Original Article

Food frequency questionnaire reproducibility for middle-aged and elderly Japanese

Koutatsu Maruyama PhD[1,2,3], Ai Ikeda PhD[2,3], Junko Ishihara PhD[3,4], Ribeka Takachi PhD[3,5], Norie Sawada MD, PhD[3], Taichi Shimazu MD, PhD[3], Kazutoshi Nakamura MD, MPH[6], Junta Tanaka MD, PhD[7], Taiki Yamaji MD, PhD[3], Motoki Iwasaki MD, PhD[3], Hiroyasu Iso MD, PhD[8], Shoichiro Tsugane MD, PhD[3] for the JPHC-NEXT Protocol Validation Study Group

[1]*Laboratory of Community Health and Nutrition, Special Course of Food and Health Science, Department of Bioscience, Graduate School of Agriculture, Ehime University, Ehime, Japan.*
[2]*Department of Public Health, Juntendo University Graduate School of Medicine, Tokyo, Japan*
[3]*Epidemiology and Prevention Group, Center for Public Health Sciences, National Cancer Center, Tokyo, Japan*
[4]*Department of Food and Life Science, School of Life and Environmental Science, Azabu University, Kanagawa, Japan.*
[5]*Department of Food Science and Nutrition, Faculty of Human Life and Environment, Graduate School of Humanities and Sciences, Nara Women's University, Nara, Japan*
[6]*Division of Preventive Medicine, Niigata University Graduate School of Medical and Dental Sciences, Niigata, Japan.*
[7]*Department of Health Promotion Medicine, Niigata University Graduate School of Medical and Dental Sciences, Niigata, Japan.*
[8]*Public Health, Department of Social Medicine, Graduate School of Medicine, Osaka University, Osaka, Japan*

Background and Objectives: The aim of this study was to examine the reproducibility of a self-administered food frequency questionnaire (FFQ) originally developed for the Japan Public Health Center-Based Prospective Study (JPHC study) and modified for use in the Next Generation (JPHC-NEXT) study. **Methods and Study Design:** Participants included 98 men and 142 women aged 40–74 years from the five areas included in the JPHC-NEXT protocol. In November 2012, participants were recruited and asked to complete the first nutrition survey. The second nutrition survey was completed after 1 year. **Results:** We estimated daily energy as well as 53 nutrient and 29 food group intakes using the FFQ. To assess reproducibility, we calculated Spearman correlation coefficients between both FFQs, which showed mostly intermediate-to-high values. Median (range) correlation coefficients and quartile distribution in the same and adjacent categories for energy-adjusted nutrient intakes were 0.55 (0.42–0.84) and 84.7% (76.5%–98.0%) in men and 0.54 (0.35–0.80) and 84.5% (76.1%–94.4%) in women. The respective values for energy-adjusted food group intakes in men and women were also mostly intermediate to high: 0.54 (0.39–0.79) and 83.7% (75.5%–90.8%) in men and 0.57 (0.40–0.83) and 84.5% (77.5%–93.7%) in women. **Conclusions:** The FFQ developed for the JPHC-NEXT study has reasonable reproducibility. Because this FFQ has also been validated in a previous study, it can be considered a useful dietary assessment tool to examine associations between dietary consumption and lifestyle-related diseases.

Key Words: FFQ, reproducibility, cohort study, Japanese, lifestyle-related diseases

INTRODUCTION

Food frequency questionnaires (FFQs) are a major assessment tool for evaluating diet through food and nutrient intake measurements.[1] Numerous FFQs have been developed to adapt to characteristics of study populations. The Japan Public Health Center-Based Prospective Study (JPHC Study), one of the largest prospective cohort studies in Japan conducted since 1989, included a self-administered FFQ (JPHC-FFQ) to examine associations

Corresponding Author: Dr Koutatsu Maruyama, Laboratory of Community Health and Nutrition, Special Course of Food and Health Science, Department of Bioscience, Graduate School of Agriculture, Ehime University. 3-5-7 Tarumi, Matsuyama, Ehime 790-8566, Japan.
Tel: +81-89-946-9960; Fax: +81-89-946-9960
Email: maruyama.kotatsu.rt@ehime-u.ac.jp; m_koutatsu_@hotmail.com
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between dietary habits and lifestyle-related diseases.

The JPHC-FFQ has reasonable validity compared with 28-day dietary records and reasonable reproducibility at 1-year intervals.[2-6] We modified the JPHC-FFQ and developed two FFQs (short and long versions) for the Japan Public Health Center-Based Prospective Study for the Next Generation (JPHC-NEXT), a prospective cohort study that began in 2011.[7] A previous study examined validation of the short and long versions of the FFQ compared with 12-day weighted dietary records and revealed that both versions had reasonable validity for major nutrient and food group intakes.[7] However, FFQ reproducibility, another major reliability index for dietary surveys, has not yet been examined.[1] Because two long-version FFQ surveys were conducted repeatedly 1-year apart, but the short-version FFQ survey was conducted only once,[7] we could not examine the reproducibility of the short-version FFQ. Thus, the objective of this study was to examine the reproducibility of the long-version FFQ developed for middle-aged and elderly Japanese people.

