreme quintiles among in adults or adolescents compared with 24-HR)..

### **Underestimation**

All dietary assessment methods have their limitations and do not necessarily provide a true absolute estimate of food consumption. Comparison of EI/BMR estimates with minimal energy requirements provides an indirect indication of bias. Energy requirements, as given by WHO (World Health Organisation, 1985), are  $1.56 \times \text{BMR}$  for subjects with light activity level,  $1.64 \times \text{BMR}$  for moderate activity level, and  $1.82 \times \text{BMR}$  for high activity level. EI/BMR as estimated in our study by the 24-hour recalls lies just under the requirements for light activities among adults, whereas the ratio estimated by the FFQ is close to the requirements for high activity among adults. Part of the absolute differences between the 24-hour recalls and FFQ data may then be partially explained by a more severe underestimation with 24-hour recalls than with FFQ or by the overestimation with FFQ as suggested by Bingham (Bingham et al, 2003). Similar differences in EI/BMR ratios calculated from 24-HRs or from FFQ were previously underlined (Bingham et al, 2001; Chen et al, 2004; Kelemen et al, 2003; Malekshah et al, 2006; McNaughton et al, 2005; Rodriguez et al, 2002; Shu et al, 2004; van

Liere *et al*, 1997; Verkleij-Hagoort *et al*, 2006). Finally, under or overestimation is not necessarily problematic in epidemiological studies if the ranking of the persons according to their dietary intake is valid (Beaton, 1991).

## 5 **Reproducibility and validity among children**

Other investigators have supported experience of difficulty in completing FFQs among young children and they found that validity of food frequency questionnaires increases with age (Field *et al*, 1999). They suggested that young children might have difficulties in thinking abstractly and in understanding the concept of 'average intake', particularly for seasonal food such as fruit. (Buzzard *et al*, 2001). However, there is a rapid increase in the ability of children to self-report food intake from the age of 8 years (Livingstone & Robson, 2000). Our results show a good applicability of a FFQ developed among adults to an adolescent population. It has previously been reported in the EPIC study (Lietz *et al*, 2002).

### **External validity**

Our validation study was performed on young and middle-aged adults and adolescents from the general population in Northern France. Volunteers to a validation study have usually a higher level of education than the average population. However subjects participating in epidemiologic studies whose FFQs are correctly filled in show the same bias.

We conclude that the FFQ questionnaire developed for the FLVS II Study can be used to classify study subjects from the general population according to their nutrients and food intakes over a one-year period among adults and adolescents in epidemiologic studies. However, our results are not sufficient to validate the questionnaire among children (aged 8 to 14 years) and for PUFA intake in all groups.

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## APPENDIX

### Development of the food frequency questionnaire

The food frequency questionnaire was developed according to the methodology proposed by Willett (Willett, 1998). The food list was defined on the basis of dietary intake data obtained from the Fleurbaix Laventie Ville Santé I (FLVS I) Study (Lafay *et al*, 1997). In 1992-93, 549 families, living in Fleurbaix and Laventie, two small towns of Northern France, participated in an epidemiologic study. Dietary intake was assessed using a one-day record (not on a school day) for children under 14 y (1146 children) and a 3-d record (two weekdays and one weekend day) for adolescents and adults (130 adolescents, aged 14 to 18 y, and 1088 adults, aged 18 y or more). The methods and results of this dietary survey were described in a previous paper (Lafay *et al*, 1998). We used regression analysis to identify the food items contributing substantially to energy and fat intake and with a high between-subjects coefficient of variation. Using this procedure, 124 items were selected. For each item, two series of three portions size were estimated, one for children aged less than 14 years and another for adolescents aged  $\geq 14$  years and adults: low, medium and high portion sizes (g) were estimated from tertiles of the amount of the FLVS I Study subjects' consumption for each item.



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**Table 1.** Nutrients. Comparison of mean daily intake of 74 persons (adults and adolescents) estimated by different dietary assessment methods (two FFQs filled one year apart and the average of four 24 hr recalls over the same year) and FFQ's reproducibility: ratio of mean daily consumption (%) estimated by the two FFQ and intraclass correlation coefficients (ICC).

