RESEARCH COMMUNICATION

Validity and Reproducibility of the PC-assisted Dietary Interview Used in the Fukuoka Colorectal Cancer Study

Kazuhiro Uchida[1], Yasumi Kimura[2], Tomoko Shirota[1], Suminori Kono[2]*

Abstract

Epidemiologic studies based on quantitative estimation of food and nutrient intake have been limited in Japan. We evaluated validity and reproducibility of a personal computer (PC)-assisted dietary interview used in the Fukuoka Colorectal Cancer Study. The subjects were 28 participants as controls in a population-based case-control study. Four 7-day diet records were kept during a period from July 2001 to May 2002, and the PC-assisted dietary interview was administered before and after the diet records (May to July 2001 and July to September 2002). Intakes of total energy, 26 nutrients, and 19 food groups were estimated. Of 26 Pearson correlation coefficients for energy-adjusted nutrients, 18 for the first interview and 19 for the second interview were 0.40 or greater, with the highest correlation for saturated fat in the first interview (0.72) and vitamin C in the second interview (0.60). Validity scores were fairly high for most of the food groups with an exceptionally low correlation for potatoes (0.19 for the first and 0.13 for the second interview). Reproducibility was good for most nutrients and foods; but low correlation was noted for Vitamin D and nuts/seeds. Reproducibility was modest for fish and fish products, beef and pork, and processed meat. The PC-assisted dietary interview was fairly valid and reproducible regarding most of the nutrients and food groups. Validity and reproducibility of meat and fish intakes were probably attenuated because of the episode of bovine spongiform encephalopathy in September 2001.

Key Words: Dietary assessment - diet record - epidemiology - reproducibility - validity

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Introduction

Dietary factors play an important role in the development of chronic diseases such as cancer and cardiovascular diseases. Measurement of habitual long-term intakes of foods and nutrients has been of major interest in nutritional epidemiology in the past decades (Willett, 1990; Sempos, 1992; Cade et al., 2002). Of several methods measuring individual's intakes of foods and nutrients, the food frequency questionnaire (FFQ), with or without quantitative assessment, has been used most frequently in epidemiologic studies primarily because of easy administration in a large number of subjects (Willett, 1990; Cade et al., 2002). While quantitative estimation of food and nutrient intake by FFQ has been done successfully for epidemiologic studies of chronic diseases such as cancer and cardiovascular diseases in Europe and North America (Willett et al., 1985; Block et al., 1986; Pietinen et al., 1988; Rimm et al., 1992; Goldbohm et al., 1994; Margetts and Pietinen, 1997; Stram et al., 2000), epidemiologic studies based on quantitative estimation of food and nutrient intakes have been limited in Japan (Hirohata et al., 1987; Shimizu et al., 1999). Recently, semiquantitative or quantitative FFQ have been developed to estimate the habitual intakes of foods and nutrients with aims of applying to epidemiologic studies in Japan (Tsubono et al., 1996; Tokudome et al., 1998; Wakai et al., 1999; Lee et al., 2002; Tsugane et al., 2003a).

Quantification is generally difficult in the dietary assessment using a questionnaire even if typical portion sizes are given in the questionnaire (Sempos, 1992). Pictures showing serving sizes of food and dish items were presented to increase accuracy in quantitative estimation (Pietinen et al., 1988; Stram et al., 2000). On the other hand, personal computers (PC) were used to facilitate administration of a dietary questionnaire and data management (Smucker et al., 1989; Slattery et al., 1994). We developed a PC-assisted quantitative dietary assessment for use in the Fukuoka Colorectal Cancer Study, a case-control study to elucidate the role for dietary and other behavioral factors and genetic susceptibility factors in colorectal carcinogenesis (Kono et al., 2004). This paper describes validity of the PC-assisted dietary interview in comparison with a 28-day diet record as well as its reproducibility over one year.

Materials and Methods

Study design and subjects

In the validation study, intakes of nutrients and foods estimated by the PC-assisted dietary interview were

*[1]Division of Food and Nutrition, Nakamura Gakuen University Junior College,Fukuoka [2]Department of Preventive Medicine, Kyushu University Faculty of Medical Sciences, Fukuoka, Japan * For Correspondence: E-mail: skono@phealth.med.kyushu-u.ac.jp*

compared with those estimated from the diet records kept over 7 consecutive days in each of the 4 seasons (Figure 1). The first and second dietary interviews were administered with an interval of one year before and after the diet records, and reproducibility was evaluated on the basis of the two interviews. The study protocol was approved in conjunction with the main study by the ethics committee of Kyushu University Faculty of Medical Sciences.

Study subjects were those who participated as controls in the Fukuoka Colorectal Cancer Study. Details of the methods of this population-based case-control study have been described previously (Kono et al., 2004). A total of 60 persons aged 40-64 years interviewed for the period of May to July 2001 were consecutively asked to participate in the validation study. Of these, 35 started to record their diets, and 28 persons completed the diet records. A gratitude of 20,000 Japanese yen was awarded after the completion of the record for the four weeks.