METHODS

Study design and participants

Participants were recruited from the five areas included in the JPHC-NEXT protocol (Yokote, Saku, Chikusei, Murakami, and Uonuma). The details of that study are described elsewhere.7 Participants were recruited and completed the first nutrition survey in November 2012. The second nutrition survey was conducted after 1 year (November 2013) in the five areas (Figure 1).

To examine FFQ reproducibility, 255 healthy men and women from the five areas were enrolled. We excluded 15 men and women from the analysis either because they were not aged between 40 and 74 years (n=13), which is an inclusion criterion for the JPHC-NEXT protocol, or they did not completely answer both FFQs (n=2). Data from the 98 men and 142 women aged 40–74 years were then used for the analyses.

This study was approved by the Institutional Review Board of the National Cancer Center in Tokyo, Japan, and all other collaborating research institutions. All participants provided written informed consent to participate in the study.

FFQ and sociodemographic data

The FFQ comprises 172 food and beverage items and 9 frequency categories ranging from “almost never” to “7 or more times per day” (or “10 or more glasses per day,” for beverages). The FFQ comprises questions about the usual consumption of listed foods during the previous year. The details and relative reasonable validity of the FFQ are described elsewhere.[7]

The estimated amount of each food item was calculated as a standard or selected portion size multiplied by frequency, which was translated to portion per day. Estimated daily energy as well as 53 nutrient and 29 food group intakes included in the FFQ were calculated using the Standard Tables of Food Composition in Japan (2010),[8] the Standard Tables of Food Composition in Japan for Fatty Acids (Fifth Revised and Enlarged Edition 2005),[9] and a specifically developed food composition table for isoflavones in Japanese foods.[10]

A self-administrated questionnaire at second survey was used to assess height, weight, smoking (current/ ex-/ never smoker) and educational attainment (junior high school/high school/some college/college or more).[7] Body mass index (BMI) was calculated as the self-reported weight (kg) divided by the square of self-reported height (m).

Statistical analysis

All nutrient and food group intakes were adjusted for energy intake by using residual methods after logarithmic transformation in both men and women. We calculated the mean, standard deviation, and median values for energy and each nutrient and food group for each FFQ. We examined the differences in energy, nutrient, and food group intakes between the first and second surveys by using the Wilcoxon signed-rank test. To assess reproducibility, we calculated the Spearman correlation coefficients and agreement of quartile distributions between the FFQs. SAS version 9.4 (SAS Inc., Cary, NC, USA) was used for statistical analyses.

RESULTS

Reproducibility of nutrient intakes

Table 1 shows sociodemographic characteristics in the men and women. The mean (standard deviation) age and

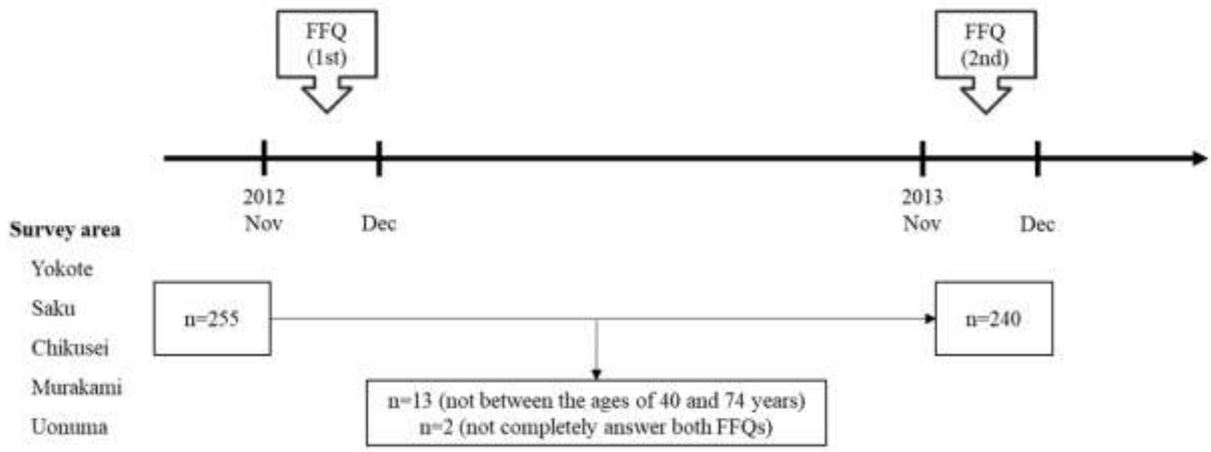

Figure 1. Data collection sequence in this study

Table 1. Sociodemographic characteristics among 98 men and 142 women aged 40–74 years†

	Men		Women	
Age (years)	57.4	(8.6)	57.0	(8.6)
BMI (kg/m^2)	23.7	(2.8)	22.8	(3.1)
Alcohol drinking				
Never/almost never	11	(11.2)	78	(54.9)
Sometimes‡	43	(43.9)	55	(38.7)
Everyday	44	(44.9)	9	(6.3)
Smoking status				
Never smoker	23	(23.5)	132	(93.0)
Ex-smoker	49	(50.0)	7	(4.9)
Current smoker	26	(26.5)	3	(2.1)
Educational attainment				
Junior high school	9	(9.2)	13	(9.2)
High school	37	(37.8)	51	(35.9)
Some college	25	(25.5)	65	(45.8)
College or more	27	(27.6)	11	(7.7)
Other	0	(0.0)	2	(1.4)

†Age and BMI are expressed as mean (SD). Alcohol drinking, smoking status and educational attainment are expressed as number (%).
‡Between 1-3 days/month and 5-6 days/week.

