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Nature of Japanese Diet : Variations in Intake of Nutrients and Foods

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ABSTRACT

We here outlined our study on the variations in intake of nutrients based on four season 7 consecutive day weighed diet records (WDRs) from 80 Japanese female dietitians in 1996 – 1997. Furthermore, we reviewed Japanese, Korean and international articles investigating variability in consumption of foods as well as nutrients. The relative contributions of variation for all nutrients by person were greater than those by day, week and season. Within individual variances were greater than that between individual variances, being generally observed in Korea and in the world. The ratios of within- vs. between-individual variations ranged from 1.3 – 26.9 in our study, the ratios being greatest in Korean, followed by Japanese and western people. Based on within individual coefficients of variation, minimal days necessary for estimating nutrient consumption per person within 10% (20%) of the true mean with 95% confidence intervals were estimated. They ranged from 10 – 35 (3 – 9) days for energy and major nutrients and 15 – 640 (4 – 160) days for micro-nutrients. Two Japanese studies reported that the ratios for foods were as a whole greater than those for nutrients, except for cereals, rice and milk. (*J Community Nutrition* 5(2) : 72~82, 2003)

KEY WORDS : international comparison · variations in intake of nutrients/foods in Japanese · weighed diet records.

Introduction

There are several approaches for estimating consumption of nutrients, including diet records/weighed diet records (abbreviated DRs/WDRs hereafter), 24-hour recall, food frequency questionnaires, diet history, replicate food methods and biochemical analysis (Margetts, Nelson 1991 ; Willett 1998). Among available approaches, DRs/WDRs appear the most precise and are often used for quantifying consumption of foods/nutrients in defined populations and ascertaining population means. Multiple DRs/WDRs data are accepted as *gold standards/references* for dietary surveys (Date 1996 ; Margetts, Nelson 1991 ; Willett 1998). However, as is reported, there are variations in dietary intake according to day, week, season, study area and person, and many days are needed to estimate long-term habitual consumption of foods and nutrients.

It thus seems useful for nutritional epidemiologists to provide information on sources and magnitudes of variations in intake of foods and nutrients. For that purpose, we outline our study on four seasonal 7 consecutive day WDRs for energy and 30 nutrients provided by 80 Japanese female dietitians (Tokudome *et al.* 2002) and report relative magnitude of day-to-day, weekly, seasonal, within/intra- and between/interindividual variance, referring relevant selected articles reported from Korea and worldwide. We quantified the number of days needed to evaluate an individual's nutrient consumption within 10% and 20% of the true mean with a specified degree of the error. Furthermore, we reviewed and discussed Japanese studies investigating the variations in intake of foods.

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Table 1. Average daily intake of energy and 30 nutrients by season[§]

Nutrient		Average		October 1996 (Autumn)		January 1997 (Winter)		April 1997 (Spring)		August 1997 (Summer)		
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Energy	[kcal]	1,820	352	1852	346	1825	352	1811	348	1792	362	**
Protein	[g]	74.3	17.3	75.7	15.9	74.8	17.3	73.6	17.9	73.1	18.1	**
Fat	[g]	56.3	18.9	58.7	19.1	55.5	18.5	55.9	18.6	54.9	19.4	***
Carbohydrate	[g]	243.6	52.5	245.5	51.6	245.9	52.3	242.8	53.2	240.1	52.8	
Carotenes	[μg]	3,620	2,430	3975	2529	3930	2456	3376	2414	3199	2225	***
Vitamin A	[μgRE][1]	756	693	824	807	779	627	715	677	707	642	**
Vitamin D	[μg]	7.4	9.0	7.8	9.3	7.4	9.4	7.4	8.6	6.9	8.6	
Vitamin E	[mg α-TE][2]	9	3	9.2	3.4	8.6	3.1	8.7	3.1	9.0	3.2	***
Vitamin C	[mg]	144	78	160	82	154	74	136	72	128	78	***
Potassium (K)	[mg]	2,913	785	3056	763	2969	780	2810	795	2817	775	***
Calcium (Ca)	[mg]	632	249	662	250	642	257	602	239	623	245	***
Magnesium (Mg)	[mg]	255	73	264	72	258	73	248	74	249	73	***
Phosphorus (P)	[mg]	1,076	259	1096	237	1077	262	1063	262	1070	274	
Iron (Fe)	[mg]	10.8	3.2	11.4	3.3	11.2	3.2	10.6	3.2	10.1	2.9	***
Zinc (Zn)	[mg]	8	5	9	5	9	8	8	2	8	2	***
Copper (Cu)	[mg]	1.2	0.5	1.3	0.6	1.3	0.7	11.7	0.4	11.5	0.3	***
SFAs[3]	[g]	15.6	6.5	16.4	6.9	15.6	6.6	15.3	6.0	15.1	6.6	**
MUFAs[4]	[g]	19.1	7.7	19.7	7.6	18.9	7.6	19.1	7.6	18.7	7.7	*
Oleic acid	[g]	16.7	6.8	17.2	5.8	16.5	6.6	16.7	6.8	16.4	7	
PUFAs[5]	[g]	13.1	5.2	13.8	5.4	12.7	4.9	13.1	5.1	13.0	5.2	**
n-6PUFAs	[mg]	10,622	4,453	11046	4767	10232	4113	10687	4411	10563	4502	**
Linoleic acid	[mg]	10,433	4,433	10838	4719	10045	4099	10500	4388	10349	4480	**
Arachidonic acid	[mg]	136	73	148	72	136	72	134	72	125	74	***
n-3PUFAs	[mg]	2,495	1,363	2701	1427	2479	1385	2410	1257	2388	1360	***
α-Linolenic acid	[mg]	1,550	838	1588	807	1519	814	1558	866	1536	863	
EPA[6]	[mg]	274	360	327	396	283	373	243	312	245	347	***
DHA[7]	[mg]	509	529	588	580	518	546	471	461	458	512	***
Cholesterol	[mg]	365	192	379	179	357	192	372	191	354	206	
TDF[8]	[g]	15.7	5.4	16.4	5.4	16.5	5.5	15.1	5.4	14.7	5.3	***
SDF[9]	[g]	3.0	1.5	3.2	1.5	3.3	1.1	2.7	1.4	3.0	1.5	***
IDF[10]	[g]	1.9	4.1	12.5	5.4	12.5	4.2	11.7	4.0	11.1	3.9	***