Dietary interview

A questionnaire was used for research nurses to perform a uniform interview regarding multifaceted lifestyle factors except diets. Individuals answered dietary questions with reference to the past one year before the interview. The dietary interview was administered by using a PC-software, which was developed with support from an external laboratory (Core Create Systems, Kitakyushu), so as to help individuals to report consumption of specific foods and dishes. A total of 149 items of foods and beverages were selected with reference to dietary questionnaires developed previously in Japan (Tsubono et al., 1996; Tokudome et al., 1998; Lee et al., 2002). Beef and pork were combined for most of the food items. Typical dishes for each food item were shown on the PC display, together with typical portion sizes (see Appendix). In-season consumption was ascertained regarding selected seasonal foods and dishes. The collected information was the same as obtained usually by the quantitative FFQ. As for consumption frequency, different numbers of response categories were prepared for boiled plain rice (staple food in Japan), food items other than rice, and non-alcoholic and alcoholic beverages. Options for serving size were 0.5, 1, 1.5, and 2 of the size displayed as a reference for most of the food items; 4 pictures of serving size were displayed for boiled plain rice. Supplementary questions included an inquiry about consumption of fat portion of beef/pork and skin of chicken at table and consumption of noodle soup. Three precoded answers were prepared for the consumption of fat portion of beef/pork, skin of chicken, and noodle soup (all, half, or null consumed). Regarding one-pot dishes, the order of consumption frequency of 5 types of dishes and proportions of meat and vegetables eaten were ascertained.

Diet records

Diet records were kept over a period of 7 consecutive days in 4 seasons in accordance with the method used in the Japanese National Nutrition Survey (Ministry of Health and Labour and Welfare, 2000). Detailed instruction was given in person by either of two dieticians in charge as to how to record the foods and beverages prior to the first record. Dieticians visited the participants or contacted them by telephone to confirm whether the record was done appropriately once during the week, and confirmed completeness of recording when the recorded forms were collected. Diet records was kept by 17 participants in person (2 men and 15 women) and by wives of 11 male participants. Amounts of foods used for each dish and of beverages taken for breakfast, lunch, supper, and between-meal snacks were weighed or alternatively estimated with reference to the list of estimated amounts. Dietetic scale apparatus were provided when needed. A set of forms recording 7-day diets was given together with an example form of recording.

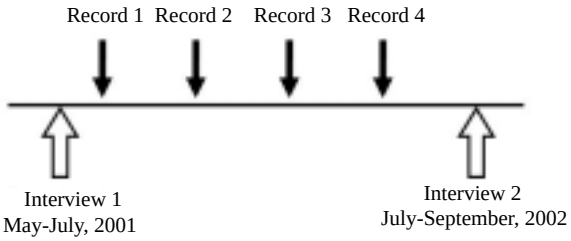

Figure 1. Time Sequence of Diet Validation Study. Four 7-day diet records were kept in July to August 2001, October to November 2001, January to February 2002, and April to May 2002

As for the second to fourth records, the instruction and record forms were mailed to each participant. Individuals in charge of recording were contacted by telephone once each week to answer any problems in recording. The recorded forms were returned by mail. For each one-week record, the record forms were inspected for completeness by the two dieticians, and ambiguous records were solved by asking persons in charge of recording by telephone or in person.

Calculation of intakes of nutrients and food groups

Based on the interview data, 149 food/dish items in the PC software were collapsed into 211 food items to calculate nutrient intake. Some items in the PC software were mixed dishes and collective foods (such as beef/pork and ham/sausage), and such composite items were disaggregated to the ingredient level of individual foods on the basis of typical recipes and market statistics. Of these 211 food items, 202 items corresponded to foods listed in the Food Composition Tables in Japan (Science and Technology Agency, 2000). An appropriate food could not be assigned to the remaining 9 items (5 groups of fish for different cookings, miso, vegetables oils, oranges other than mandarin, and pickles of non-green vegetables), and composition data were created from the diet records in the present study.

Diet records were analysed to calculate intakes of nutrients and food groups by using an add-in software of Microsoft EXCEL (Yoshimura, 2001) based on the Food Composition Tables in Japan (Science and Technology Agency, 1986, 1989, 2000). For each of the reported foods that were not in the Food Composition Tables, an expert dietician, one of the authors (KU), chose the most appropriate substitute food in the Food Composition

Table 1. Daily Intakes of Energy and Nutrients Estimated by Four 7-day Diet Records and by Interviews