BMI were 57.4 (8.6) years and 23.7 (2.8) kg/m^2 in men and 57.0 (8.6) years and 22.8 (3.1) kg/m^2 in women, respectively. The proportions of current smokers, drinking every day and college or more were 26.5%, 44.9% and 27.6% among men and 2.1%, 6.3% and 7.7% among women, respectively.

Table 2 lists the mean, standard deviation, and median values and Spearman correlation coefficients between the FFQs for nutrient intakes in the men and women. We observed higher intakes of cholesterol, retinol, vitamin B2, vitamin B12, and biotin, and lower intake of calcium in the second survey than in the first survey in women, but no differences in men. Spearman correlation coefficients between the two FFQs revealed mostly intermediate-to-high values and were significant. The median (range) value of the Spearman correlation coefficients for crude intakes of energy and nutrients was 0.61 (0.48–0.82). This correlation was unaltered after adjustment for energy intake (0.55; 0.42–0.84). Similar Spearman correlation coefficients were observed in women. The respective median (range) values of Spearman correlation coefficients for crude and energy-adjusted intakes were 0.68 (0.54–0.82) and 0.54 (0.35–0.80).

Percentages of agreement of quartile distribution of energy and energy-adjusted nutrient intakes between the two FFQs are shown in Table 3. Similar correlations in Spearman correlation coefficients were observed. Energy, ethanol, potassium, copper, and vitamin C intakes exhibited relatively higher percentages in the same and adjacent categories and lower percentages in the extreme categories in both men and women. By contrast, selenium, retinol, and vitamin B1 intakes, which exhibited lower Spearman correlation coefficients, had relatively lower percentages in the same and adjacent categories and higher percentages in the extreme categories in both men and women. The median (range) values in the same and adjacent categories of quartile distribution were 84.7% (76.5%–98.0%) in men and 84.5% (76.1%–94.4%) in women.

Reproducibility of food group intakes

Table 4 shows the mean, standard deviation, and median values and Spearman correlation coefficients between the FFQs of food group intakes in men and women. Higher intakes of potatoes, starches, and coffee were observed in the second survey than in the first survey in men. Moreover, higher intakes of eggs and milk and dairy products and lower intakes of confectionaries were observed in the second survey than in the first survey in women. Spearman correlation coefficients for each sex were mostly intermediate-to-high values and were statistically significant. The respective median (range) values of Spearman correlation coefficients for crude and energy-adjusted intakes were 0.58 (0.42–0.78) and 0.54 (0.39–0.79) in men and 0.65 (0.50–0.84) and 0.57 (0.40–0.83) in women.

The percentages of agreement of quartile distribution of the energy-adjusted food group intakes between the two FFQs were also similar to the Spearman correlation coefficients (Table 5). White and pickled vegetables, milk and dairy products, alcoholic beverages, green tea, coffee, and seasoning and spice intakes had relatively high percentages in the same and adjacent categories and low percentages in the extreme categories in both men and women. However, cereal, cruciferous vegetable, and meat intakes had relatively low percentages in the same and adjacent categories and high percentages in the extreme categories in both men and women. The median (range) values in the same and adjacent categories of quartile distribution were 83.7% (75.5%–90.8%) in men and 84.5% (77.5%–93.7%) in women.

We also re-examined 107 men and 146 women, including 13 persons who were not aged 40–74 years. The Spearman correlation coefficients were unaltered, and the median (range) values of the Spearman correlation coefficients for energy-adjusted nutrient and food group intakes were 0.54 (0.35–0.80) and 0.57 (0.41–0.83) in men and 0.57 (0.44–0.85) and 0.54 (0.41–0.79) in women.

Table 2. Daily energy and nutrient intakes according to FFQs and their correlations among 98 men and 142 women aged 40–74 years