§ Cited from Tokudome *et al* 2002
1) μgRE : Retinol equivalent
2) mg α-TE : α-Tocopherol equivalent
3) SFAs : Saturated fatty acids
4) MUFAs : Monounsaturated fatty acids
5) PUFAs : Polyunsaturated fatty acids
6) EPA : Eicosapentaenoic acid
7) DHA : Docosahexaenoic acid
8) TDF : Total dietary fiber
9) SDF : Soluble dietary fiber
10) IDF : Insoluble dietary fiber
* : $p<0.05$, ** : $p<0.01$, *** : $p<0.001$

Subjects and Methods

1. Weighed Diet Records

1) Subjects and 28 day WDRs

Our variation study has been described elsewhere (Tokudome *et al.* 1998, 2001 ; Tokudome *et al.* 2002). In brief, the research was based on the 28 day WDRs or four seasonal 7 consecutive day WDRs among 80 female dietitians living in Aichi Prefecture, in Central Japan in autumn 1996, and at about 3 month intervals in winter, spring and summer 1997. Their mean age (years of age ± standard deviation (minimum-maximum)) was 48 ± 8 (32 − 66) in autumn 1996. The values for height (cm), weight (kg) and BMI (kg/m^2) were 156.9 ± 5.1 (146.1 − 172.1), 52.2 ± 5.5 (37.5 − 69.4), and 21.5 ± 2.2 (15.9 − 29.5), respectively.

2) Nutrients selected

We chose energy and 30 nutrients, including protein, fat, carbohydrate, vitamins (including carotenes, and vitamins A, D, E and C), minerals (including potassium, calcium, magnesium, phosphorus, iron, zinc and copper) and total dietary fiber (TDF) (including soluble DF and insoluble DF). Fat was divided into saturated fatty acids (abbreviated SFAs hereafter) (including myristic acid (14 : 0), palmitic acid (16 : 0), and stearic acid (18 : 0)), monounsaturated fatty acids (abbreviated MUFAs hereafter) (including palmitoleic acid (16 : 1) and oleic acid (18 : 1)), polyunsaturated fatty acids (abbreviated PUFAs hereafter), n-6 PUFAs, n-3 PUFAs and cholesterol. n-6 PUFAs were separated into linoleic acid (18 : 2n-6) and arachidonic acid (20 : 4n-6), and n-3 PUFAs into α-linolenic acid (18 : 3n-3), eicosapentaenoic acid (EPA, 20 : 5n-3) and docosahexaenoic acid (DHA, 22 : 6n-3).

3) Calculation of intake of energy and nutrients

We computed average daily consumption of major and micro-nutrients by multiplying the food intake (in grams) or serving/portion size and the nutrient content per 100 grams of food as listed in the Standard Tables of Food Composition, Version 4, the Follow-up of Standard Tables of Food Composition (Science and Technology Agency, Japan, 1982, 1994), Composition Table of Processed Foodstuff (Kagawa 1995) and Table of Trace Element Contents in Japanese Foodstuff (Suzuki 1993). Since the composition tables are incomplete for certain foods, estimation was largely made according to analogies from same/similar foods and to assessment based on model recipes for relevant foods as reported (Imaeda *et al.* 2000).

