Development of a Data-based Short Food Frequency Questionnaire for Assessing Nutrient Intake by Middle-aged Japanese

Shinkan Tokudome¹, Chiho Goto², Nahomi Imaeda³, Yuko Tokudome², Masato Ikeda⁴, Shinzo Maki⁵

Abstract

Objective: Development of a data-based short food frequency questionnaire (FFQ) for evaluating intake of nutrients by middle-aged Japanese. Methods: Of 102 foods listed in the formerly developed semi-quantitative FFQ, foods having similar nutrient contents were combined into 72 foods/food groups by research dietitians. Nutrient contents were computed by multiplying the weight of foods consumed and its nutrient contents. Next, a cumulative multiple regression coefficient up to 0.85 was applied, and 47 foods/food groups were chosen for a brief FFQ for assessing intake of 21 nutrients including energy, protein, fat, carbohydrate, vitamins, minerals, and dietary fibers. Results: The 47 foods/food groups comprised rice, bread and noodles (3), margarine/butter (2), eggs (1), milk and dairy products (2), soybean and soybean products (3), miso-soup (1), meat including beef, pork and chicken (4), fish (3), other fish, shellfish and fish products (4), green-yellow vegetables (5), other vegetables and mushrooms (3), edible roots (4), seaweeds (1), mayonnaise (1), fried dishes (2), seeds (1), fruit (2), beverages, including alcohol (3), and confectioneries (2). Conclusions: The evidence-based short FFQ efficiently covered the intake of 21 nutrients, and may be competent to rank the middle-aged general public Japanese according to intake of nutrients.

Key Words: food frequency questionnaire - food intake - nutrient intake - multiple regression - weighed diet record

Introduction

In order to assess population/individual intake of foods and nutrients, several methods are available, including the diet record (DR)/weighed diet record (WDR), 24 hour recall, and duplicate method, as well as biomarker approaches, taking advantage of blood and urine parameters (Margetts and Nelson, 1990; Thompson and Byers, 1994; Willett, 1998). There are strengths and weaknesses for each procedure. Selection criteria may depend on the nature of the protocol, including the aim, time frame, dietary elements and subjects studied. For example, 24 hour recall or DR/WDR may be chosen for evaluating population values. For collecting information on individual habitual intake of foods/food groups for cohort and case-control studies, the food frequency questionnaire (FFQ)/semi-quantitative food frequency questionnaire (SQFFQ) is more often employed.

Recently, using multiple regression analysis (MRA) (Byers et al., 1985; Hankin et al., 1968; Overvad et al., 1991) as well as contribution analysis (CA) (Block et al., 1985; Freudenheim et al., 1993), we designed an evidence-based SQFFQ on the basis of WDRs from 351 participants (Tokudome et al., 1998). Calibration/validation and reproducibility studies in terms of the food list, intake frequency, and portion size were executed, as detailed elsewhere (Imaeda et al., 2002; Tokudome et al., 2001); however, the SQFFQ was primarily designed for the JADE (Japanese Dietitians’ Epidemiologic) Study. For epidemiologic studies of the general middle-aged populace, we here evolved a self-administered brief FFQ by MRA.

Subjects and Methods

Subjects and Selection of Foods/Food Groups

The subjects and methods for developing the SQFFQ were described elsewhere (Tokudome et al., 1998). In brief, nutrient intake by food was computed by multiplying the food intake (in grams) and the nutrient content (per gram)
of food as listed in the Standard Tables of Food Composition, Version 4 and the Follow-up of the Standard Tables of Food Composition, Version 4 (Resources Council, 1982; ibid, 1992). In all, 102 foods/food groups were listed in the SQFFQ. Those foods/food groups having similar nutrient contents were combined into 72 foods/food groups by research nutritionists (Figure 1). Next, forward MRA was performed with total intake of specific nutrients as the dependent variables and overall amounts of nutrients from 72 foods/food groups as the independent variables from 351 individuals (Byers et al., 1985; Hankin et al., 1968; Overvad et al., 1991). Foods/food groups with a cumulative multiple regression coefficient/cumulative R² up to 0.85 were chosen (SAS, 1999).

Nutrients Selected

The following 21 nutrients were selected: energy, protein, fat, carbohydrate, vitamins (including carotene, and vitamins A, C, D and E), minerals (calcium and iron) and total dietary fiber (TDF) (including soluble DF and insoluble DF). The fat was divided into cholesterol, saturated fatty acid, mono-unsaturated fatty acid (including oleic acid), poly-unsaturated fatty acid (PUFA), n-6 PUFA, n-3 PUFA, and n-3 HUFA (including eicosapentaenoic acid [EPA, 20: 5n-3] and docosahexaenoic acid [DHA, 22: 6n-3]).

Food Intake Frequency and Weight Assigned

Food intake frequencies were classified into eight categories: that is, never or seldom, 1-3 times per month, 1-2 times per week, 3-4 times per week, 5-6 times per week, once a day, twice a day, and 3 or more times a day, and weights assigned were shown in Table 1.