	Men						Women					
	First		Second		Spearman correlation coefficients		First		Second		Spearman correlation coefficients	
	Mean (SD)	Median	Mean (SD)	Median	Crude intake	Energy adjusted intake	Mean (SD)	Median	Mean (SD)	Median	Crude intake	Energy adjusted intake
Energy (kcal)	2516 (1413)	2135	2390 (697)	2251	0.60		2040 (757)	1938	2036 (671)	1886	0.71	
Water (g)	2935 (1375)	2495	2915(1089)	2672	0.55	0.46	2630 (957)	2463	2665 (1009)	2517	0.72	0.64
Protein (g)	86.8 (71.1)	70.2	78.8 (31.8)	70.5	0.59	0.61	75.7 (39.7)	68.2	76.7 (30.0)	70.7	0.65	0.48
Sum of amino acid residues (g)	35.0 (26.8)	28.0	31.1 (11.0)	29.9	0.61	0.55	31.5 (16.0)	27.4	31.6 (13.3)	28.8	0.66	0.59
Total fat (g)	70.6 (89.3)	51.8	61.1 (29.3)	52.8	0.58	0.53	64.3 (39.7)	57.4	64.5 (29.8)	58.7	0.67	0.50
Total fat in % energy	22.6 (8.2)	22.6	22.5 (6.1)	22.2	0.51	0.54	27.0 (6.5)	26.5	27.5 (5.7)	27.4	0.54	0.50
Saturated fatty acid (g)	20.3 (24.4)	15.0	17.5 (9.3)	15.9	0.57	0.50	18.1 (10.8)	15.9	19.0 (10.5)	16.3	0.64	0.53
Monounsaturated fatty acid (g)	25.9 (35.2)	18.5	22.6 (11.1)	20.0	0.56	0.55	23.7 (14.6)	20.6	23.6 (11.1)	21.3	0.66	0.44
Polyunsaturated fatty acid (g)	15.8 (19.4)	11.6	13.7 (6.8)	12.4	0.61	0.58	15.0 (13.0)	12.9	14.1 (6.4)	12.9	0.64	0.52
n-3 PUFA (g)	3.2 (5.3)	2.2	2.6 (1.4)	2.4	0.63	0.58	2.8 (1.8)	2.4	2.7 (1.4)	2.4	0.67	0.49
n-6 PUFA (g)	12.6 (14.1)	9.3	11.0 (5.6)	9.7	0.60	0.56	12.2 (11.5)	10.5	11.3 (5.2)	10.2	0.64	0.54
Triacylglycerol equivalents (g)	64.7 (81.9)	47.7	56.1 (26.9)	48.9	0.58	0.53	59.3 (37.6)	53.6	59.3 (27.6)	54.2	0.67	0.51
Cholesterol (mg)	363.2 (431.0)	247.2	341.1 (341.3)	244.4	0.66	0.56	265.8 (192.1)	244.6	316.5 (229.4)	272.8*	0.62	0.52
Carbohydrate (g)	316.5 (113.1)	298.0	309.7 (100.5)	302.9	0.71	0.62	280.7 (87.4)	260.2	276.7 (87.0)	257.0	0.74	0.54
Total dietary fiber (g)	16.3 (14.1)	12.5	14.5 (7.0)	13.0	0.60	0.52	18.9 (11.0)	16.6	17.6 (8.6)	15.8	0.72	0.58
Water soluble fiber (g)	3.8 (3.4)	2.9	3.4 (1.8)	3.1	0.59	0.52	4.5 (2.7)	4.0	4.2 (2.1)	3.7	0.71	0.58
Water insoluble fiber (g)	12.0 (10.7)	8.8	10.6 (5.1)	9.8	0.61	0.52	13.9 (8.2)	12.2	12.9 (6.2)	11.5	0.72	0.58
Sodium (mg)	5053 (5298)	4033	4360 (2077)	3889	0.62	0.64	4546 (2366)	4089	4480 (2080)	4020	0.74	0.66
Potassium (mg)	3483 (2982)	2686	3142 (1298)	2883	0.65	0.68	3594 (1743)	3399	3610 (1587)	3167	0.76	0.67
Calcium (mg)	665 (547)	501	595 (393)	476	0.62	0.63	697 (461)	624	754 (474)	632*	0.72	0.67
Magnesium (mg)	375 (246)	309	353 (130)	320	0.62	0.63	364 (195)	335	359 (143)	311	0.74	0.62
Phosphorus (mg)	1356 (974)	1094	1247 (514)	1111	0.61	0.52	1235 (610)	1175	1278 (537)	1202	0.68	0.53
Iron (mg)	10.5 (9.0)	8.4	9.7 (4.1)	8.7	0.61	0.72	10.0 (5.5)	9.0	9.7 (3.8)	8.9	0.69	0.58
Zinc (mg)	10.0 (6.9)	8.7	9.3 (3.2)	8.6	0.55	0.49	8.7 (3.8)	8.1	8.7 (3.1)	8.2	0.66	0.48
Copper (mg)	1.46 (0.85)	1.24	1.40 (0.50)	1.33	0.66	0.66	1.45 (0.80)	1.31	1.38 (0.49)	1.26	0.69	0.62
Manganese (mg)	4.70 (3.15)	4.06	4.50 (1.94)	4.21	0.68	0.67	4.40 (1.77)	4.09	4.31 (1.77)	3.78	0.69	0.65
Iodine (µg)	240 (353)	156	202 (192)	157	0.48	0.53	237 (231)	171	252 (251)	183	0.58	0.52
Selenium (µg)	78 (79)	60	66 (31)	60	0.54	0.46	65 (38)	55	64 (30)	58	0.61	0.44
Chromium (µg)	8 (7)	6	7 (4)	6	0.68	0.54	8 (4)	7	8 (4)	7	0.77	0.35
Molybdenum (µg)	257 (131)	235	249 (84)	243	0.70	0.69	233 (157)	215	224 (96)	213	0.54	0.50

All correlation coefficients were statistically significant ($p<0.001$).
*$p<0.05$ (Wilcoxon signed-rank test).