2. Statistical analysis

Using all data of 2240 day WDRs or four seasonal 7 consecutive day WDRs completed by 80 female dietitians, we firstly calculated mean and standard deviation along with minimum and maximum values, and compared differences in intakes of selected nutrients by day, week, season and person according to analysis of variance (ANOVA) (Armitage, Berry 1994). We scrutinized the relative contributions of day-to-day, weekly, seasonal, between-individual variation and residual to total variation according to analysis of components of variance (Armitage, Berry 1994 ; Beaton *et al.* 1979 ; SAS Institute 1990). The ratio of within- (intra-) and between- (inter-) individual variance with 95% confidence intervals was then computed.[11-13] In the calculation, variation due to day, week and season was included in within-individual variation. Furthermore, we quantified minimal days required to estimate nutrient consumption within 10% and 20 of the true mean with 95% confidence intervals on the basis of within-individual coefficients of variation.

Results

1. Our study

1) Intake of energy and nutrients

Most nutrients, except for carbohydrate, phosphorus, vitamin D, oleic acid, α-linolenic acid and cholesterol, were significantly different by season (Table 1). Remarkable seasonal differences were observed for carotenes, vitamin A, vitamin C, iron, zinc, AA, n-3 PUFAs, EPA, DHA and dietary fiber, including TDF, SDF and IDF ($p < 0.001$). Among these, daily intakes of carotenes and vitamin C in autumn were about 20% larger than in summer. Intakes of several nutrients were mostly influenced by the sequence of days but not by day of week. Intake of energy and all nutrients significantly differed by person ($p < 0.001$ for all).

2) Relative contributions of day-to-day, weekly, seasonal and personal variances

As shown in Table 2, the relative contributions of variance (%) by person were largest for all nutrients. The contributions of residual variation of 52.3 − 91.1 were greater

Table 2. Relative contributions of variance (%) for intake of energy and 30 nutrients[§]

Nutrient	Sequence of days	Day of week	Season	Between-individual	Residual
Energy	1.0	0.1	0.4	33.4	65.1
Protein	0.7	0.0	0.3	33.3	65.6
Fat	0.8	0.0	0.6	24.2	74.4
Carbohydrate	1.4	0.2	0.2	34.8	63.3
Carotenes	0.5	0.1	1.9	22.9	74.5
Vitamin A	0.8	0.0	0.5	9.8	89.1
Vitamin D	1.1	0.2	0.1	7.8	91.1
Vitamin E	1.0	0.0	0.6	19.7	78.7
Vitamin C	0.8	0.0	2.0	28.0	68.5
Potassium (K)	9.5	0.2	1.8	44.8	52.8
Calcium (Ca)	0.7	0.0	0.8	37.3	61.2
Magnesium (Mg)	0.3	0.0	0.8	39.9	58.9
Phosphorus (P)	0.6	0.0	0.2	37.9	61.3
Iron (Fe)	0.5	0.0	2.7	32.9	63.9
Zinc (Zn)	0.9	0.0	2.1	9.8	87.3
Copper (Cu)	0.7	0.0	2.0	14.1	83.3
SFAs	1.2	0.0	0.5	18.9	79.3
MUFAs	0.7	0.0	0.3	24.2	74.8
Oleic acid	0.7	0.0	0.2	23.8	75.2
PUFAs	1.0	0.1	0.6	22.8	75.6
n-6PUFAs	1.1	0.0	0.4	22.1	76.3
Linoleic acid	1.1	0.0	0.4	22.1	76.4
Arachidonic acid	1.3	0.0	1.2	15.5	81.9
n-3PUFAs	1.2	0.3	0.8	14.5	83.2
α-Linolenic acid	0.6	0.1	0.1	22.7	76.5
EPA	1.6	0.1	0.9	7.1	90.3
DHA	1.3	0.2	0.9	6.9	90.6
Cholesterol	0.7	0.0	0.3	18.1	80.9
TDF	0.3	0.0	2.1	45.3	52.3
SDF	0.4	0.0	2.5	33.2	63.9
IDF	0.4	0.1	2.1	44.8	52.6

[§] Cited from Tokudome *et al* 2002

than between-individual variation of 6.9 – 45.3. The values for day-to-day (sequence by days), day of week, and by season ranged form 0.3 – 9.5, 0 – 0.3, and 0.1 – 2.7, respectively.

3) Comparison between within- and between-individual variations in intake of nutrients

Within-individual variances were larger than between-individual variances (Table 3), and the ratios were greater than one. They ranged from 1.3 (0.7 – 2.6) for potassium, TDF and IDF – 26.9 (15.1 – 53.0) for DHA. The ratios for micro-nutrients (1.3 – 26.9) were generally greater than those (2.1 – 3.6) for energy and major nutrients. The variations for vitamins were generally greater than other nutrients.