	Daily intake of nutrients			Reproducibility	
	24-HR	FFQ1	FFQ2	FFQ2 (%FFQ1)	ICC
Energy (kcal)	2025 (513)	2753 (1071) *	2626 (1047) *	95	0.60
Proteins (g)	80 (20)	106 (36) *	103 (40) *	97	0.39
Total fat (g)	91 (25)	119 (48) *	114 (52) *	96	0.55
SFA (g)	39 (12)	50 (21) *	47 (22) *	94	0.55
MUFA (g)	30 (9)	39 (15) *	38 (17) *	97	0.45
PUFA (g)	12 (4)	17 (9) *	16 (8) *	96	0.57
Cholesterol (g)	394 (115)	489 (184) *	477 (185) *	97	0.48
Carbohydrates (g)	222 (71)	309 (139) *	290 (129) *	94	0.70
Simple sugars (g)	92 (42)	118 (68) *	110 (68) *	92	0.77
Dietary fiber (g)	12 (4)	18 (7) *	18 (6) *	95	0.51
Alcohol (g)	16 (20)	13 (19) *	13 (23)	105	0.83

Mean (SD).

\* Significantly different from the value of the 24-HR: Student's paired t-test on log transformed values,  $p < 0.05$

No significant difference was observed between FFQ1 and FFQ2

**Table 2.** Food groups. Comparison of mean daily intake (g) of 74 persons (adults and adolescents) estimated by different dietary assessment methods (two FFQs filled one year apart and the average of four 24 hr recalls over the same year) and FFQ's reproducibility: ratio of mean daily consumption (%) estimated by the two FFQ and intraclass correlation coefficients (ICC).

	Daily intake of nutrients			Reproducibility	
	24-HR	FFQ1	FFQ2	FFQ2 (%FFQ1)	ICC
Inner organs	3 (10)	3 (3)	4 (14)	139	0.11
Pork meat products	43 (33)	37 (33)	36 (34)	99	0.64
Eggs	18 (19)	21 (14)	22 (13)	103	0.48
Meat	86 (55)	131 (67) *	138 (91) *	106	0.34
Cooked dishes	54 (66)	105 (68) *	94 (69) *	90	0.51
Fish	25 (38)	18 (16)	20 (17)	110	0.58
Cheese	39 (31)	35 (37)	26 (29) *	73	0.48
Yoghurt	62 (65)	73 (82)	79 (93)	108	0.45
Dairy desserts	33 (37)	41 (59)	36 (47)	89	0.39
Sugars and confectionery	44 (33)	57 (40) *	58 (39) *	101	0.65
Fats	31 (25)	29 (23)	28 (23)	98	0.48
Milk	92 (132)	150 (204) *	132 (192) *	88	0.80
Bread	78 (48)	121 (64) *	111 (68) *	92	0.46
Cereals, pasta and rice	75 (54)	119 (84) *	112 (78) *	94	0.48
Potatoes	89 (61)	168 (105) *	157 (95) *	93	0.38
Cakes/pastries/biscuits	67 (45)	51 (56) *	48 (44) *	94	0.45
Oleaginous fruits	6 (11)	8 (15)	8 (13)	107	0.73
Fruits	71 (79)	133 (127) *	123 (107) *	93	0.53
Vegetables	180 (136)	213 (134) *	199 (152)	94	0.57
Pulses	5 (12)	5 (7)	5 (5)	90	0.40
Sweet beverage and sodas	174 (254)	314 (499) *	257 (416) *	82	0.80
Water	1143 (578)	593 (342) *	614 (358) *	104	0.54
Alcoholic beverage	191 (241)	206 (379)	206 (417)	100	0.90
Fat reduced foods	2 (4)	29 (50) *	30 (53) *	104	0.63
Mean (SD)					

\* Significantly different from the value of the 24-HR: Student's paired t-test, p=0.05

No significant difference was observed between FFQ1 and FFQ2 (Student's paired t-test, p=0.05)

**Table 3.** Validity FFQs vs average of four 24-HR recalls. Nutrients: ratio of mean daily consumption (%) by the two methods and Pearson correlation coefficients (n=74 adults and adolescents).