Table 2. Daily energy and nutrient intakes according to FFQs and their correlations among 98 men and 142 women aged 40–74 years (cont.)

	Men						Women					
	First		Second		Spearman correlation coefficients		First		Second		Spearman correlation coefficients	
	Mean (SD)	Median	Mean (SD)	Median	Crude intake	Energy adjusted intake	Mean (SD)	Median	Mean (SD)	Median	Crude intake	Energy adjusted intake
Retinol (µg)	428 (706)	169	342 (359)	182	0.49	0.45	269 (297)	160	343 (474)	197*	0.57	0.39
Alpha-carotene (µg)	439 (426)	278	458 (449)	275	0.61	0.60	704 (978)	463	672 (1030)	414	0.65	0.58
Beta-carotene (µg)	3486 (5574)	2256	3022 (2377)	2531	0.64	0.61	4672 (4152)	3640	4443 (4016)	3411	0.74	0.62
Cryptoxanthin (µg)	841 (1171)	403	607 (544)	522	0.57	0.54	1446 (1547)	895	1335 (1580)	1030	0.72	0.58
Beta carotene equivalents (µg)	4130 (5804)	2655	3562 (2671)	2973	0.62	0.61	5741 (4729)	4466	5446 (4698)	4403	0.72	0.58
Retinol equivalents (µg)	776 (1115)	498	642 (468)	530	0.55	0.53	750 (516)	635	800 (668)	651	0.70	0.49
Vitamin D (µg)	10.7 (16.4)	6.9	9.1 (5.9)	8.0	0.51	0.44	9.5 (9.6)	7.2	9.6 (6.9)	8.3	0.63	0.55
Alpha-tocopherol (mg)	8.8 (10.2)	6.9	8.0 (4.0)	7.2	0.57	0.59	9.9 (6.9)	8.9	9.3 (4.6)	8.6	0.68	0.45
Beta-tocopherol (mg)	0.5 (0.5)	0.4	0.4 (0.2)	0.4	0.58	0.42	0.5 (0.3)	0.4	0.4 (0.2)	0.4	0.67	0.49
Gamma-tocopherol (mg)	13.2 (16.7)	10.2	11.1 (6.1)	9.8	0.65	0.52	13.4 (11.1)	12.1	12.3 (6.4)	10.9	0.62	0.49
Delta-tocopherol (mg)	3.1 (3.6)	2.5	2.6 (1.9)	2.3	0.68	0.57	3.1 (3.3)	2.7	2.8 (1.6)	2.5	0.63	0.55
Vitamin K (µg)	324 (450)	224	270 (163)	239	0.67	0.62	360 (374)	288	341 (236)	287	0.62	0.54
Vitamin B-1 (mg)	1.15 (1.11)	0.91	1.02 (0.40)	0.97	0.54	0.44	1.11 (0.49)	1.09	1.10 (0.45)	1.02	0.74	0.46
Vitamin B-2 (mg)	1.65 (1.41)	1.30	1.46 (0.77)	1.30	0.59	0.52	1.53 (0.78)	1.40	1.65 (0.80)	1.52*	0.66	0.52
Niacin (mg)	26.9 (22.5)	20.5	24.9 (9.8)	23.3	0.60	0.43	23.1 (12.2)	21.1	22.6 (8.8)	21.6	0.73	0.59
Vitamin B-6 (mg)	1.83 (1.68)	1.42	1.64 (0.63)	1.55	0.63	0.55	1.64 (0.80)	1.49	1.61 (0.67)	1.47	0.75	0.63
Vitamin B-12 (µg)	9.5 (14.5)	6.2	7.7 (4.5)	7.2	0.61	0.59	7.1 (5.2)	5.8	7.5 (4.6)	6.7*	0.64	0.54
Folate (µg)	462 (492)	345	403 (204)	361	0.63	0.66	488 (269)	432	484 (239)	435	0.73	0.68
Pantothenic acid (mg)	8.35 (5.78)	6.79	7.63 (3.21)	6.86	0.59	0.52	7.91 (4.05)	7.40	8.08 (3.48)	7.27	0.68	0.53
Biotin (µg)	46.7 (29.9)	40.1	44.0 (18.2)	39.8	0.64	0.54	42.7 (19.3)	39.5	44.0 (18.1)	40.3*	0.72	0.61
Vitamin C (mg)	149 (170)	94	123 (86)	113	0.66	0.66	188 (122)	157	184 (110)	166	0.78	0.66
Daidzein (mg)	17.44 (16.70)	13.14	17.12 (16.62)	13.23	0.66	0.65	19.89 (30.82)	15.03	17.28 (12.43)	14.65	0.66	0.61
Genistein (mg)	28.42 (27.40)	21.63	28.16 (27.89)	21.77	0.67	0.64	33.10 (52.39)	24.50	28.57 (20.88)	23.77	0.66	0.61
Ethanol (g)	32.8 (30.6)	26.0	35.1 (30.7)	31.1	0.82	0.84	3.8 (8.2)	0.0	4.3 (8.9)	0.0	0.82	0.80
Median					0.61	0.55					0.68	0.54

All correlation coefficients were statistically significant ($p<0.001$).
*$p<0.05$ (Wilcoxon signed-rank test).

