Validity and Reproducibility of Food Frequency Questionnaire in Japanese Children Aged 6 Years

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Summary The aim of the present study was to evaluate the validity and reproducibility of a food frequency questionnaire (FFQ) for use among young Japanese children. Forty-seven mothers of children aged 6 y completed two 3-d diet records and two FFQs over a 6-mo period. The FFQ asked the mothers how often, on average, their children consumed each of the 162 food items listed and what the usual serving size of each item was during the 6 mo prior to the study. Intakes of macro- and micronutrients were estimated by multiplying the frequency by the serving size for each food item. The validity of the FFQ was assessed by comparison of the two 3-d diet records. The reproducibility of the FFQ was based on the first and second FFQ administrations. The validity correlation ranged from 0.05 for /H9251-tocopherol to 0.59 for retinol. The median correlation was 0.40. The reproducibility correlation was higher than 0.50 for all nutrients. For most nutrients, FFQ had acceptable reproducibility, whereas validity showed low to moderate correlations. Our FFQ could reasonably rank individuals according to dietary intake for epidemiologic studies, although the validity of the questionnaire is limited to specific nutrients.

Key Words food frequency questionnaire, validity, reproducibility

Much evidence suggests that diet during early childhood could be an important determinant of risk of chronic disease later in life (1, 2). The accurate measurement of diet in children is essential to investigate the nutrition habits of children. The most commonly used measures in epidemiological studies are food frequency questionnaires (FFQs) as they can reflect long-term intake and have relatively low respondent burden and ease in data processing (3). However, developing an FFQ for children is challenging because of their rapid changes in eating habits along with their growth and development (4). To our knowledge, only six studies have reported the validity of an FFQ developed to assess the general diet of children aged around 5 to 6 y (5–10). The FFQ used in this study was derived from an adult version that had been previously validated in a sample of adult Japanese (11, 12). We modified the adult FFQ by including food items and portion sizes that were applicable to 5- to 6-y old children. The present study aimed to assess the reproducibility of this FFQ and its validity against two 3-d diet records.

MATERIALS AND METHODS

Subjects. Subjects were drawn from a sample of mothers who had participated in a study investigating maternal diet and pregnancy hormones in 2001 and 2002 (13). In 2007, 101 mothers who had responded each year to our follow-up letter inquiring about the growth and health of their children were invited to participate in the present study. The ages of the children ranged from 5.3 to 6.7 y. Of the 55 mothers who agreed to participate, 48 completed the present study. We excluded one child who was reported on the FFQ to have had staple foods more than five times a day in addition to school lunches. Thus, 47 children (23 boys and 24 girls) were included in the present study. All of them were attending preschool (n= 36) or elementary school (n=11). As compared with those who were invited but did not participate, the study subjects were more likely to be older (mean±SD, 6.4±0.03 vs. 5.7±0.03 y). The height and weight reported 1 y before the present study and the birth weight recorded at the hospital were similar between the participants and nonparticipants after controlling for age. The age and educational level of the mothers and the number of siblings of the children, as reported at pregnancy, did not differ between the two groups. Each mother signed a consent form. The study complied with the code of ethics of the World Medical Association (Declaration of Helsinki) and was approved by the ethical board of the Gifu University Graduate School of Medicine.

FFQ. The first FFQ was mailed to the mothers in October. The questionnaire included items regarding the child’s usual frequency of consumption of 162 food and beverage items during the previous 6 mo. For each item, eight response categories were provided in a list of frequencies: never or almost never; once a month; twice
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or three times a month; once a week; twice or three times a week; 4–6 times a week; once a day; twice or more a day. For seasonal fruits, mothers were asked to report usual intake during seasons of maximal consumption. The FFQ also contained three portion-size categories per food item. Drawings of actual-sized bowls and plates and foods in different sizes were used as an aid in the estimation of amounts. Mothers were also asked about the frequency of lunches and snacks provided by preschools or elementary schools. For snacks, six food items were included. To measure how much lunch and snack a child ate, seven response categories ranging from “none/not served” to “always gets another helping” were provided for each of nine food groups.

Study design. During the 6 mo after the completion of the first FFQ, 3-d diet records including two successive weekdays and one weekend day were administered twice, at approximately 2-mo intervals. Mothers quantified the amount consumed by their children by weighing foods or using standard potions or units. For foods eaten at preschools or elementary schools, mothers were asked to record the amounts of foods using standard potions or units as accurately as possible as by referring to the lunch menu distributed by the school and guessing the leftover amounts. All records were reviewed by a dietitian and checked for accuracy of portion sizes, preparation methods, and types or brands of foods. The second FFQ was sent to the mothers about 6 mo after the first FFQ. Nutrient values were derived from each of diet records and FFQ using the Japanese Standard Tables of Food Composition, 5th revised and enlarged edition, published by the Science and Technology Agency of Japan. Fatty acid composition was evaluated using data published by Sasaki et al. (14).