Nutrient (unit)	Record		Interview 1		Interview 2	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Energy (kcal)	2125.1	(426.7)	2402.0	(664.5)	2375.4	(621.2)
Protein (g)	80.5	(17.8)	85.5	(25.9)	86.1	(24.5)
Total fat (g)	60.9	(13.5)	77.2	(26.7)	78.5	(29.0)
Saturated fat (g)	16.9	(4.3)	19.7	(6.7)	20.4	(7.1)
MUFA (g)	20.8	(5.1)	24.7	(9.0)	25.6	(9.2)
PUFA	13.4	(3.4)	19.0	(7.2)	18.6	(6.8)
n-6 PUFA (g)	10.6	(2.8)	14.5	(5.5)	15.0	(6.6)
n-3 PUFA (g)	2.9	(0.8)	3.4	(1.3)	3.6	(1.4)
Cholesterol (mg)	350.6	(102.9)	345.6	(142.4)	338.3	(131.4)
Carbohydrates (g)	283.2	(53.1)	295.1	(67.3)	296.0	(77.5)
Calcium (mg)	604.2	(212.3)	722.7	(276.1)	718.0	(292.1)
Magnesium (mg)	323.6	(91.9)	348.1	(105.5)	333.2	(99.7)
Iron (mg)	10.5	(3.7)	10.0	(3.2)	10.1	(3.3)
Retinol (μg)	258.2	(162.3)	500.4	(324.7)	520.6	(534.3)
Carotene (μg)	4026.0	(3205.2)	5244.2	(2796.4)	5049.0	(3097.6)
Vitamin D (μg)	10.4	(4.2)	10.1	(5.6)	10.1	(4.9)
Vitamin E (mg)	9.4	(3.6)	13.3	(5.2)	12.6	(4.9)
Vitamin B1 (mg)	1.1	(0.3)	1.11	(0.36)	1.1	(0.4)
Vitamin B2 (mg)	1.5	(0.4)	1.63	(0.53)	1.7	(0.6)
Vitamin B6 (mg)	1.5	(0.4)	1.59	(0.53)	1.5	(0.4)
Vitamin B12 (μg)	8.9	(4.9)	9.6	(5.0)	9.6	(5.0)
Folate (μg)	407.8	(156.5)	421.0	(141.2)	424.8	(165.5)
Vitamin C (mg)	118.3	(41.8)	142.8	(60.1)	136.4	(51.8)
Dietary fiber (g)	16.1	(6.2)	17.3	(6.1)	17.1	(6.5)
Soluble fiber (g)	3.5	(1.1)	4.1	(1.5)	4.1	(1.7)
Insoluble fiber (g)	11.3	(4.3)	12.2	(4.2)	12.0	(4.4)
Methionine (mg)	1582.8	(384.6)	1712.2	(541.4)	1715.2	(464.7)

MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

Tables. It was possible to calculate intakes of total energy, 39 nutrients, 20 amino acids, and 36 individual fatty acids. Analyzed in the present study were intakes of total energy, 26 nutrients, and 19 food groups.

Statistical analysis

Mean and standard deviation are shown regarding absolute intakes of nutrients and foods. Pearson and Spearman correlation coefficients were used to examine the agreement in nutrient and food intakes in the validation and reproducibility studies. The distributions of most nutrients and foods were skewed toward higher values, and thus natural-log transformation was done for all of the dietary variables. Nutrient and food intakes adjusted for total energy intake were calculated by the regression residual method (Willett, 1990). Using intakes for each of the 28 days, the ratios of within-subject variance to between-subject variance (Armitage et al., 2002) and deattenuation coefficients to correct for within-subject random variation (Willett, 1990) were calculated on the basis of analysis of variance. Intraclass correlation coefficients were calculated over 4 seasons, with average daily intakes for each season as values of each individual, using two-way analysis of variance. All statistical computations were done by using the SAS version 8.2 (SAS Institute, Inc., Cary, North Carolina).

Results

Average daily intakes of energy and nutrients estimated from the dietary interview were generally greater than those derived from the 28-day record, whereas there was no material difference in estimated intakes between the first and second interview (Table 1). Total energy intake and fat intake estimated from the interview were approximately 10% and 30%, respectively, greater as compared with those based on the record data. The difference between record and interview was fairly large for retinol and vitamin E intake.

As regards food groups (Table 2), while average intakes of cereals, rice, and bread estimated from the first and second interviews were almost the same as those based on the diet records, intakes of potatoes, nuts and seeds, and alcoholic beverages in the first, not second, interview were larger than the estimates from the records. Noodles, soy and soy products, vegetables, milk, and fats and oils showed no difference between the first and second interview, but intakes of these food groups were larger in the interview than in the record.

Correlation coefficients of nutrient intakes estimated from the diet records with those from the first and second interview were generally high although the correlation for energy intake was much lower for the second interview (Table 3). Spearman correlation coefficients were almost the same as Pearson correlation coefficients regarding most nutrients. Energy adjustment substantially decreased correlation coefficients for protein, cholesterol, and vitamin D in the first interview, and increased correlation coefficients for protein, polyunsaturated fatty acids (PUFA), n-3 PUFA, and vitamin E in the second interview. Of 26 Pearson correlation coefficients for energy-adjusted nutrients, 18 for the first interview and 19 for the second

Table 2. Daily Intakes of Food Groups Estimated by Four 7-day Diet Records and by Interviews

Food group (unit)	Record		Interview 1		Interview 2	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
Cereals (g)	470	(126)	472	(144)	488	(155)
Rice (g)	335	(146)	325	(150)	329	(167)
Bread (g)	52	(43)	49	(38)	55	(65)
Noodles (g)	74	(39)	91	(56)	96	(59)
Potatoes (g)	38	(16)	53	(37)	37	(22)
Soy and soy products (g)	60	(37)	96	(53)	98	(49)
Nuts and seeds (g)	4	(3)	7	(11)	4	(5)
Vegetables (g)	255	(92)	331	(134)	342	(169)
Fruits and fruit juice (g)	108	(80)	136	(88)	113	(65)
Fish and fish product (g)	85	(36)	88	(47)	85	(40)
Beef and pork (g)	36	(18)	41	(19)	45	(26)
Processed meat (g)	12	(7)	9	(9)	10	(10)
Poultry (g)	20	(13)	24	(22)	26	(26)
Eggs (g)	38	(14)	29	(17)	27	(16)
Milk (g)	62	(74)	83	(69)	76	(81)
Other dairy products (g)	41	(45)	44	(49)	54	(52)
Fats and oils (g)	10	(5)	11	(6)	13	(9)
Confectionaries (g)	34	(22)	34	(42)	39	(40)
Alcohol[a] (g)	14	(18)	23	(27)	16	(17)

[a]Alcoholic beverages as expressed by ethanol amount.

interview were 0.40 or greater; and correlation coefficients of 0.60 or greater numbered 5 for the first interview and one for the second interview. Intakes of n-3 PUFA in the second interview and vitamin D in the both interviews showed low correlation coefficients.