Table 3. Comparison of the two FFQs for energy and energy-adjusted nutrient intakes based on cross-classification by quartile in men and women

	Men			Women		
	Same category (%)	Same and adjacent category (%)	Extreme category (%)	Same category (%)	Same and adjacent category (%)	Extreme category (%)
Energy	51.0	87.8	12.2	54.2	90.1	9.9
Water	39.8	79.6	20.4	47.2	86.6	13.4
Protein	37.8	84.7	15.3	39.4	78.9	21.1
Sum of amino acid residues	37.7	83.6	16.3	44.4	82.4	17.6
Total fat	43.9	78.6	21.4	39.4	82.4	17.6
Total fat in % energy	45.9	78.6	21.4	40.1	81.7	18.3
Saturated fatty acid	35.7	80.6	19.4	45.1	81.7	18.3
Monounsaturated fatty acid	40.8	84.7	15.3	43.7	79.6	20.4
Polyunsaturated fatty acid	48.0	84.7	15.3	41.6	84.5	15.5
n-3 PUFA	45.9	81.6	18.4	41.6	80.3	19.7
n-6 PUFA	50.0	85.7	14.3	44.4	81.7	18.3
Triacylglycerol equivalents	42.9	78.6	21.4	43.7	82.4	17.6
Cholesterol	43.9	81.6	18.4	44.4	86.6	13.4
Carbohydrate	43.9	82.6	17.3	41.6	87.3	12.7
Total dietary fiber	40.8	78.6	21.4	43.0	85.9	14.1
Water soluble fiber	37.7	79.6	20.4	48.6	84.5	15.5
Water insoluble fiber	33.7	79.6	20.4	40.1	85.9	14.1
Sodium	36.7	86.7	13.3	49.3	89.4	10.6
Potassium	51.0	90.8	9.2	45.8	87.3	12.7
Calcium	50.0	85.7	14.3	45.1	85.9	14.1
Magnesium	52.0	87.7	12.2	44.4	86.6	13.4
Phosphorus	44.9	81.6	18.4	40.2	83.8	16.2
Iron	51.0	90.8	9.2	47.9	85.2	14.8
Zinc	40.8	84.7	15.3	40.9	81.0	19.0
Copper	40.8	88.8	11.2	45.1	87.3	12.7
Manganese	46.9	86.7	13.3	52.8	85.9	14.1
Iodine	45.9	83.7	16.3	40.8	83.8	16.2
Selenium	37.7	76.5	23.5	37.3	76.1	24.0
Chromium	39.8	85.7	14.3	38.0	77.5	22.5
Molybdenum	46.9	90.8	9.2	44.4	80.3	19.7
Retinol	40.8	79.6	20.4	46.5	78.2	21.8
Alpha-carotene	50.0	87.7	12.2	45.8	85.9	14.1
Beta-carotene	44.9	84.7	15.3	50.0	87.3	12.7
Cryptoxanthin	40.8	81.6	18.4	42.3	83.8	16.2
Beta carotene equivalents	45.9	84.7	15.3	38.0	84.5	15.5
Retinol equivalents	43.9	81.6	18.4	42.3	81.7	18.3
Vitamin D	38.8	80.6	19.4	38.7	84.5	15.5
Alpha-tocopherol	57.2	84.7	15.3	41.6	79.6	20.4
Beta-tocopherol	42.8	80.6	19.4	38.0	80.3	19.7
Gamma-tocopherol	43.9	83.7	16.3	41.6	81.7	18.3
Delta-tocopherol	49.0	85.7	14.3	45.1	80.3	19.7
Vitamin K	45.9	88.8	11.2	47.2	85.2	14.8
Vitamin B-1	34.7	77.5	22.4	38.0	79.6	20.4
Vitamin B-2	36.7	81.6	18.4	44.4	82.4	17.6
Niacin	36.7	79.6	20.4	57.0	87.3	12.7
Vitamin B-6	44.9	84.7	15.3	46.5	86.6	13.4
Vitamin B-12	49.0	84.7	15.3	45.1	82.4	17.6
Folate	52.0	85.7	14.3	53.5	86.6	13.4
Pantothenic acid	44.9	83.7	16.3	48.6	82.4	17.6
Biotin	40.8	86.7	13.3	52.1	85.9	14.1
Vitamin C	54.1	90.8	9.2	48.6	88.0	12.0
Daidzein	43.9	88.8	11.2	50.7	84.5	15.5
Genistein	39.8	86.7	13.3	51.4	85.2	14.8
Ethanol	62.3	98.0	2.0	61.3	94.4	5.6
Median	43.9	84.7	15.3	44.4	84.5	15.5

DISCUSSION

In this study, we confirmed the reproducibility of a self-administered long-version FFQ developed for the JPHC-NEXT protocol and observed reasonable reproducibility at 1-year intervals for major energy, nutrient, and food group intakes.