Statistical analyses. To assess the validity of the FFQ, the median nutrient values estimated from the two 3-d diet records were compared with those from the second FFQ by Wilcoxon paired-sample test and the relative

| Table 1. Daily nutrient intakes assessed with two 3-d diet records and FFQ and their correlations. |
|----------------------------------|----------------------------------|----------------------------------|
|                                  | Diet record                      | Median (95% CI)                  | FFQ                              | Median (95% CI)                  | Spearman correlation coefficients |
| Energy (kcal)                    | 1,442 (1,372–1,552)              | 1,483 (1,411–1,657)              | 0.34                             | *                                |
| Protein (g)                      | 49.7 (46.9–52.7)                 | 54.5 (50.2–59.1)                 | 0.40                             | **                               |
| Total fat (g)                    | 47.8 (44.3–51.8)                 | 48.1 (44.7–53.1)                 | 0.24                             | **                               |
| Saturated fat (g)                | 15.9 (14.2–17.4)                 | 16.2 (14.9–17.6)                 | 0.32                             | *                                |
| Monounsaturated fat (g)          | 16.6 (15.5–17.9)                 | 16.6 (15.2–18.4)                 | 0.23                             | *                                |
| Polyunsaturated fat (g)          | 9.2 (8.6–10.0)                   | 9.8 (8.4–10.5)                   | 0.32                             | *                                |
| Cholesterol (mg)                 | 236 (211–255)                    | 254 (228–281)                    | 0.41                             | **                               |
| Carbohydrate (g)                 | 200.5 (192.3–217.9)              | 213.4 (197.5–241.3)              | 0.38                             | **                               |
| Calcium (mg)                     | 488 (444–530)                    | 560 (502–624)                    | 0.48                             | **                               |
| Magnesium (mg)                   | 172 (165–187)                    | 204 (188–225)                    | 0.53                             | **                               |
| Phosphorus (mg)                  | 816 (769–842)                    | 920 (828–996)                    | 0.44                             | **                               |
| Iron (mg)                        | 5.5 (5.0–5.9)                    | 5.8 (5.3–7.0)                    | 0.50                             | **                               |
| Zinc (mg)                        | 6.0 (5.8–6.5)                    | 6.8 (6.2–7.2)                    | 0.48                             | **                               |
| Sodium (mg)                      | 2,480 (2,365–2,646)              | 2,650 (2,480–3,089)              | 0.48                             | **                               |
| Potassium (mg)                   | 1,824 (1,696–1,959)              | 2,145 (1,979–2,366)              | 0.47                             | **                               |
| Vitamin A (µg)                   | 418 (366–465)                    | 479 (446–601)                    | 0.59                             | **                               |
| Retinol (µg)                      | 169 (137–176)                    | 187 (170–201)                    | 0.59                             | **                               |
| α-Carotene (µg)                  | 494 (412–593)                    | 605 (547–720)                    | 0.27                             | **                               |
| β-Carotene (µg)                  | 2,279 (1,916–2,792)              | 3,005 (2,681–3,443)              | 0.35                             | *                                |
| Cryptoxanthin (µg)               | 468 (271–523)                    | 262 (190–430)                    | 0.31                             | *                                |
| Carotene 1 (µg)                  | 2,756 (2,330–3,201)              | 3,466 (3,083–4,288)              | 0.41                             | **                               |
| Vitamin B1 (mg)                  | 0.70 (0.68–0.75)                 | 0.80 (0.73–0.91)                 | 0.40                             | **                               |
| Vitamin B2 (mg)                  | 0.94 (0.92–1.01)                 | 1.05 (0.93–1.16)                 | 0.48                             | **                               |
| Vitamin B3 (mg)                  | 0.86 (0.79–0.91)                 | 1.03 (0.91–1.10)                 | 0.45                             | **                               |
| Vitamin B12 (mg)                 | 3.6 (3.1–4.3)                    | 4.5 (4.1–5.7)                    | 0.53                             | **                               |
| Folate (µg)                       | 221 (199–234)                    | 258 (229–313)                    | 0.38                             | **                               |
| Niacin (mg)                       | 10.1 (9.1–10.9)                  | 12.2 (10.7–13.3)                 | 0.46                             | **                               |
| Vitamin C (mg)                   | 85 (76–93)                       | 91 (79–109)                      | 0.22                             | **                               |
| Vitamin D (µg)                   | 3.3 (3.0–3.8)                    | 5.0 (4.5–5.8)                    | 0.14                             | **                               |
| α-Tocopherol (mg)                | 5.2 (4.8–5.5)                    | 5.6 (5.0–6.1)                    | 0.05                             | **                               |
| Dietary fiber (mg)               | 9.4 (8.9–10.5)                   | 10.6 (9.2–11.6)                  | 0.37                             | **                               |
| Salt (g)                          | 6.3 (6.0–6.7)                    | 6.7 (6.3–7.9)                    | 0.49                             | **                               |