Intakes of foods estimated from the first and second interview each showed fairly high correlations with the estimates from the diet records, with the highest correlation coefficients for rice, bread, milk, and alcohol (Table 4). No marked change occurred after adjustment for energy intake regarding almost all food groups with an exception for fish and fish products. Potato intakes estimated from the first and second interview both showed a very low correlation with the record-based estimate. Relatively low

Table 3. Pearson (and Spearman) Correlation Coefficients of Energy and Nutrient Intakes in the Natural Log-scale Between Diet Records and Interviews

Nutrient	Interview 1 versus record		Interview 2 versus record	
	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted
Energy	0.56 (0.61)		0.34 (0.33)	
Protein	0.65 (0.58)	0.36 (0.24)	0.22 (0.13)	0.41 (0.40)
Total fat	0.67 (0.47)	0.70 (0.60)	0.23 (0.09)	0.53 (0.62)
Saturated fat	0.74 (0.67)	0.72 (0.70)	0.37 (0.24)	0.56 (0.51)
MUFA	0.69 (0.55)	0.66 (0.63)	0.35 (0.23)	0.56 (0.67)
PUFA	0.52 (0.39)	0.42 (0.41)	0.17 (0.02)	0.48 (0.52)
n-6 PUFA	0.46 (0.36)	0.41 (0.37)	0.27 (0.15)	0.54 (0.57)
n-3 PUFA	0.49 (0.41)	0.34 (0.36)	0.04 (0.03)	0.22 (0.21)
Cholesterol	0.61 (0.54)	0.28 (0.34)	0.21 (0.15)	0.20 (0.19)
Carbohydrates	0.44 (0.43)	0.48 (0.50)	0.45 (0.44)	0.55 (0.51)
Calcium	0.61 (0.62)	0.59 (0.58)	0.33 (0.33)	0.55 (0.56)
Magnesium	0.53 (0.59)	0.41 (0.41)	0.22 (0.23)	0.38 (0.40)
Iron	0.44 (0.47)	0.35 (0.45)	0.17 (0.16)	0.26 (0.45)
Retinol	0.48 (0.45)	0.39 (0.34)	0.35 (0.30)	0.35 (0.36)
Carotene	0.43 (0.48)	0.40 (0.39)	0.39 (0.38)	0.48 (0.51)
Vitamin D	0.42 (0.42)	0.14 (0.07)	0.06 (0.11)	0.18 (0.13)
Vitamin E	0.46 (0.45)	0.45 (0.41)	0.08 (0.09)	0.34 (0.52)
Vitamin B1	0.65 (0.57)	0.63 (0.46)	0.18 (0.09)	0.44 (0.44)
Vitamin B2	0.64 (0.55)	0.57 (0.41)	0.35 (0.23)	0.49 (0.43)
Vitamin B6	0.52 (0.57)	0.61 (0.45)	0.28 (0.30)	0.56 (0.50)
Vitamin B12	0.30 (0.37)	0.13 (0.11)	0.33 (0.37)	0.48 (0.46)
Folate	0.48 (0.58)	0.48 (0.47)	0.37 (0.44)	0.55 (0.64)
Vitamin C	0.49 (0.42)	0.44 (0.42)	0.50 (0.42)	0.60 (0.53)
Dietary fiber	0.44 (0.48)	0.48 (0.51)	0.19 (0.28)	0.44 (0.50)
Soluble fiber	0.42 (0.43)	0.50 (0.53)	0.28 (0.28)	0.54 (0.52)
Insoluble fiber	0.41 (0.44)	0.44 (0.51)	0.18 (0.31)	0.40 (0.45)
Methionine	0.59 (0.55)	0.36 (0.27)	0.28 (0.20)	0.45 (0.42)

MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

Table 4. Pearson (and Spearman) Correlation Coefficients of Food Group Intakes in the Natural log-scale between Diet records and Interviews

Food group	Interview 1 vs. record		Interview 2 vs. record	
	Unadjusted	Energy-adjusted	Unadjusted	Energy-adjusted
Cereals	0.65 (0.68)	0.62 (0.70)	0.75 (0.81)	0.69 (0.70)
Rice	0.89 (0.84)	0.87 (0.69)	0.91 (0.88)	0.85 (0.65)
Bread	0.84 (0.74)	0.82 (0.69)	0.74 (0.72)	0.74 (0.72)
Noodles	0.47 (0.42)	0.46 (0.44)	0.57 (0.59)	0.60 (0.53
Potatoes	0.07 (0.02)	0.19 (0.21)	0.02 (0.05)	0.13 (0.18)
Soy and soy products	0.57 (0.50)	0.50 (0.52)	0.33 (0.35)	0.43 (0.38)
Nuts and seeds	0.65 (0.61)	0.44 (0.38)	0.26 (0.34)	0.29 (0.36)
Vegetables	0.40 (0.34)	0.44 (0.33)	0.43 (0.39)	0.60 (0.48)
Fruits and fruit juice	0.35 (0.38)	0.29 (0.33)	0.36 (0.28)	0.32 (0.31)
Fish and fish products	0.44 (0.39)	0.21 (0.27)	0.24 (0.36)	0.42 (0.55)
Beef and pork	0.66 (0.54)	0.70 (0.59)	0.22 (0.25)	0.33 (0.37)
Processed meat	0.60 (0.68)	0.57 (0.66)	0.28 (0.31)	0.29 (0.31)
Poultry	0.38 (0.42)	0.24 (0.28)	0.57 (0.63)	0.58 (0.66)
Eggs	0.62 (0.61)	0.53 (0.56)	0.37 (0.24)	0.41 (0.31)
Milk	0.82 (0.71)	0.80 (0.60)	0.67 (0.70)	0.63 (0.63)
Other dairy products	0.77 (0.81)	0.77 (0.76)	0.62 (0.83)	0.61 (0.81)
Fats and oils	0.56 (0.41)	0.58 (0.55)	0.35 (0.29)	0.50 (0.52)
Confectionaries	0.37 (0.37)	0.37 (0.35)	0.56 (0.40)	0.56 (0.40)
Alcohol[a]	0.61 (0.61)	0.65 (0.69)	0.76 (0.80)	0.58 (0.62)