4) Number of days needed to evaluate the true intake of energy and nutrients

Table 3 also shows within-individual coefficients of variation with 95% confidence intervals, and minimal days needed to ascertain an individual's nutrient consumption

Table 3. Intake of energy and 30 nutrients, within- and between-individual variation, coefficients of variation and minimal days needed to estimate nutrient intake within 10% and 20% of the true mean with 95% confidence intervals

	Mean	Sw^2/Sb^2	(95% CIs)	Coefficient of variation		Number of days needed to lie within 10% and 20% of true means			
				Within-individual	Between-individual	10% Mean	10% (95% CIs)	20% Mean	20% (95% CIs)
Energy	1820 [kcal]	2.2	(1.2 – 4.3)	16.1	10.8	10	(10 – 11)	3	(3 – 3)
Protein	74.3 [g]	2.2	(1.2 – 4.3)	19.4	13.1	15	(14 – 16)	4	(4 – 4)
Fat	56.3 [g]	3.6	(2.0 – 7.2)	29.8	15.6	35	(32 – 37)	9	(8 – 10)
Carbohydrate	243.6 [g]	2.1	(1.2 – 4.1)	17.7	12.4	13	(12 – 13)	4	(3 – 4)
Carotenes	3620 [μg]	3.9	(2.2 – 7.7)	60.0	30.3	139	(122 – 160)	35	(31 – 40)
Vitamin A	756 [μgRE]	14.2	(8.0 – 28.0)	88.6	23.5	302	(273 – 337)	76	(69 – 85)
Vitamin D	7.4 [μg]	23.1	(13.0 – 45.5)	119.6	24.9	550	(494 – 617)	138	(124 – 155)
Vitamin E	9 [mg α-TE]	5.1	(2.8 – 10.0)	71.7	32.3	198	(172 – 230)	50	(43 – 58)
Vitamin C	144 [mg]	2.7	(1.5 – 5.4)	45.8	27.2	81	(72 – 92)	21	(18 – 23)
Potassium (K)	2913 [mg]	1.3	(0.7 – 2.6)	20.4	17.7	16	(15 – 18)	4	(4 – 5)
Calcium (Ca)	632 [mg]	1.8	(1.0 – 3.6)	31.8	23.4	39	(36 – 44)	10	(9 – 11)
Magnesium (Mg)	255 [mg]	1.7	(0.9 – 3.3)	22.6	17.7	20	(19 – 22)	5	(5 – 6)
Phosphorus (P)	1076 [mg]	1.8	(1.0 – 3.5)	19.3	14.5	15	(14 – 16)	4	(4 – 4)
Iron (Fe)	10.8 [mg]	2.3	(1.3 – 4.4)	25.0	16.7	25	(23 – 26)	7	(6 – 7)
Zinc (Zn)	8 [mg]	14.2	(8.0 – 28.0)	55.3	14.7	118	(111 – 126)	30	(28 – 3)
Copper (Cu)	1.2 [mg]	8.1	(4.5 – 16.0)	40.8	14.3	64	(61 – 69)	16	(16 – 18)
SFAs	15.6 [g]	5.3	(3.0 – 10.5)	38.5	16.7	57	(53 – 62)	15	(14 – 16)
MUFAs	19.1 [g]	3.6	(2.0 – 7.0)	35.6	18.3	49	(45 – 53)	13	(12 – 14)
Oleic acid	16.7 [g]	9.4	(5.3 – 18.5)	36.2	18.8	51	(47 – 55)	13	(12 – 14)
PUFAs	13.1 [g]	4.0	(2.2 – 7.9)	35.1	17.6	48	(44 – 52)	12	(11 – 13)
n-6PUFAs	10622 [mg]	4.1	(2.3 – 8.1)	37.7	18.6	55	(51 – 60)	14	(13 – 15)
Linoleic acid	10433 [mg]	1.6	(0.9 – 3.2)	38.2	18.7	57	(52 – 62)	15	(13 – 16)
Arachidonic acid	136 [mg]	6.8	(3.8 – 13.5)	50.1	20.2	97	(89 – 106)	25	(23 – 27)
n-3PUFAs	2495 [mg]	7.7	(4.3 – 15.1)	51.2	18.5	101	(93 – 110)	26	(24 – 28)
α-Linolenic acid	1550 [mg]	4.0	(2.2 – 7.8)	48.4	24.3	90	(82 – 101)	23	(21 – 26)
EPA	274 [mg]	25.4	(14.2 – 50.0)	129.0	25.5	640	(573 – 720)	160	(144 – 180)
DHA	509 [mg]	26.9	(15.1 – 53.0)	102.6	19.6	400	(372 – 443)	100	(93 – 111)
Cholesterol	365 [mg]	5.5	(3.1 – 10.9)	48.5	20.5	91	(83 – 100)	23	(21 – 25)
TDF	15.7 [g]	1.3	(0.7 – 2.6)	26.1	22.9	27	(24 – 30)	7	(6 – 8)
SDF	3.0 [g]	2.3	(1.3 – 4.4)	39.7	26.6	61	(54 – 69)	16	(14 – 18)
IDF	11.9 [g]	1.3	(0.7 – 2.6)	25.8	22.5	26	(24 – 29)	7	(6 – 8)