	Variance ratio <sup>a</sup>	FFQ1 / 24-HR				FFQ2 / 24-HR			
		FFQ1 (% 24-HR)	r <sup>b</sup>	r <sup>c</sup>	r <sup>d</sup>	FFQ2 (% 24-HR)	r <sup>b</sup>	r <sup>c</sup>	r <sup>d</sup>
Energy (kcal)	1.3	136	0.46	0.53		130	0.61	0.70	
Proteins (g)	0.6	133	0.26	0.27	0.33	129	0.41	0.44	0.39
Total fat (g)	0.9	130	0.40	0.44	0.42	126	0.59	0.66	0.48
SFA (g)	0.5	127	0.47	0.49	0.41	119	0.63	0.67	0.42
MUFA (g)	0.8	129	0.35	0.38	0.25	125	0.54	0.60	0.40
PUFA (g)	1.0	141	0.18	0.20	0.24	135	0.25	0.28	0.23
Cholesterol (g)	0.9	124	0.20	0.22	0.15	121	0.46	0.50	0.20
Carbohydrates (g)	2.1	140	0.55	0.68	0.57	131	0.60	0.74	0.62
Simple sugars (g)	0.4	129	0.57	0.60	0.36	119	0.57	0.60	0.53
Dietary fiber (g)	0.1	152	0.33	0.34	0.44	145	0.25	0.25	0.40
Alcohol (g)	1.0	79	0.85	0.95	0.79	83	0.80	0.90	0.82

<sup>a</sup>ratio between within-person ( $S_w^2$ ) and between-person ( $S_b^2$ ) daily variances computed with

the four 24-HRs. <sup>b</sup> FFQ/24-HR Pearson correlation coefficient. <sup>c</sup> FFQ/24-HR de-attenuated

Pearson correlation coefficient (corrected for within-person variation in 24-HRs). <sup>d</sup> FFQ/24-

HR de-attenuated and energy-adjusted Pearson correlation coefficient. Correlation

coefficients computed with log transformed values

**Table 4.** Validity FFQs vs average of four 24-HR recalls. Nutrients: percentage of subjects classified in the same, adjacent or extreme quintiles of nutrient distribution by the FFQs and the 24 HR recall (n=74 adults and adolescents).

	FFQ1 / 24-HR			FFQ2 / 24-HR		
	% in the same quintile	% in adjacent quintiles	% in extreme quintiles	% in the same quintile	% in adjacent quintiles	% in extreme quintiles
Energy (kcal)	41	31	0	28	49	5
Proteins (g)	27	50	0	26	38	4
Total fat (g)	28	47	0	28	43	5
SFA (g)	38	42	0	32	42	5
MUFA (g)	34	36	0	26	42	4
PUFA (g)	23	34	1	18	38	7
Cholesterol (g)	26	43	4	28	31	4
Carbohydrates (g)	38	39	1	36	43	4
Simple sugars (g)	36	41	3	31	43	3
Dietary fiber (g)	23	39	5	28	36	5
Alcohol (g)	42	51	0	46	49	0



**Table 5.** Validity FFQs vs average of four 24-HR recalls. Food groups: ratio of mean daily consumption (%) by the two methods and Pearson correlation coefficients (n=74 adults and adolescents).

	Variance ratio <sup>a</sup>	FFQ1 / 24-HR				FFQ2 / 24-HR			
		FFQ1 (% 24-HR)	r <sup>b</sup>	r <sup>c</sup>	r <sup>d</sup>	FFQ2 (% 24-HR)	r <sup>b</sup>	r <sup>c</sup>	r <sup>d</sup>
Inner organs	3.8	81	0.47	0.65	0.64	113	0.38	0.53	0.37
Pork meat products	0.7	85	0.24	0.26	0.14	84	0.38	0.41	0.21
Eggs	2.7	116	0.13	0.16	0.01	120	0.02	0.02	0.01
Meat	0.5	151	0.33	0.35	0.12	160	0.39	0.41	0.21
Cooked dishes	4.6	196	0.20	0.30	-0.04	176	0.06	0.09	-0.13
Fish	5.5	72	0.09	0.13	-0.06	79	0.19	0.30	-0.09
Cheese	1.1	91	0.25	0.28	0.32	66	0.23	0.26	0.23
Yoghurt	1.4	119	0.56	0.65	0.61	128	0.38	0.44	0.42
Dairy desserts	2.4	124	0.41	0.52	0.00	110	0.44	0.55	0.24
Sugars and confectionery	1.4	129	0.50	0.58	0.31	130	0.59	0.68	0.49
Fats	4.3	94	0.29	0.42	0.26	92	0.37	0.53	0.59
Milk	0.7	162	0.66	0.71	0.49	142	0.70	0.76	0.51
Bread	1.0	154	0.24	0.27	0.17	142	0.38	0.42	0.27
Cereals, pasta and rice	6.7	159	-0.06	-0.09	0.04	150	0.06	0.10	0.17
Potatoes	2.5	189	0.25	0.32	-0.04	176	0.32	0.41	0.00
Cakes/pastries/biscuits	2.8	77	0.46	0.60	0.40	72	0.56	0.73	0.42
Oleaginous fruits	3.3	129	0.15	0.20	0.25	138	0.27	0.36	0.43
Fruits	0.5	188	0.29	0.31	0.26	174	0.36	0.38	0.35
Vegetables	1.8	118	0.65	0.78	0.76	111	0.60	0.72	0.65
Pulses	2.4	101	0.06	0.07	0.08	91	0.09	0.12	0.18
Sweet beverage and sodas	0.1	181	0.61	0.62	0.36	148	0.67	0.68	0.26
Water	0.1	52	0.38	0.39	0.32	54	0.37	0.37	0.38
Alcoholic beverage	0.8	108	0.84	0.91	0.84	108	0.77	0.84	0.78
Fat reduced foods	1.3	1494	0.44	0.51	0.46	1549	0.34	0.40	0.33