1 Retinol equivalents.
2 β-carotene equivalents.
*p<0.05 for correlation coefficient or difference in estimates between diet record and FFQ.
**p<0.01 for correlation coefficient or difference in estimates between diet record and FFQ.
validity was determined by the correlation analysis. Spearman rank correlation coefficient was used for this analysis because the distribution was skewed in most of the nutrients. The second FFQ was used for the validity analysis as it represents the time period during which the diet records were collected. For the reproducibility of the FFQ, nutrient estimates were compared between the first and second FFQ administrations and Spearman rank correlation coefficients were calculated. All the statistical analyses were performed using SAS programs (SAS Institute Inc., Cary, NC, USA).

**RESULTS**

Table 1 shows the nutrient intakes estimated from the diet records and the FFQs as well as their correlation coefficients. Except for total energy, fats and some vitamins, the median intake estimated from the second FFQ was significantly higher than that derived from diet records. Spearman correlation coefficients between the diet records and the second FFQ ranged from 0.05 for α-tocopherol to 0.59 for retinol. The median correlation coefficient was 0.40. The correlations for total fat, monounsaturated fat, vitamin C, vitamin D, retinol, and β-carotene were lower than 0.30. For reproducibility of the FFQ, the mean estimates of vitamin B12 and vitamin D differed significantly between the first and second FFQs. Spearman correlation coefficients above 0.50 were found for all the nutrients listed (Table 2). The correlations ranged from 0.53 for vitamin D to 0.85 for carotene. The results were similar when lunches and snacks served at schools were not included (data not shown).

**DISCUSSION**

In the previous six studies on the validity of FFQ to assess general nutrient intake among normal children...
aged 5–6 y, diet records or 24-h recall was commonly used as the validation standard (5–9). Three studies (5–7) used an FFQ based on the Willett FFQ (15). In a study reported by Stein et al. (6), correlation coefficients for estimates of nutrient intake between FFQ and diet records were generally weak to moderate among children aged 44 to 60 mo (ranging from 0.16 for polyunsaturated fat to 0.60 for potassium). On the other hand, in another study using Willett FFQ (7), the average correlation was as high as 0.52 (ranging from 0.26 for dietary fiber to 0.60 for magnesium) among children aged 1 to 5 y. One study (8), in which the Block FFQ (16) was used, reported moderate correlations (r = 0.40 to 0.55) but only four nutrients were assessed. The remaining studies used their own developed FFQs (9, 10). The correlation coefficients between the FFQ and one 3-d diet record ranged from 0.021 for fiber to 0.686 for calcium among Brazilian children aged 5 to 10 y (9). The median correlation coefficient between the FFQ and four 1-d diet records was 0.55 among Japanese children aged 3 to 11 y (10). The heterogeneity of study design hinders the comparison among the five studies, but relatively high correlations were observed in three studies in which the referent period was only 1 mo (7, 9, 10).

Our FFQ had generally weak to moderate correlations with diet records. The correlation coefficients for total fat, monounsaturated fat, and vitamins C, D and E were less than 0.30. The low correlation for monounsaturated fat resulted in a low correlation for total fat. In the two studies based on the Willett FFQ, the correlation for total fat intake was high (r = 0.62) in one (7) but low (r = 0.19 in boys and r = 0.28 in girls) in the other (6). The latter study assessed diet during the previous 6 mo (6), and the former assessed that during the previous 4 wk (7). A low correlation for total fat was also reported in the study among Brazilians (r = 0.153) in spite of the short duration of assessment (1 mo) (9). Among the studies that assessed diet during more than 1 mo, only the study by Stein et al. (6) reported correlations according to the types of fat; the correlation coefficients for saturated fat and polyunsaturated fat were 0.27 and 0.04, respectively, in boys and 0.27 and 0.24, respectively, in girls. These values are comparable to those in our study. Only four (6, 8–10), out of six studies reported the validation results for total energy, with correlations ranging from 0.28 to 0.66. The results from our study as well as those from previous studies indicate that assessing the diet of children by FFQ is difficult. Total fat and total energy are dispersed through many foods. Therefore, our FFQ may have missed the foods that could fairly discriminate these intakes between individuals, which may explain the observed low correlation for total fat as well as total energy.