Table 4. International comparison of variation in intake of energy and 12 nutrients

	Tokudome et al	Ogawa et al		Egami et al		Oh et al		Beaton et al		Hunt et al		Nelson et al	
	(2002 Japan)	(1999 Japan)		(1999 Japan)		(1996 Korea)		(1983 Canada)		(1983 USA)		(1989 UK)	
Survey method	28 Day WDRs	12 Day DRs		16 Day WDRs		5 – 6 Dietary recalls		3 Day dietary recalls		6 Day DRs		7 – 21 Day DRs	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Subjects	80	59	60	46	42	47	36	30	30	25	25	105	112
Age	48 ± 8	62.5 ± 8.4	61.2 ± 8.5	52.5 ± 4.5	49.8 ± 8.6	y>60	y>60	25 – 44	25 – 44	y>60	y>60	18 – 57	18 – 57
Days of diet record	28	12	12	16	16	5 – 6	5 – 7	6	6	6	6	7	7
Energy													
Mean (kcal)	1820	2372	1849	2063	1646	1959.3	1646.0	2637	1792	2073	1617	2815	1957
CVw[1]	16.1	18.2	17.9	16.8	19.8	25.0	28.8	25.7	30.8	–	–	23.52	25.91
CVb[2]	10.8	18.4	13.3	15.3	15.9	12	18.9	24.5	25.4	–	–	21.56	20.90
Sw^2/Sb^2	2.2	1.0	1.8	1.20	1.55	4.34	2.34	1.1[3]	1.5	0.97	0.83	1.19[3]	1.54
Protein													
Mean (g)	74.3	94.0	79.2	76.1	63.0	84.4	73.6	98.2[3]	69.9	79.40	64.20	89.3	65.3
CVw	19.4	23.1	23.6	22.6	23.5	37.8	44.3	35.7	31.0	–	–	26.65	28.02
CVb	13.1	17.0	15.0	17.2	20.0	17.8	32.4	29.1	25.0	–	–	19.82	19.30
Sw^2/Sb^2	2.2	1.8	2.5	1.74	1.38	4.52	1.87	1.5	1.5	1.20	1.33	1.81	2.11
Fat													
Mean (g)	56.3	55.8	51.6	54.7	49.8	41.1	31.7	113.9[3]	82.1	85.3	69.7	123.1	89.7
CVw	29.8	36.7	33.5	32.3	33.3	57.4	68.7	30.8	39.3	–	–	30.38	31.10
CVb	15.6	20.7	18.3	22.6	27.9	18.3	29.9	28.1	30.7	–	–	23.40	22.30
Sw^2/Sb^2	3.6	3.2	3.3	2.04	1.43	9.80	5.29	1.2	1.6	1.18	0.90	1.69	1.95
Carbohydrate													
Mean (g)	243.6	329.1	266.8	281	226	282.2	252.6	264.4	180.6	235.2	171.0	328.8	225.0
CVw	17.7	18.7	18.3	17.7	22.1	21.8	26.1	29.5	35.7	–	–	24.21	26.53
CVb	12.4	20.4	14	18.6	14.4	9.4	14.3	23.0	29.9	–	–	24.60	27.73
Sw^2/Sb^2	2.1	0.8	1.5	0.9	2.36	5.43	3.31	1.7	1.4	2.05	1.16	0.97	0.92
Calcium													
Mean (mg)	632	678.0	668	460	452	662.6	582.2	902	671.3	709.1	601.8	1126	896
CVw	31.8	34.9	34.9	39.6	41.1	48.3	64.5	41.0	43.6	–	–	34.46	31.47
CVb	23.4	26.3	24.1	28.7	29.2	14.8	29.0	27.9	45.8	–	–	30.02	32.70
Sw^2/Sb^2	1.8	1.8	2.1	1.90	1.98	10.65	4.95	2.6	2.3	1.13	1.74	1.32	0.93
Iron													
Mean (mg)	10.8	13.0	12.0	10.1	8.7	16.7	14.5	15.7	11.3	14.2	10.9	13.8	10.32
CVw	25.0	27.2	26.7	28.8	28.3	61.1	59.3	34.6	31.2	–	–	42.46	40.70
CVb	16.7	17.0	17.2	18.5	24.0	18.2	39.4	26.9	19.6	–	–	21.16	25.10
Sw^2/Sb^2	2.3	2.6	2.4	2.42	1.39	11.28	2.26	3.6	2.6	1.83	1.52	4.03	2.63
Vitamin A													
Mean (RE)	756	–	–	2748[4]	2446[4]	405.9	265.4	6369[4]	5188[4]	6295[4]	5495[4]	–	–
CVw	88.6	–	–	143.8	126.1	103.2	85.4	146.6	111.9	–	–	–	–
CVb	23.5	–	–	41.1	42.3	63.7	35.3	0	22.7	–	–	–	–
Sw^2/Sb^2	14.2	–	–	12.27	8.88	2.26	5.86	> 100	47.6	1.63	2.50	–	–