Table 1. Food Intake Frequency and Weight Assigned

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never or seldom</td>
<td>0</td>
</tr>
<tr>
<td>1-3 times per month</td>
<td>0.1</td>
</tr>
<tr>
<td>1-2 times per week</td>
<td>0.2</td>
</tr>
<tr>
<td>3-4 times per week</td>
<td>0.5</td>
</tr>
<tr>
<td>5-6 times per week</td>
<td>0.8</td>
</tr>
<tr>
<td>Once a day</td>
<td>1</td>
</tr>
<tr>
<td>Twice a day</td>
<td>2</td>
</tr>
<tr>
<td>Three or more times a day</td>
<td>3</td>
</tr>
</tbody>
</table>

Portion Size

The mean portion size was calculated for respective foods from the one-day WDRs, and typical/standard values and/or natural units from the literature were also cited for evaluating intake of nutrients of interest.

Staple Foods

Rice, bread and noodles are the Japanese staple foods which provide most nutrients. They were here investigated in a special manner: namely, taking into account the intake frequency and portion size for breakfast, lunch, and supper, separately. The intake frequencies were categorized as follows: never or seldom, 1-3 times per month, 1-2 times per week, 3-4 times per week, 5-6 times per week and daily. The portion size was also determined in an open-ended manner.

Lifestyle Items

In addition, lifestyle items were included in the questionnaire, with parameters such as smoking, drinking, physical exercise, sleeping hours, and intake of vitamin and mineral supplements, as well as functional (or designer) foods.

Results

Number of Foods/Food Groups Contributing to Nutrients Selected

The foods/food groups contributing to the nutrients selected are listed in Table 2. For example, the n-3 HUFAs and vitamin D were each provided by specific foods/food groups, while iron was contributed by a total of 17 foods/food groups.

List of Foods/Food Groups

The 47 foods/food groups were included in the questionnaire: rice, bread and noodles (3), margarine/butter (2), eggs (1), milk and dairy products (2), soybean and soybean products (3), miso-soup (1), meat including beef, pork and chicken (4), fish (3), other fish, shellfish and fish products (4), green-yellow vegetables (5), other vegetables and mushrooms (3), edible roots (4), seaweeds (1), mayonnaise (1), fried dishes (2), seeds (1), fruit (2), beverages, including alcohol (3), and confectioneries (2) (Appendix).

Table 1. Food Intake Frequency and Weight Assigned
Shinkan Tokudome et al

Discussion

Following a systematic data-based procedure, we chose 47 foods/food groups for categorizing people according to 21 nutrients estimated. The questionnaire is concise and brief, and it could be self-administered to the general public. The food list was arranged considering Japanese dietary habits and lifestyle. Staple foods, for example, were listed first and related foods/food groups were itemized adjacent to one another. Although we included inquiries about intake of vitamin and mineral supplements and functional (or designer) foods, data on type (liquid, granule, tablet), quantity (portion size) and frequency were not sufficient to validly estimate consumption. Vitamin and mineral supplements are actually not so popular in Japan; however, we should take into account this drawback, particularly when executing relevant studies.

For choosing foods/food groups, there are two contrasting methods (Margetts and Nelson, 1990; Mark et al., 1996; Stryker et al., 1991; Thompson and Byers, 1994; Willett, 1998): one is based on CA (Block et al., 1985; Freudenberg et al., 1993), and the other on MRA (Byers et al., 1985; Hankin et al., 1968; Overvad et al., 1991). Each method has its respective advantages and disadvantages. The former approach is based on absolute nutrient intakes. Thus, the procedure is especially suitable for studies to clarify the association with energy intake and energy-adjusted intake of nutrients. The latter is based on the variance of nutrient intakes. The cumulative R² can generally be explained by a smaller number of foods than the cumulative % contribution. Substantial foods/food groups selected by MRA were covered by those chosen by CA; in addition, specific foods were chosen by MRA. Thus, the latter may be efficient for categorizing individuals, although it is unsuitable to compute absolute nutrient levels.

Admittedly, the sample size for the one-day WDRs was not large, and the survey was performed in a selected area and in a specific season in Japan. It is known that within-individual variation is greater than inter-individual variation (Beaton et al., 1983; Margetts and Nelson, 1990; Mark et al., 1996; Nelson et al., 1989; Stryker et al., 1991; Thompson and Byers, 1994; Tokudome et al., 2002; Willett, 1998); however, we were here naturally unable to estimate inter- and within-individual variation on the basis of one-day WDRs. Although Japan is relatively small country in terms of area, the length from the North (latitude ca 45 degree) to the South (latitude ca 25 degree) is rather great. Accordingly there are wide varieties of foods consumed even though mass-transportation systems have been developed throughout the country. Furthermore, there are four seasons in Japan and seasonal variations in intake of foods, vegetables and fruit, in particular (Shahar et al., 1999; Tokudome et al., 2003; Ziegler et al., 1987). We should therefore take into account these variations in evaluating intake of foods and nutrients.