[a]Alcoholic beverages as expressed by ethanol amount.

correlation coefficients were observed for nuts and seeds, beef and pork, processed meat in the second interview and for poultry as well as fish and fish products in the first interview.

Deattenuation coefficients based on the 28 day records were 1.10 or less for most of the nutrients and foods; i.e., correction for within-subject random variation did not increase most of the observed Pearson correlation coefficients by more than 10%. Nutrients and food groups with a deattenuation coefficient of greater than 1.10 were vitamin D (1.161), n-3 PUFA (1.104), noodles (1.146), potatoes (1.285), fish and fish products (1.136), beef/pork (1.139), processed meat (1.121), poultry (1.213), and eggs (1.164). Intraclass correlation coefficients over four seasons for these nutrients and food groups were: vitamin D 0.35, n-3 PUFA 0.40, noodles 0.24, potatoes 0.14, fish and fish products 0.44, beef/pork 0.46, processed meat 0.24, poultry 0.40, and eggs 0.29.

Table 5. Pearson (and Spearman) Correlation Coefficients of Energy and Nutrient Intakes in the Natural Log-scale Between the First and Second Interviews

Nutrient	Unadjusted	Energy-adjusted
Energy	0.64 (0.63)	
Protein	0.56 (0.49)	0.56 (0.47)
Total fat	0.61 (0.55)	0.80 (0.85)
Saturated fat	0.65 (0.54)	0.78 (0.77)
MUFA	0.63 (0.53)	0.74 (0.84)
PUFA	0.54 (0.50)	0.72 (0.76)
n-6 PUFA	0.63 (0.60)	0.81 (0.78)
n-3 PUFA	0.45 (0.40)	0.51 (0.47)
Cholesterol	0.45 (0.31)	0.42 (0.43)
Carbohydrates	0.68 (0.65)	0.69 (0.67)
Calcium	0.74 (0.73)	0.89 (0.85)
Magnesium	0.65 (0.60)	0.68 (0.73)
Iron	0.62 (0.62)	0.64 (0.69)
Retinol	0.71 (0.70)	0.56 (0.49)
Carotene	0.64 (0.62)	0.66 (0.62)
Vitamin D	0.10 (0.14)	0.17 (0.29)
Vitamin E	0.63 (0.65)	0.79 (0.78)
Vitamin B1	0.64 (0.48)	0.59 (0.59)
Vitamin B2	0.72 (0.62)	0.66 (0.76)
Vitamin B6	0.61 (0.61)	0.67 (0.63)
Vitamin B12	0.51 (0.59)	0.36 (0.51)
Folate	0.75 (0.66)	0.72 (0.70)
Vitamin C	0.84 (0.79)	0.84 (0.88)
Dietary fiber	0.77 (0.74)	0.84 (0.80)
Soluble fiber	0.81 (0.79)	0.82 (0.84)
Insoluble fiber	0.75 (0.67)	0.83 (0.77)
Methionine	0.52 (0.44)	0.55 (0.42)

MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.

Reproducibility was good for most nutrients and foods, with fairly high correlation coefficients of 0.60-0.80 for both energy-unadjusted and energy-adjusted intakes (Tables 5 and 6). Correlation coefficients for reproducibility were fairly low for Vitamin D, nuts and seeds, fish and fish products, beef and pork, and processed meat.

Discussion

In the present study, habitual intakes of nutrients and foods assessed by a PC-assisted dietary interview were validated with reference to intakes estimated from 4 one-week diet records kept over one year. Most of the foods and nutrients under study were found to be moderately or highly valid with some exceptions as discussed below. Reproducibility was fairly good regarding most nutrients and food groups.

It is the most challenging to measure habitual intakes of nutrients and foods as reference values for validation. The method used in the present study, i.e., four 7-day diet records kept over one year, is probably the best achievable method because it substantially reduces the within-subject day-to-day variation as well as seasonal variation.