Table 4. Continued

	Tokudome et al	Ogawa et al		Egami et al		Oh et al		Beaton et al		Hunt et al		Nelson et al	
	(2002 Japan)	(1999 Japan)		(1999 Japan)		(1996 Korea)		(1983 Canada)		(1983 USA)		(1989 UK)	
Survey method	28 Day WDRs	12 Day DRs		16 Day WDRs		5 – 6 Dietary recalls		3 Day dietary recalls		6 Day DRs		7 – 21 Day DRs	
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Subjects	80	59	60	46	42	47	36	30	30	25	25	105	112
Age	48 ± 8	62.5 ± 8.4	61.2 ± 8.5	52.5 ± 4.5	49.8 ± 8.6	y>60	y>60	25 – 44	25 – 44	y>60	y>60	18 – 57	18 – 57
Days of diet record	28	12	12	16	16	5 – 6	5 – 7	6	6	6	6	7	7
Retinol													
Mean(μ g)	329	348	309	372	284	–	–	–	–	–	–	1635	1252
CVw	233.1	261.2	314.9	293.5	283.8	–	–	–	–	–	–	317.74	279.87
CVb	31.4	35.9	0.0	58.2	37.2	–	–	–	–	–	–	0.00	25.16
Sw^2/Sb^2	54.9	52.9	∞	25.48	58.16	–	–	–	–	–	–		123.74
Carotenes													
Mean(μ g)	3620	3345	3394	2669	2646	–	–	–	–	–	–	2952	2413
CVw	60.0	66.4	60.3	78.6	81.9	–	–	–	–	–	–	153.42	149.81
CVb	30.3	36.2	34.4	47.7	56.7	–	–	–	–	–	–	40.28	47.20
Sw^2/Sb^2	3.9	3.4	3.1	2.72	2.09	–	–	–	–	–	–	14.51	10.07
Thiamin													
Mean(mg)	0.77	1.14	1.01	–	–	1.16	0.93	1.75	1.29	1.31	0.95	1.33	0.99
CVw	36.6	34.2	29.6	–	–	50.6	49.1	43.4	52.4	–	–	34.59	34.34
CVb	24.2	16.4	14.5	–	–	18.2	28.7	27.3	25.0	–	–	22.56	25.25
Sw^2/Sb^2	2.3	4.3	4.2	–	–	7.69	2.93	2.5	4.4	0.94	1.56	2.35	1.85
Riboflavin													
Mean(mg)	1.13	1.63	1.54	–	–	1.18	1.02	2.38	1.71	1.71	1.31	2.2	1.75
CVw	25.9	27.1	26.9	–	–	39.5	54.4	43.1	42.7	–	–	55.45	49.71
CVb	18.6	19.1	17.9	–	–	19.9	23.6	27.7	28.7	–	–	27.27	29.71
Sw^2/Sb^2	1.9	2.0	2.2	–	–	3.94	5.29	2.4	2.2	0.86	1.79	4.13	2.80
Niacin													
Mean(mg)		19.5	16.0	–	–	18.8	17.2	25.3	16.7	20.4	16	19.57	13.63
CVw		39.9	40.4	–	–	42.5	54.9	35.9	36.0	–	–	36.38	37.64
CVb		21.4	19.5	–	–	18.1	31.9	28.8	17.9	–	–	25.19	22.60
Sw^2/Sb^2		3.5	4.3	–	–	5.55	2.96	1.6	4.0	2.2	2.52	2.09	2.77
Ascorbic acid													
Mean(mg)	144	124	141	85	88	91.3	78.6	111.5	105.9	122.0	116.0	58	54.7
CVw	45.8	52.2	45.7	58.5	58.5	45.7	46.3	67	65.2	–	–	59.31	74.59
CVb	27.2	27.5	25.5	36.6	39.4	12.9	24.2	35.9	46.2	–	–	31.21	61.24
Sw^2/Sb^2	2.7	3.6	3.2	2.55	2.21	12.52	3.66	3.4	2.0	2.28	2.78	3.61	1.48

1) [(within-individual variance)$^{0.5}$/mean] × 100
2) [(between-individual variance)$^{0.5}$/mean] × 100
3) Values of Sw^2/Sb^2 were estimated according to the values of CVw and CVb
4) IU

within 10%(20%) of the true mean with 95% confidence intervals. They ranged from 10 − 35(3 − 9) for energy and major nutrients and from 15 − 640(4 − 160) for micro-nutrients. Those for energy and major nutrients were generally smaller than those for micro-nutrients.

