



Correlations between Fruit, Vegetables, Fish, Vitamins, and Fatty Acids Estimated by Web-Based Nonconsecutive Dietary Records and Respective Biomarkers of Nutritional Status



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ABSTRACT

Background It is of major importance to measure the validity of self-reported dietary intake using web-based instruments before applying them in large-scale studies.

Objective This study aimed to validate self-reported intake of fish, fruit and vegetables, and selected micronutrient intakes assessed by a web-based self-administered dietary record tool used in the NutriNet-Santé prospective cohort study, against the following concentration biomarkers: plasma beta carotene, vitamin C, and n-3 polyunsaturated fatty acids.

Participants/setting One hundred ninety-eight adult volunteers (103 men and 95 women, mean age=50.5 years) were included in the protocol: they completed 3 nonconsecutive-day dietary records and two blood samples were drawn 3 weeks apart. The study was conducted in the area of Paris, France, between October 2012 and May 2013.

Main outcome measures Reported fish, fruit and vegetables, and selected micronutrient intakes and plasma beta carotene, vitamin C, and n-3 polyunsaturated fatty acid levels were compared.

Statistical analyses Simple and adjusted Spearman's rank correlation coefficients were estimated after de-attenuation for intra-individual variation.

Results Regarding food groups in men, adjusted correlations ranged from 0.20 for vegetables and plasma vitamin C to 0.49 for fruits and plasma vitamin C, and from 0.40 for fish and plasma c20:5 n-3 (eicosapentaenoic acid [EPA]) to 0.55 for fish and plasma c22:6 n-3 (docosahexaenoic acid). In women, correlations ranged from 0.13 (nonsignificant) for vegetables and plasma vitamin C to 0.41 for fruits and vegetables and plasma beta carotene, and from 0.27 for fatty fish and EPA to 0.54 for fish and EPA+docosahexaenoic acid. Regarding micronutrients, adjusted correlations ranged from 0.36 (EPA) to 0.58 (vitamin C) in men and from 0.32 (vitamin C) to 0.38 (EPA) in women.

Conclusions The findings suggest that three nonconsecutive web-based dietary records provide reasonable estimates of true intake of fruits, vegetables, fish, beta carotene, vitamin C, and n-3 fatty acids. Along with other validation studies, this study shows acceptable validity of using such diet-assessment methods in large epidemiologic surveys and broadens new perspectives for epidemiology.

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CONSUMPTION OF FRUIT AND VEGETABLES (F/V) AND fish can play a critical role in the prevention of some cancers and cardiovascular disease,^{1,2} which together represent the heaviest global disease burden. These food groups are of particular interest, as the consumption of nonstarchy vegetables and fruits is one of the

recommendations issued by the World Cancer Research Fund¹ and, according to the World Health Organization, low intake of F/V and fish are linked to cardiovascular disease risk.² In large-scale epidemiologic studies, from which an important part of the evidence is based, dietary information is reported through self-administered instruments, such as multiple 24-hour recalls, diet records, or food frequency questionnaires (FFQs). Inherent to the self-reporting administration mode, none of these instruments provide unbiased estimates of the true intakes,³ and this measurement error can bias or attenuate the observed relationships between F/V or fish and health outcomes. For instance, it is known that

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F/V consumption is overestimated by FFQs.⁴ To assess individual usual intake as accurately as possible, the data-collection tool that performs optimally is suggested to be several nonconsecutive days of diet records or recalls,⁵⁻⁷ where within-individual error can be taken into account. In turn, it is of major importance to measure the validity of such instruments—that is, their ability to properly assess food group consumption or nutrient intake—before applying them in large-scale studies.

Only a handful of biomarkers can adequately reflect true dietary intake and can be used to validate specific dietary assessment instruments. They are qualified as “recovery biomarkers”⁸ and are specifically energy (doubly labeled water), nitrogen, potassium, and sodium (24-hour urinary excretion). Even if they do not relate directly to intakes of F/V or fish because of complex metabolic regulations and influence of individual characteristics,⁹ plasma levels of beta carotene, vitamin C,¹⁰⁻¹³ and polyunsaturated fatty acids^{14,15} have proven to be reliable “concentration biomarkers” of intake. This means that they can be used to capture the validity of reported intake of F/V and fish, respectively.