The median (range) values of the Spearman correlation coefficients for energy-adjusted major nutrient and food intakes of the JPHC-FFQ at 1-year intervals were 0.49 (0.30–0.82) and 0.50 (0.41–0.71) in men and 0.50 (0.32-0.68) and 0.49 (0.30–074) in women, respectively.[11] A review of 21 Japanese FFQs revealed that correlation

Table 4. Daily food-group intakes according to the FFQs and their correlations among 98 men and 142 women aged 40–74 years

	Men						Women					
	First		Second		Spearman correlation coefficients		First		Second		Spearman correlation coefficients	
	Mean (SD) (g)	Median (g)	Mean (SD) (g)	Median (g)	Crude	Energy adjusted	Mean (SD) (g)	Median (g)	Mean (SD) (g)	Medi-an (g)	Crude	Energy adjusted
Cereals	623 (239)	580	637 (264)	596	0.59	0.53	481 (126)	480	472 (131)	467	0.50	0.40
Rice	441 (185)	510	460 (177)	510	0.61	0.55	329 (110)	330	326 (100)	330	0.55	0.56
Potatoes and starches	34 (31)	25	37 (29)	30*	0.56	0.49	47 (52)	36	44 (31)	35	0.70	0.57
Sugar	1 (6)	0	0 (2)	0	0.42	0.54	1 (2)	0	1 (1)	0	0.52	0.55
Pulses	73 (82)	49	78 (105)	53	0.62	0.59	94 (159)	58	77 (66)	58	0.64	0.56
Vegetables	312 (464)	200	277 (217)	222	0.56	0.52	374 (258)	312	359 (227)	315	0.69	0.59
Green and yellow	139 (223)	80	132 (153)	85	0.50	0.54	164 (124)	137	156 (114)	130	0.65	0.56
White vegetables	173 (255)	102	145 (104)	125	0.58	0.50	209 (159)	170	202 (132)	173	0.69	0.59
Pickled vegetables	43 (73)	19	33 (49)	20	0.64	0.64	49 (65)	23	46 (54)	26	0.74	0.74
Cruciferous vegetables	66 (122)	40	55 (50)	41	0.58	0.55	79 (81)	58	81 (66)	62	0.69	0.58
Fruits	195 (244)	114	147 (127)	120	0.70	0.59	267 (218)	212	260 (230)	197	0.76	0.59
Citrus fruit	62 (88)	28	43 (42)	36	0.55	0.53	101 (102)	64	103 (159)	73	0.72	0.55
Other fruit	130 (180)	70	102 (102)	71	0.69	0.60	164 (141)	126	155 (126)	123	0.75	0.59
Fungi	11 (12)	7	11 (11)	7	0.44	0.40	18 (18)	13	16 (12)	13	0.62	0.59
Algae	8 (8)	5	8 (10)	5	0.62	0.59	8 (7)	6	9 (15)	6	0.66	0.54
Fish and shellfish	93 (160)	58	76 (48)	70	0.58	0.54	77 (67)	57	76 (53)	64	0.63	0.55
Meats	87 (137)	52	71 (48)	59	0.51	0.43	56 (43)	48	56 (38)	53	0.58	0.49
Processed meat	12 (22)	6	10 (10)	7	0.54	0.49	9 (8)	7	9 (8)	8	0.57	0.57
Red meat	51 (122)	26	40 (31)	31	0.42	0.42	30 (25)	25	30 (23)	24	0.53	0.45
Poultry	21 (27)	12	19 (20)	13	0.54	0.42	16 (16)	11	16 (16)	11	0.57	0.50
Eggs	43 (73)	25	44 (73)	25	0.65	0.60	27 (35)	25	37 (49)	25*	0.58	0.55
Milk and dairy products	247 (341)	126	200 (263)	131	0.59	0.59	252 (296)	207	314 (340)	210*	0.65	0.60
Fats and oils	14 (25)	10	12 (6)	11	0.57	0.46	14 (8)	13	14 (8)	12	0.60	0.41
Confectionaries	20 (25)	14	18 (23)	11	0.69	0.69	32 (27)	23	28 (23)	20*	0.71	0.54
Alcoholic beverages	398 (398)	311	420 (384)	375	0.77	0.79	72 (143)	0	88 (198)	0	0.82	0.80
Non-alcoholic beverages	670 (445)	583	709 (430)	604	0.49	0.39	663 (351)	601	694 (417)	600	0.60	0.57
Green tea	346 (444)	181	337 (373)	256	0.66	0.65	371 (340)	300	401 (419)	300	0.77	0.76
Coffee	265 (233)	239	299 (261)	276*	0.78	0.73	228 (195)	179	236 (204)	197	0.84	0.83
Seasonings and spices	24 (17)	21	22 (12)	20	0.71	0.69	24 (13)	21	23 (13)	22	0.80	0.75
Median					0.58	0.54					0.65	0.57

All correlation coefficients were statistically significant (p<0.001).
*p<0.05 (Wilcoxon signed-rank test).