2. International comparison

1) Variations in intake of energy and selected nutrients

Within-individual coefficients of variation in Japanese for energy, protein, fat, and carbohydrate ranged 16 − 35% and 20 − 70% for Korean, being greater than 25 − 35% for western people(Table 4). Those for energy and major nutrients were mostly smaller than those for micro-nutrients. Similarly, the ratios for within- vs. between-individual variations in intake of nutrients for Japanese were generally greater than those for western countries but smaller than those for Koreans. There were also some differences in the ratios by gender.

2) Variations in intake of foods in Japanese

Ogawa *et al.*(1999) and Egami *et al.*(1999) reported the variations in intake of foods in Japanese(Table 5). Similarly to nutrients, the ratios of the within- vs. between-individual variations in intake of foods were generally greater than one, except for cereals(0.6 − 0.9), rice(0.83 − 1.79) and milk (0.78 − 2.92), and ranged up to 12.9 − 113.2 for noodles. The values were generally greater than those for nutrients.

Discussion

The accuracy of DRs/WDRs is, as mentioned, greatest when taken on the actual day of consumption of foods/nutrients(Margetts, Nelson 1991 ; Willett 1998). DRs/WDRs have been adopted for nutritional surveys in the world. They are employed as gold standards/references for dietary surveys ; however, there are variations according to day, week, season and person. Among them, the greatest source of variation, including foods and nutrients, was brought about by person(Beaton *et al.* 1979 ; Egami *et al.* 1999 ; Hartman *et al.* 1990 ; Hunt *et al.* 1983 ; McGee *et al.* 1983 ; Nelson *et al.* 1989 ; Ogawa *et al.* 1999 ; Oh, Hong 1999 ; Rosner *et al.* 1988 ; Sempos *et al.* 1985 ; Tokudome *et al.* 2002). The within-individual variability would invariably yield misclassification of subjects and inconsistencies in epidemiological observations(Margetts, Nelson 1991 ; Willett 1998).

Table 5. Variation in intake of 21 food groups in Japanese

	Ogawa et al (1999)		Egami et al (1999)	
Surevey methods	12 Day diet Records		16 Day weighed diet records	
Subjects	Men	Women	Men	Women
Number of subjects	59	60	46	42
Age	62.5 ± 8.4	61.2 ± 8.5	52.5 ± 4.5	49.8 ± 8.6
Cereals				
Mean(g)	641.6	428.1	−	−
CVw	20.6	19.8	−	−
CVb	26.6	20.4	−	−
Sw^2/Sb^2	0.6	0.9	−	−
Rice				
Mean(g)	−	−	431	300
CVw	−	−	30.5	38.9
CVb	−	−	33.4	29
Sw^2/Sb^2	−	−	0.83	1.79
Bread				
Mean(g)	−	−	35	38
CVw	−	−	95.7	107.3
CVb	−	−	100.1	71.6
Sw^2/Sb^2	−	−	0.92	2.25
Noodle				
Mean(g)	−	−	104	66
CVw	−	−	113.2	151.6
CVb	−	−	48.2	38.6
Sw^2/Sb^2	−	−	113.2	12.93
Potatoes and starches				
Mean(g)	56.3	54.9	40	43
CVw	104.2	93.4	121.5	125.3
CVb	27.7	26.3	20.7	34.8
Sw^2/Sb^2	14.1	12.6	34.32	12.93
Sugar and sweeteners				
Mean(g)	9.5	10.2	9.4	7.4
CVw	94.2	99.0	82.8	99.2
CVb	56.5	43.2	48.4	43.8
Sw^2/Sb^2	2.8	5.3	2.92	5.12
Confectionery				
Mean(g)	23.6	41.7	29	38
CVw	172.1	109.6	156	151.8
CVb	67.9	54.4	81.6	65.5
Sw^2/Sb^2	6.4	4.1	3.65	5.36
Fats and oils				
Mean(g)	8.7	8.3	11.8	10.3
CVw	89.3	82.0	73.1	80.7
CVb	29.1	27.5	31.2	47.9
Sw^2/Sb^2	9.4	8.9	5.48	2.84