Table 6. Pearson (and Spearman) Correlation Coefficients of Food Group Intakes Between the Fisrt and Second Interviews

Food group	Unadjusted	Energy-adjusted
Cereals	0.60 (0.67)	0.73 (0.73)
Rice	0.85 (0.81)	0.92 (0.85)
Bread	0.79 (0.76)	0.78 (0.77)
Noodles	0.61 (0.58)	0.65 (0.60)
Potatoes	0.53 (0.51)	0.64 (0.65)
Soy and soy products	0.53 (0.59)	0.60 (0.62)
Nuts and seeds	0.09 (0.27)	0.07 (0.19)
Vegetables	0.67 (0.57)	0.68 (0.60)
Fruits and fruit juice	0.86 (0.80)	0.85 (0.81)
Fish and fish products	0.16 (0.27)	0.29 (0.26)
Beef and pork	0.23 (0.31)	0.22 (0.32)
Processed meat	0.25 (0.41)	0.29 (0.47)
Poultry	0.67 (0.64)	0.65 (0.44)
Eggs	0.41 (0.37)	0.53 (0.48)
Milk	0.75 (0.64)	0.74 (0.70)
Other dairy products	0.83 (0.78)	0.83 (0.74)
Fats and oils	0.64 (0.65)	0.70 (0.70)
Confectionaries	0.76 (0.61)	0.77 (0.58)
Alcohol[a]	0.83 (0.88)	0.77 (0.85)

[a]Alcoholic beverages as expressed by ethanol amount.

Previously, few studies relied upon the four 7-day diet records over one year (Willett et al., 1985; Tokudome et al., 2001; Lee et al., 2002; Tsugane et al., 2003a). With use of the statistical method for deattenuation, one study was based on 4-day diet records with a 3-month interval over one year (Egami et al., 1999; Wakai et al., 1999). Multiple 24-hour diet recalls over one year may be an alternative method in the validation study (Margetts & Pietinen, 1997; Shimizu et al., 1999; Shu et al., 2004). The method of multiple diet records or recalls over shorter periods of 2-6 months has also been employed for the assessment of the reference measure (Pietinen et al., 1988; Rimm et al., 1992; Goldbohm et al., 1994; Stram et al., 2000).

Another issue in validation study is whether the test instrument is administered before or after the period of diet records or recalls. In the present study, two dietary interviews before and after the diet records were validated, as reported in several studies (Willett et al., 1985; Pietinen et al., 1988; Rimm et al., 1992; Egami et al., 1999).

Validation has most frequently been evaluated for the test questionnaire administered subsequently to assessment of the reference measure (Goldbohm et al., 1994; Margetts and Pietinen 1997; Stram et al., 2000; Lee et al., 2002; Tsugane et al., 2003a; Shu et al., 2004). This sequence for validation is seemingly justified, but diet records or recalls may increase respondents' attention to their diets, thereby overestimating validity (Cade et al., 2002). It may be preferable to validate the test questionnaire administered prior to the diet records or recalls if the primary interest is to assess long-term habitual intakes (Tokudome et al., 2001). Higher validity scores were reported for the second questionnaire than for the first questionnaire in some studies (Willett et al., 1985; Rimm et al., 1992), but not always (Pietinen et al., 1988; Wakai et al., 1999). In the present study, for whatever reason, validity seemed better for the first interview than for the second one.

As for most of the foods and nutrients under study, the absolute intake estimated from the PC-based interview was greater than the intake based from the diet records. However, difference in the absolute intake does not necessarily cause a problem in epidemiological studies on diet and diseases because relative ranking of the individual's intake is a primary interest in studies of diet-disease relation (Willett, 1990; Cade et al., 2002).

Vitamin D and potatoes showed a fairly low validity in the present study. Vitamin D intake also showed a poor reproducibility. Even with deattenuation for the within-subject random variation in the diet records, Pearson correlation coefficients increased by no more than 16%. Only one study previously estimated vitamin D intake for validation in Japan, and reported a Pearson correlation coefficient of 0.55 without deattenuation (Tokudome et al., 2001). The present dietary method needs further improvement regarding the measurement of vitamin D intake. On the other hand, potato consumption showed a fairly high reproducibility. Therefore the diet records may not necessarily have captured habitual intake of potatoes correctly.

Validity scores for fish and fish products, beef and pork, and processed meat were rather low especially for the second dietary interview. Reproducibility was also relatively poor for these food groups. The incident of bovine spongiform encephalopathy (BSE) occurred in September 2001 in Japan (Mohri, 2005), and this episode probably affected meat consumption among the study subjects. Average daily intakes of beef/pork in the 4 periods (July to August 2001, October to November 2001, January to February 2002, and April to May 2002) were 31, 18, 24, and 28 g, respectively; intakes of poultry were 7, 14, 8, and 7 g, respectively; and intakes of fish and fish products were 71, 82, 80, and 67 g, respectively. These figures indicate a temporary decrease in beef/pork intake and reciprocal increases in fish and poultry intake. Daily intakes of processed meat in the 4 periods were 10, 4, 9, and 5 g, respectively. This temporal pattern was probably due to gift seasons of summer and winter. It is also conceivable that the BSE episode influenced the subjects' response with respect to meat intake in the second dietary interview.

In summary, the PC-assisted dietary interview used in the Fukuoka Colorectal Cancer Study was found to be fairly valid and reproducible regarding most of the nutrients and food groups under study. Validity and reproducibility of meat and fish were probably attenuated because of the episode of BSE in the middle of the study period.

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References

Armitage P, Berry G, Matthews JNS (2002). Statistical Methods in Medical Research. Blackwell Science, Oxford, pp218-23.

Block G, Hartman AM, Dresser CM, et al (1986). A data-based approach to diet questionnaire design and testing. *Am J Epidemiol*, **124**, 453-9.