For most of the nutrients, intake estimates using the FFQ were higher than those estimated from diet records. The FFQ used close-ended questions with predefined portion sizes, while in the diet records the amount of food consumed was recorded. The portion size assigned to food items in the FFQ may have been overestimated. A number of questionnaires, mainly food-based FFQs have been widely employed especially in Western populations, which are typically based on the consumption of a single food. Kim et al. (17) reported potential advantages of a dish-based FFQ over a food-based FFQ to assess the Korean diet. Japanese also eat many kinds of mixed dishes. Thus, we included several names of dishes as well as food items into our FFQ. Mixed dishes were broken down to individual foods for the estimation of nutrient intakes. Overestimation may have occurred for some foods which were listed as single food items and included in mixed dishes as ingredients. It is also possible that foods consumed rarely were not reported on the diet records, because the probability of assessing such foods on the two 3-d diet records is low. Previous studies have yielded higher intake for FFQ than for recall or record (5, 6, 8, 9). For example, in the study using the Willett FFQ, the mean intake estimates derived from the FFQ were 1.4–1.9 times higher than those derived from 24-h recall (6). In general, FFQs are better at ranking, rather than quantifying, usual intake (4). However, we have to keep in mind that our FFQ cannot capture the absolute values of nutrients. Calibration approach to make the estimates obtained through the FFQ closer to the quantities actually consumed should be considered in our future study.

Acceptable repeatability was shown in our study. Two previous studies measured the reproducibility of FFQs administered 6 mo apart. Shea et al. (18) noted intra-class correlations of 0.39 for energy, 0.38 for total fat, 0.37 for saturated fat and 0.19 for cholesterol. Stein et al. (6) reported a wide range of correlations (coefficient alpha), ranging from 0.17 for sodium to 0.73 for total energy.

Limitations of the present study include the small sample size and the limited number of days to measure habitual food intake. A sample size of at least 50, and preferably much larger (100 or more subjects, say) is thought to be desirable (19). The use of the mean of two 3-day diet records would not be enough to obtain stable estimates of the usual intake of children. However, the extent to which repeat dietary records are administered to estimate the habitual diets of children has not been established. With respect to tracking of diet, Stein et al. (20) reported that despite intra-individual day-to-day variation, the underlying dietary habits were reasonably stable over a 19-mo period in US children aged 45–60 mo. However, we are not sure whether 6 mo was appropriate as the referent period for FFQ in our study subjects. There was a decrease in the median intake of energy or some nutrients after 6 mo based on the FFQs. Similarly, the median of total energy derived from the second 3-d diet records was lower than that from the first 3-d diet records (1.408 vs. 1.472 kcal). It is unlikely that the children actually ate less. It could be due to seasonal change or omission of some foods they had as the mothers became tired of repeating diet records or FFQ. In the light of seasonal variation, the administrations of FFQ with an interval of 6 mo cannot
give a complete picture of the reproducibility and is thus also a limitation of the study. Our study subjects were likely to be highly motivated, and may therefore have responded differently to an FFQ than other populations. They may also have had different dietary habits. Selection of these subjects may have affected the results. The study subjects were children aged 6 y. The results could not be transferable to another age group. Our FFQ included the estimation of intake from lunches and snacks served at preschools or schools since most children do not eat all of their meals at home. The validation results were similar regardless of the inclusion or exclusion of lunches and snacks served at school. However, the recording of school lunches or snacks on the 3-d diet records was done by the mother. If dietitian or teachers had measured and recorded the leftovers and snacks at school, the reports likely would have been more accurate. As in our study, meals consumed at school were also recorded in writing in the study among Brazilian children (9). Another study did not include children’s consumption at times when they were not under the direct supervision of the parents (6). In the other studies, whether school lunches or snacks were considered on the FFQs is not clear.

In conclusion, our FFQ had validity coefficients similar to those of FFQs in previous studies. For epidemiologic studies, our FFQ could reasonably rank individuals according to the intakes, although the use would be limited to specific nutrients. Additional refinements for estimating nutrient intakes of preschool children. Am J Epidemiol 135: 667–677.

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