Table 5. Continued

	Ogawa et al (1999)		Egami et al (1999)	
Surevey methods	12 Day diet Records		16 Day weighed diet records	
Subjects	Men	Women	Men	Women
Number of subjects	59	60	46	42
Age	62.5 ± 8.4	61.2 ± 8.5	52.5 ± 4.5	49.8 ± 8.6
Nuts and seeds				
Mean(g)	2.9	2.8	1.8	2
CVw	297.6	256.8	291.5	391.8
CVb	63.0	77.4	98.4	58.4
Sw^2/Sb^2	22.3	11.0	8.78	44.97
Pulses				
Mean(g)	111.8	99.5	73	54
CVw	60.5	60.5	102.9	105.9
CVb	26.9	25.7	57.1	26.0
Sw^2/Sb^2	5.1	5.5	3.25	16.56
Fish and shellfish				
Mean(g)	141.2	111.9	89	69
CVw	59.5	64.9	77	89.6
CVb	26.3	23.5	40.4	39.5
Sw^2/Sb^2	5.1	7.6	3.64	5.14
Meat				
Mean(g)	55.5	41.5	66	55
CVw	122.7	126.9	83.4	84.5
CVb	21.3	46.9	32.2	45.4
Sw^2/Sb^2	33.1	7.3	6.70	3.46
Eggs				
Mean(g)	48.4	41.5	47	37
CVw	73.2	76.0	80.0	89.0
CVb	36.4	37.6	35.6	34.4
Sw^2/Sb^2	4.0	4.1	5.04	6.69
Milk				
Mean(g)	139.4	175.0	85	123
CVw	81.5	61.8	98.7	87.5
CVb	78.6	47.6	111.7	51.2
Sw^2/Sb^2	1.1	1.7	0.78	2.92
Vegetables				
Mean(g)	310.0	331.3	–	–
CVw	42.9	41.3	–	–
CVb	24.7	30.3	–	–
Sw^2/Sb^2	3.0	1.9	–	–
Green & yellow vegetable				
Mean(g)	–	–	85	74
CVw	–	–	86.9	81.9
CVb	–	–	55.9	51.1
Sw^2/Sb^2	–	–	2.42	2.36

Table 5. Continued

	Ogawa et al (1999)		Egami et al (1999)	
Surevey methods	12 Day diet Records		16 Day weighed diet records	
Subjects	Men	Women	Men	Women
Number of subjects	59	60	46	42
Age	62.5 ± 8.4	61.2 ± 8.5	52.5 ± 4.5	49.8 ± 8.6
Other vegetables				
Mean(g)	–	–	146	136
CVw	–	–	58.3	63.6
CVb	–	–	26.2	42.8
Sw^2/Sb^2	–	–	4.96	2.20
Fruit				
Mean(g)	116.8	152.3	86	91
CVw	120.8	81.5	109.3	107.1
CVb	45.1	41.4	87.3	54.2
Sw^2/Sb^2	7.2	3.9	1.57	3.90
Fungi				
Mean(g)	11.6	11.4	9.5	10.4
CVw	150.8	170.3	193.8	191.3
CVb	40.4	30.8	41.2	68.6
Sw^2/Sb^2	13.8	3.2	22.11	7.76
Algae				
Mean(g)	13.4	13.3	6.9	7.5
CVw	185.1	166.7	163.9	262.8
CVb	46.4	40.1	43.0	64.6
Sw^2/Sb^2	15.9	15.1	14.52	16.56
Beverages				
Mean(g)	788.30	628.8	244	19
CVw	52.50	50.3	104.1	311.5
CVb	52.30	45.1	92.8	162.3
Sw^2/Sb^2	1.00	1.2	1.26	3.7

Every effort should therefore be exerted to evade categorization bias in studies related to dietary surveys.

The ratios of the within- vs. between-individual variations nutrients for Japanese were greater than those for western countries ; however, smaller than those for Koreans. The precise reasons were unknown to us. Intake of foods/nutrients in Korea may actually vary although the study subjects were elderly people who tended to maintain their customary dietary habits. The greater within-individual variations unduly impose longer DRs/WDRs on us to ascertain habitual dietary intake and may be an obstacle to execute dietary epidemiologic studies.

The ratios of the within- vs. between-individual variations for energy and macro-nutrients were smaller than those for micronutrients in Japan, Korea and in international literature. Accordingly, minimal days required for evaluating a person's true intake of energy and macro-nutrients were generally fewer than for micro-nutrients in line with earlier findings (Beaton *et al.* 1979 ; Nelson *et al.* 1989 ; Ogawa *et al.* 1999 ; Oh, Hong 1999). At least 10 days were needed for energy to secure values within 10% of the true mean, in contrast to one year or more for micronutrients, including vitamin A, vitamin D, EPA and DHA. We did not have to overlook dietary variations in people in the real world.

In order to precisely assess average individual habitual consumption of foods/nutrients, we need long-term DRs/WDRs, as mentioned. It is obviously very laborious to keep multiple DRs/WDRs and does not seem pertinent to administer multiple DRs/WDRs, particularly to the general population, but rather apt for food frequency questionnaire/semi-quantitative food frequency questionnaire instead. Although less precise/less quantifiable than DRs/WDRs, food frequency questionnaire/semi-quantitative food frequency questionnaire may be suitable for case-referent and prospective studies to clarify the association between long-term habitual intake of foods/nutrients and health/diseases.

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