Most epidemiologic studies on large populations to date have used FFQs because traditional diet records or 24-hour recalls by a dietitian require substantial logistic resources. The Internet, among other technologies, can help overcome logistical and cost issues with the implementation of web-based self-administered instruments. However, very few studies have evaluated the validity of Internet-based dietary data collection tools with regard to F/V intake^{16,17} and, to our knowledge, no study focused on validating fish intake with such a tool.

NutriNet-Santé is a French web-based prospective cohort study that aims to investigate the relationship between nutrition and health.¹⁸ Diet is assessed by three nonconsecutive records at baseline and at each year of follow-up. Dietary records are self-administered through a specific web-based tool, which has shown high agreement (median intra-class correlation and Pearson's correlation 0.7 to 0.8) with an interview with a dietitian.¹⁹

In a companion article,²⁰ it was shown that the web-based repeated nonconsecutive-day dietary records tool used in the NutriNet-Santé cohort study performs well in estimating protein, potassium, and sodium intake, with correlations of 0.61, 0.78, and 0.47 for men and 0.64, 0.42, and 0.37 for women, respectively. In the present study, the aim was to investigate the validity of intake of F/V and fish and of a range of micronutrients reported through three web-based self-administered dietary records against corresponding concentration biomarkers.

METHODS

Study Population and Ethics Statement

Participants were a sample of volunteers from the NutriNet-Santé study, an ongoing web-based cohort study launched in France in May 2009, the aims and methods of which have been described elsewhere.^{18,21} Using a dedicated website, adult volunteers (aged older than 18 years) are followed for at least 10 years (recruitment still ongoing). Informed consent is obtained electronically from all participants. All procedures were approved by the International Research Board of the French Institute for Health and Medical Research (IRB Inserm

no. 0000388FWA00005831) and the French National Information and Citizen Freedom Committee “CNIL” (no. 908450 and 909216). Briefly, at the beginning of the study, participants complete a set of questionnaires assessing demographic, socioeconomic and lifestyle factors, dietary intake (three dietary records), physical activity, anthropometry, and health status. Dietary intake is evaluated again every year and questionnaires on health status are sent on a regular basis.

Among participants of the NutriNet-Santé study living in Paris and the greater area (chosen for logistical reasons), a total of 1,400 randomly selected participants stratified by sex, age (younger than 45 years, older than 45 years), and education level (primary and secondary up to some college, university graduate) were invited by e-mail to take part in the dietary validation study. The objective was to include 200 stable-weight participants, free from chronic disease in the NutriNet-Santé Dietary Validation Study. For enrollment in the NutriNet-Santé study, they had to have at least basic computer knowledge and no difficulty understanding or reading French language. The ancillary protocol of the NutriNet-Santé Dietary Validation Study was approved by the Consultation committee for the Protection of Participants in Biomedical Research of Paris Saint-Louis (No. 2011/22) and the “CNIL” (DR-2012-467). Participants provided written informed consent at their first visit.

Study Design

Study schematic of the NutriNet-Santé Dietary Validation Study is presented in [Figure 1](#). Recruitment was carried out between October 2012 and April 2013. The study consisted of two visits at the clinical center (Hôtel Dieu Hospital, Paris) in a fasting state (at least 6 hours). At the first visit, a blood sample was drawn and clinical measurements were taken. Two questionnaires were given to complete at home (paper, self-administered) before the second visit. The first was a physical activity questionnaire on occupational, transport, and leisure time physical activity during the last 4 weeks. The second was a food propensity questionnaire on usual consumption (frequency, no quantity) of 11 major food groups during the last year. The dietary record days were scheduled in advance (1 weekend day, 2 weekdays) during the following 2 weeks. To complete the three dietary records, a specific login and password were given to the participants. The second visit was scheduled approximately 3 weeks after the first visit, where participants provided a second fasting blood specimen. Between the two visits, three dietary records were self-administered on the specific web-based tool, with a time lag of approximately 2 weeks between first and third dietary record. These procedures correspond to the design in the NutriNet-Santé study. Participants received a €100 (US\$110) incentive after the second visit.

Dietary Data Collection

The web-based tool is designed for self-administration and based on a secured user-friendly interface, designed by Medical Expert Systems MXS. Participants report all foods and beverages (type and quantity) consumed at each meal (breakfast, lunch, dinner) or any other eating occasion. The system allows logging in on the day to fill out the questionnaire immediately and access to the questionnaire is maintained open for 2 weeks. Participants first fill out a list of

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