<sup>a</sup>ratio between within-person ( $S_w^2$ ) and between-person ( $S_b^2$ ) daily variances computed with

the four 24-HRs. <sup>b</sup> FFQ/24-HR Pearson correlation coefficient. <sup>c</sup> FFQ/24-HR de-attenuated

Pearson correlation coefficient (corrected for within-person variation in 24-HRs). <sup>d</sup> FFQ/24-

HR de-attenuated and energy-adjusted Pearson correlation coefficient.

**Table 6.** Validity FFQs vs average of four 24-HR recalls. Food groups: percentage of subjects classified in the same, adjacent or extreme quintiles of food intake distribution by the FFQs and the 24 HR recall (n=74 adults and adolescents).

	FFQ1 / 24-HR			FFQ2 / 24-HR		
	% in the same quintile	% in adjacent quintiles	% in extreme quintiles	% in the same quintile	% in adjacent quintiles	% in extreme quintiles
Inner organs	57	0	0	55	0	0
Pork meat products	22	34	1	20	34	5
Eggs	16	32	7	22	28	11
Meat	32	24	3	28	39	4
Cooked dishes	20	27	7	18	35	4
Fish	24	35	3	32	32	5
Cheese	24	34	3	19	32	3
Yoghurt	28	36	3	39	36	1
Dairy desserts	34	32	3	35	35	3
Sugars and confectionery	36	41	3	32	41	4
Fats	23	50	4	26	35	4
Milk	31	53	0	43	24	1
Bread	30	42	3	22	47	3
Cereals, pasta and rice	23	30	7	19	35	9
Potatoes	27	30	4	27	35	5
Cakes/pastries/biscuits	36	39	1	32	32	4
Oleaginous fruits	28	28	1	18	46	3
Fruits	35	28	4	28	34	4
Vegetables	30	46	4	45	31	1
Pulses	0	69	1	5	54	1
Sweet beverage and sodas	36	47	0	45	34	0
Water	27	38	4	38	35	3
Alcoholic beverage	50	42	1	54	41	0
Fat reduced foods	45	26	0	18	55	3

**Table 7.** Comparison of de-attenuated Pearson correlation coefficients for various nutrients in two French validation studies comparing dietary records and food frequency questionnaires.

	Bonifacj <sup>1</sup> (N=98) 68 women, 30 men	Van Liere <sup>2</sup> (N=119) 119 women	FLVS study <sup>3</sup> (N=74) 38 women, 36 men
Energy	0.42	0.43	0.70
Total protein	0.31	0.35	0.44
Total fat	0.44	0.55	0.66
Saturated fat	0.30	-	0.67
Monounsaturated fat	0.39	-	0.60
Polyunsaturated fat	0.70	-	0.28
Cholesterol	0.52	0.53	0.50
Total carbohydrate	0.27	0.45	0.74
Simple sugars	0.25	-	0.60
Dietary fiber	0.56	-	0.25
Alcohol	0.80	0.70	0.90

<sup>1</sup> FFQ / 7 days estimated-diet records in adults; <sup>2</sup> FFQ / twelve 24-h recalls in adults; <sup>3</sup> FFQ / four 24-h recalls in adults and adolescents

**Figure 1.** Validity FFQ2 vs the average of four 24-HR. Nutrients: de-attenuated Pearson correlation coefficients among adults (n=57), adolescents (n=17) and children (n=20).

**Figure 2.** Mean Energy Intake / BMR ratio and error bars according to the dietary assessment methods: two FFQs filled one year apart and the average of four 24 HR recalls over the same year (n=74 adults and adolescents).