In epidemiological studies, validity and reproducibility are two important components. Validity is defined as being free from bias, and reproducibility as being low in random variation. Those should be evaluated prior to actually applying an FFQ for investigations, including case-control and cohort studies. We thus propose relative validation of the present FFQ versus 7 day WDRs and blood parameters. With the latter, we would validate the FFQ against concentrations of plasma fatty acids because we are particularly interested in lifestyle-related diseases, including cancers, cerebrovascular disease and chronic heart disease, related to excess/imbalanced intake of fats/oils. Reproducibility studies are now underway with the public in community and company employee settings.

Table 2. Number of Foods/food Groups Contributing to 21 Nutrients with a Cumulative R² up to 0.85

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Cumulative R²</th>
<th>Number of food groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>0.861</td>
<td>14</td>
</tr>
<tr>
<td>Protein</td>
<td>0.858</td>
<td>15</td>
</tr>
<tr>
<td>Fat</td>
<td>0.856</td>
<td>11</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0.868</td>
<td>3</td>
</tr>
<tr>
<td>SFAs</td>
<td>0.867</td>
<td>8</td>
</tr>
<tr>
<td>MUFAs</td>
<td>0.873</td>
<td>7</td>
</tr>
<tr>
<td>PUFAs</td>
<td>0.864</td>
<td>8</td>
</tr>
<tr>
<td>n-6 PUFAs</td>
<td>0.872</td>
<td>7</td>
</tr>
<tr>
<td>n-3 PUFAs</td>
<td>0.904</td>
<td>4</td>
</tr>
<tr>
<td>n-3 HUFAs</td>
<td>0.872</td>
<td>1</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0.869</td>
<td>7</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>0.852</td>
<td>10</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>0.851</td>
<td>17</td>
</tr>
<tr>
<td>Carotene</td>
<td>0.928</td>
<td>2</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0.933</td>
<td>4</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>0.894</td>
<td>7</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>0.942</td>
<td>1</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>0.856</td>
<td>9</td>
</tr>
<tr>
<td>TDF</td>
<td>0.855</td>
<td>13</td>
</tr>
<tr>
<td>SDF</td>
<td>0.854</td>
<td>10</td>
</tr>
<tr>
<td>IDF</td>
<td>0.866</td>
<td>13</td>
</tr>
</tbody>
</table>

Acknowledgments

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References


[Appendix]

List of Foods/Food Groups Included in a Short FFQ

1. Rice
2. Bread (including White Bread, Bun etc.)
3. Noodles (Japanese noodle; Udon [Wheat noodle], Soba [Buckwheat noodle], Chinese noodle; Ramen)
4. Margarine
5. Butter
6. Milk
7. Yogurt
8. Miso soup
9. Tofu (Soybean curd) for Hiyayakko, Yu-dofu
10. Natto (Fermented soybean), Soybean
11. Egg
12. Chicken
13. Beef, Pork
14. Liver
15. Ham, Sausage, Bacon, Salami-sausage
16. Fish
17. Bone-edible small fish (e.g. Shirasuboshi [Boiled and semi-dried whitebait], Shishamo [Smelt])
18. Canned tuna
19. Cuttlefish, Squid, Octopus, Shrimp, Crab
20. Shellfish (e.g. Short-necked clam, Corbicula, Oyster)
21. Fish egg (e.g. Tarako [Cod fish egg], Ikura [Salted salmon egg], etc.)
22. Fish paste products (e.g. Kamaboko, Chikuwa)
23. Gammosoki (Fried tofu paste), Nama-age (Fried tofu)
24. Potatoes (e.g. Potato, Sweet-potato, Taro, Yam)
25. Pumpkin/squash
26. Carrot
27. Broccoli
28. Green leaves vegetables (e.g. Spinach, Komatsuna, Shungika, etc.)
29. Other green-yellow vegetables (e.g. Green pepper, String beans, etc.)
30. Cabbage
31. Daikon (Japanese radish)
32. Kiritosshi-daikon (Dried strips of Japanese radish)
33. Burdock, Bamboo shoot
34. Other vegetables (e.g. Cucumber, Lettuce, Bean sprouts, Onion, Chinese cabbage etc.)
35. Mushrooms (e.g. Shiitake, Shimeji, Enoki, etc.)
36. seaweeds (e.g. Hijiki [Brown algae], Kombu [Kelp], etc.)
37. Mayonnaise (including Salad dressed with mayonnaise [e.g. Potato-salad, etc.])
38. Deep fried food
39. Light fried food
40. Citrus fruits (e.g. Orange, Tangerine, Mandarin orange, etc.)
41. Other fruits
42. Peanut, Almond
43. Western style confectioneries (e.g. Short cake, Cream puff, etc.)
44. Japanese style confectioneries (Manju, etc.)
45. Green tea
46. Coffee
47. Alcohol