Table 5. Comparison of energy-adjusted food groups between the two FFQs based on cross-classification by quartile in men and women

	Men			Women		
	Same category (%)	Same and adjacent category (%)	Extreme category (%)	Same category (%)	Same and adjacent category (%)	Extreme category (%)
Cereals	43.9	81.6	18.4	41.6	77.5	22.5
Rice	43.9	85.7	14.3	52.8	84.5	15.5
Potatoes and starches	43.9	80.6	19.4	45.1	83.8	16.2
Sugar	56.1	82.6	17.3	54.2	81.7	18.3
Pulses	44.9	88.8	11.2	45.8	83.8	16.2
Vegetables	43.9	82.6	17.3	42.3	83.8	16.2
Green and yellow	42.9	83.7	16.3	40.9	85.2	14.8
White vegetables	37.8	85.7	14.3	43.7	88.0	12.0
Pickled vegetables	49.0	89.8	10.2	55.6	93.7	6.3
Cruciferous vegetables	41.8	81.6	18.4	43.7	83.1	16.9
Fruits	46.9	84.7	15.3	33.1	87.3	12.7
Citrus fruit	48.0	84.7	15.3	48.6	85.2	14.8
Other fruit	48.0	88.8	11.2	43.7	84.5	15.5
Fungi	35.7	78.6	21.4	43.0	85.2	14.8
Algae	40.8	83.7	16.3	44.4	85.2	14.8
Fish and shellfish	49.0	83.7	16.3	46.5	83.8	16.2
Meats	33.7	78.5	21.4	41.5	80.3	19.7
Processed meat	38.8	81.6	18.4	40.8	84.5	15.5
Red meat	34.7	75.5	24.5	40.1	78.9	21.1
Poultry	33.7	77.5	22.4	38.0	81.0	19.0
Eggs	51.0	83.7	16.3	39.4	84.5	15.5
Milk and dairy products	49.0	85.7	14.3	45.8	85.9	14.1
Fats and oils	37.8	83.7	16.3	38.0	81.7	18.3
Confectionaries	48.0	87.7	12.2	39.4	82.4	17.6
Alcoholic beverages	63.3	90.8	9.2	63.4	93.7	6.3
Non-alcoholic beverages	32.6	76.5	23.5	47.9	83.1	16.9
Green tea	51.0	86.7	13.3	54.9	93.7	6.3
Coffee	58.2	90.8	9.2	69.0	93.0	7.1
Seasonings and spices	43.9	88.8	11.2	54.9	89.4	10.6
Median	43.9	83.7	16.3	43.7	84.5	15.5

between two administrations of the same FFQ at 9- and 12-month intervals ranged from 0.50 to 0.72.[12] Furthermore, several major cohort studies outside Japan also examined the 9- to 14-month interval reproducibility of the FFQs. The mean (range) correlation coefficients for assessing the reproducibility for major nutrients among nurses in the United States, health professionals in the United States, and men in Shanghai were 0.62 (0.52–0.71), 0.59 (0.38–0.79), and 0.46 (0.38–0.53), respectively.[13-15]

According to previous studies, the correlation coefficients for assessing the reproducibility of dietary nutrient intakes ranged from 0.50 to 0.70.[1] In the present study, we observed that the Spearman correlation coefficients for energy-adjusted nutrient or food group intakes (excluding zinc, selenium, alpha-tocopherol, vitamin B1, meats, fats, and oils) for both men and women were greater than 0.50, which is sufficient for examining the association between diet and lifestyle-related diseases. Therefore, this FFQ has relatively high 1-year interval reproducibility for energy as well as major nutrient and food intakes compared with other FFQs, including the JPHC-FFQ.

The strength of this study is that we observed reasonable reproducibility despite the original version of this FFQ being developed based on weighted food records of the JPHC Study in 1989–1991.[2-6] Intraindividual variations in food intakes, which may influence reproducibility, may have been larger due to the development and expansion of the food service industry, transportation network, and convenience stores over the past two to three decades.[16-17] However, this FFQ comprises reasonable food items that contribute to estimate the major nutrient intakes.[7] Therefore, the findings of this study may be time independent. Other strengths of the study are the small number of dropouts (n=2), enrollment of participants from most regions of the JPHC-NEXT in 2011, and adequate number of men and women.

Some limitations of this study must be discussed. Because the participants of this study were not randomly selected, volunteer bias may have occurred, meaning that the results may be overestimated. Another limitation is that we examined the reproducibility for only a 1-year interval. The Nurses' Health Study found a decline in correlation coefficients for the reproducibility of their FFQ over 18 years.[1] Therefore, when we analyze the data for longer follow-up periods, the reasonable reproducibility observed in this study may also decline.

Conclusion

The FFQ developed for the JPHC-NEXT protocol to estimate habitual nutrition and food group intake has reasonable reproducibility. The FFQ also has reasonable validity compared with 12-day dietary records.[7] Therefore, the FFQ used in this study shows reasonable reliability and is useful for detecting associations between dietary consumption and lifestyle-related diseases.

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AUTHOR DISCLOSURES
The authors declare no conflict of interest.

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