Cade J, Thompson R, Burley V, et al (2002). Development, validation and utilisation of food-frequency questionnaires. A review. *Public Health Nutr*, **5**, 567-87.

Egami I, Wakai K, Kato K, et al (1999). A simple food frequency questionnaire for Japanese diet. Part II. Reproducibility and validity for nutrient intakes. *J Epidemiol*, **9**, 227-34.

Goldbohm RA, van den Brandt PA, Brants HA, et al (1994). Validation of a dietary questionnaire used in a large-scale prospective cohort study on diet and cancer. *Eur J Clin Nutr*, **48**, 253-65.

Hirohata T, Nomura AM, Hankin JH,et al (1987). An epidemiologic study on the association between diet and breast cancer. *J Natl Cancer Inst*, **78**, 595-600.

Kono S, Toyomura K, Yin G, et al (2004). A case-control study of colorectal cancer in relation to lifestyle factors and genetic polymorphisms: design and conduct of the Fukuoka Colorectal Cancer Study. *Asian Pac J Cancer Prev*, **5**, 393-400.

Lee KY, Uchida K, Shirota T, et al (2002). Validity of a self-administered food frequency questionnaire against 7-day dietary records in four seasons. *J Nutr Sci Vitaminol*, **48**, 467-76.

Margetts BM, Pietinen P (1997). European Prospective Investigation into Cancer and Nutrition: validity studies on dietary assessment methods. *Int J Epidemiol*, **26 (Suppl 1)**, S1-5.

Ministry of Health, Labour and Welfare, Japan (2000). The National Nutrition Survey in Japan, 1998. Dai-ichi-shupppan, Tokyo.

Mohri S (2005). Bovine spongiform encephalopathy (BSE) and its control. Meeting report of the 46th Annual Meeting of Japanese Clinical Viroligy Society. *Fukuoka Igaku Zasshi*, **96**, 335-6.

Pietinen P, Hartman AM, Haapa E, et al (1988). Reproducibility and validity of dietary assessment instruments. I. A self-administered food use questionnaire with a portion size picture booklet. *Am J Epidemiol*, **128**, 655-66.

Rimm EB, Giovannucci EL, Stampfer MJ, et al (1992). Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health professionals. *Am J Epidemiol*, **135**, 1114-26.

Sasaki S, Kobayashi M, Tsugane S (2003). Validity of a self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I: comparison with dietary records for food groups. *J Epidemiol*, **13 (Suppl 1)**, S57-S63.

Science and Technology Agency, Japan (1986). Standard Tables of Food Composition in Japan. Amino Acid Composition of Foods, Revised Edition. Ministry of Finance Printing Bureau, Tokyo.

Science and Technology Agency, Japan (1989). Standard Tables of Food Composition in Japan. Fatty acids, Cholesterol and Vitamin E (Tocopherols). Ministry of Finance Printing Bureau, Tokyo.

Science and Technology Agency, Japan (2000). Standard Tables of Food Composition in Japan, Fifth Revised Edition. Ministry of Finance Printing Bureau, Tokyo.

Sempos C (1992). Invited commentary: Some limitations of semiquantitative food frequency questionnaires. *Am J Epidemiol*, **135**, 1127-32.

Shimizu H, Ohwaki A, Kurisu Y, et al (1999). Validity and reproducibility of a quantitative food frequency questionnaire for a cohort study in Japan. *Jpn J Clin Oncol*, **29**, 38-44.

Slattery ML, Caan BJ, Duncan D, et al (1994). A computerized diet history questionnaire for epidemiologic studies. *J Am Diet Assoc*, **94**, 761-6.

Smucker R, Block G, Coyle L, et al (1989). A dietary and risk factor questionnaire and analysis system for personal computers. *Am J Epidemiol*, **129**, 445-9.

Shu XO, Yang G, Jin F, et al (2004). Validity and reproducibility of the food frequency questionnaire used in the Shanghai Women's Health Study. *Eur J Clin Nutr*, **58**, 17-23.

Stram DO, Hankin JH, Wilkens LR, et al (2000). Calibration of the dietary questionnaire for a multiethnic cohort in Hawaii and Los Angeles. *Am J Epidemiol*, **151**, 358-70.

Tokudome S, Ikeda M, Tokudome Y, et al (1998). Development of data-based semi-quantitative food frequency questionnaire for dietary studies in middle-aged Japanese. *Jpn J Clin Oncol*, **28**, 679-87.

Tokudome S, Imaeda N, Tokudome Y, et al (2001). Relative validity of a semi-quantitative food frequency questionnaire versus 28 day weighed diet records in Japanese female dietitians. *Eur J Clin Nutr*, **55**, 735-42.

Tsubono Y, Takamori S, Kobayashi M, et al (1996). A data-based approach for designing a semiquantitative food frequency questionnaire for a population-based prospective study in Japan. *J Epidemiol*, **6**, 45-53.

Tsugane S, Sasaki S, Kobayashi M, et al (2003a). Validity and reproducibility of the self-administered food frequency questionnaire in the JPHC Study Cohort I: study design, conduct and participant profiles. *J Epidemiol*, **13 (Suppl 1)**, S2-S12.

Tsugane S, Kobayashi M, Sasaki S (2003b). Validity of the self-administered food frequency questionnaire used in the 5-year follow-up survey of the JPHC Study Cohort I: comparison with dietary records for main nutrients. *J Epidemiol*, **13 (Suppl 1)**, S51-S6.

Wakai K, Egami I, Kato K, et al (1999). A simple food frequency questionnaire for Japanese diet. Part I. Development of the questionnaire, and reproducibility and validity for food groups. *J Epidemiol*, **9**, 216-26.

Willett WC (1990). Nutritional Epidemiology. Oxford University Press, New York, Oxford.

Willett WC, Sampson L, Stampfer MJ, et al (1985). Reproducibility and validity of a semiquantitative food frequency questionnaire. *Am J Epidemiol*, **122**, 51-65.

Yoshimura Y, Takahashi K (2001). Excel Eiyoukun Ver 3.0. Kenpakusha, Tokyo.

Appendix. List of Food and Dish Items Questioned in the PC-assisted Dietary Interview

Food/dish category	Food and dish item in question (number of displayed pictures)
Rice	Boiled plain rice (4); bowl of rice with meat (6); curry & rice (1); Chinese-style fried rice (3); sushi (5)
Meat with rice in bowl	Beef bowl (1); pork-cutlet bowl (1); chicken & egg bowl (1)
Noodles and pasta	Japanese noodles (4); Chinese noodles (1); champon (1); chow mein (3); cold Chinese noodles[a] (1); spaghetti (3); instant noodles (5); doria/gratin/pizza (3); okonomiyaki[b] (1)
Bread	Plain bread (5); croissant/brioche (2); sandwiches (6); hamburger/hot dog (3)
Spread	Butter (3); margarine (3); strawberry jam (4); honey (4)
Beef/pork dish	Broiled or fried beef/pork (6); beef/pork cutlet (3); boiled beef/pork (5); minced beef/pork (6); mixed dish with beef/pork (6); Chinese beef/pork dish (3); gyoza/shaomai[c] (5)
Processed meat	Ham/sausage (5); bacon (3)
Chicken dish	Deep-fried chicken (4); broiled or fried chicken (4); mixed dish with chicken (3)
Liver	Liver of various types (4)
Special mixed dish	One-pot dish of meat and vegetablesa (6); beef stew (1); cream stew (1)
Eggs	Egg and egg dishes (6)
Fish dish	Sashimi (6); soy-cooked fish (6); broiled fish (6); deep-fried fish (6); dried small fish (5); canned fish (6); barbecued eel (2)
Blue-skin fish[d]	Mackerel/sardine (6); yellowtails (3); saury[a] (1)
Marine foods other than fish	Fish roes (3), fish paste products (6), cuttlefish/octopus (6); prawns in tempura (3); cooked prawns (3); shellfish (3)
Soy and soy products[e]	Miso soup (1); miso-cooked dishes (6); tofu (6); atsuage/ganmodoki (3); abura-age (2); mixed dish with abura-age (2); natto (2); cooked soybeans (3); bean curd refuse (1); soy milk (2)
Pickled vegetables	Pickled ume (4); scallion (2); green leafy vegetables (3); non-green leafy and root vegetables (6)
Raw vegetables	Mixed vegetable salad (6); tomato (3); tomato in garnish (1); cucumber (4); cabbage (3); lettuce (3); daikon/turnip (6); onion (4)
Cooked vegetables	Green leafy vegetables (5); non-green leafy vegetables (6); pumpkin (4); carrot (4); green pepper (6); burdock (3); Welsh onion (6); Chinese chives (3); garlic (5); fried mixed vegetables (2); green soybeans (1)
Deep-fried vegetable dish	Assorted tempura (1); deep-fried mixed vegetables (6)
Potatoes	Fried potatoes (3); potato chips (2); potato dishes (6); konjak (3)
Seaweed	Wakame (3); hijiki (1); other seaweeds (4)
Vegetable juice	Tomato juice (2); mixed vegetable juice (4)
Fruits and fruit juice	Fresh fruits[f] (6); canned fruits (6); apple (3); banana (1); mandarin[a] (1); orange (5) watermelon[a] (2); strawberry[a] (1) grape[a] (4); kaki[a] (3), fruit juice (4)
Milk and dairy products	Milk (4); low-fat milk (3); non-sugar yogurt (6); sweetened yogurt (6); ice cream (5); cheese (3)
Nuts	Peanuts and other nuts (3)
Confectionaries	Chocolate (2); biscuits/cookies (4); Japanese crackers (6); candy (2); cakes (6); Japanese cakes (4); pastry (4); doughnut (4)
Soft drinks	Soft drinks (4)
Seasonings	Mayonnaise at table (5); mayonnaise-dressed dish (3); salad dressing (5); ketchup at table (3); ketchup-cooked dish (3); soy sauce at table (6); sesame (6)
Non-alcoholic beverages	Green tea (5); oolong tea (3); black tea (4); brewed coffee (4); instant coffee (6); canned coffee (3)
Alcoholic beverages	Beer (6); sake (3); shochu (2); shochu cocktel (6); whisky (5); wine (4)

[a]In-season consumption only. [b]Unsweetened batter fried with vegetables. [c]Gyoza, dumpling stuffed with minced pork; shaomai, steamed meat dumpling. [d]Supplemetal questions not used in the analysis. [e]Annotations of soy products: miso, fermented soybean paste; atsuage, thick deep-fried bean curd; ganmodoki, fried bean curd with vegetables; [a]bura-age, deep-fried slice of bean curd; natto, fermented soybeans. [f]An introductory question not used in the analysis.