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Accuracy of Estimating Energy Intake in the Korean Urban Elderly: 24-Hour Dietary Recall

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ABSTRACT

Critical evaluation of energy intake data from dietary studies is difficult but important. To investigate the underreporting of total energy intake, we analyzed the one-day dietary intake data collected by 24-hour recall method from 550 elderly Koreans aged 60 years or older. Underreporting was addressed by computing the ratio of energy intake (EI) to estimated basal metabolic rate (BMRest). EI : BMRest ratio was found to be 1.38 for men and 1.33 for women, with about 14% of men and women classified as underreporters. Underreporting of energy intake was highest in men and women who were overweight, had lower family income, or no school education. For men, the most significant variables to predict the ratio of energy intake to estimated basal metabolic rate (EI : BMRest) were weight status, members of household, alcohol consumption and age, while income and education level were most significant for women.

KEY WORDS: energy intake, 24-h recall, underreporting, estimated basal metabolic rate.

INTRODUCTION

The results of dietary surveys, whether limited in size or national in scope, are influential in determining many important conclusions relating to nutritional status and risks of various diseases in populations and their subgroups (Mertz et al., 1991). Accuracy is required to avoid the attenuation of relative risks and confounding by biased assessments (Bingham and Day, 1997). Although much effort has been spent by epidemiologists and dietitians to improve the estimation methods of individual food intake, there are no absolute standards that can accurately estimate regular intake.

Several studies that have been conducted using doubly-labeled water (Johnson et al., 1994; Black et al., 1993) or intakes determined to maintain weight (Mertz et al., 1991; de Vries et al., 1994) have suggested that food recording results in much lower energy intakes than actual values. Energy intake underestimation is less when multiple-pass 24-hour recall procedures are employed rather than food records. (Johnson et al., 1996; Jonnalagadda et al., 1996). Although doubly-labeled water can accurately measure energy intake, its use is quite limited due to high cost and setup inconvenience. For these reasons, some researchers have tried to estimate total energy expenditure using prediction equations (Schofield, 1985; Johnson et al., 1994; Goldberg et al., 1991; Black et al., 1991; Briefel et al., 1997). However, it is also possible that certain characteristics may serve to predict the discrepancy between reported energy intake and total energy expenditure.

According to the results of the American National Health and Nutrition Examination Survey, the underreporting of energy intake was highest in women and in persons who were older, overweight, or trying to lose weight (Briefel et al., 1997). In addition to this, the underreporting of energy intake increased with the amount of adiposity in older women (Johnson, 1994). It has also been suggested that the degree of underreporting increases with the degree of energy intake (Mertz et al., 1991; Scholler, 1990). One possible explanation for this could be that individuals tend to report intakes closer to perceived norms than to actual intake (Scholler, 1990).

The aims of this study were to determine whether Korean older people would provide valid energy intake information using 24-hr recall method and to determine which characteristics were predictive of underreporting of energy intake. We used prediction equations to estimate the total energy expenditure of Korean elderly and then evaluated the relation of underreporting of energy intake to sociodemographic variables, weight status, and health

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risk factors.

METHODS

1. Subjects

Participants of the study were 391 females and 241 males of 60 years of age or older living in two large cities, Seoul and Tae-Gu, recruited using a non-probability sampling strategy. For example, in the Sang-gye Dong district of Seoul, the managers of apartment buildings were contacted to identify the leaders of elderly groups, who were then asked to participate in recruiting. Attendees of monthly neighborhood meetings held regularly in communities were also asked to help in recruiting. Demographic characteristics, anthropometric and dietary data of subjects were obtained by in-person interviews.

2. Anthropometric data

Self-reported height (cm) and weight (kg) were collected. Weight status was defined using calculated body

Table 1. Equations for estimated basal metabolic rate from weight (wt)*

		BMR +	n	R	SEE
30 – 60 y	Male	0.048 wt+3.653	646	0.60	0.6997
	Female	0.034 wt+3.538	372	0.68	0.4653
> 60 y	Male	0.049 wt+2.459	50	0.71	0.6865
	Female	0.038 wt+2.755	38	0.68	0.4511

*From Schofield WN et al., Human Nutr Clin Nutr. 1985; 39c (suppl 1): 1-96

+BMR, basal metabolic rate expressed in MJ/24h; weight in kg

Table 2. Characteristics of subjects

Characteristics	All subjects		Male		Female	
	N	%	N	%	N	%
Age (yr)	(n = 550)		(n = 241)		(n = 309)	
60 – 69	227	41	93	39	134	43
70 – 79	252	46	117	48	135	44
≥80	71	13	31	13	40	13
Marital status*	(n=547)		(n=241)		(n=306)	
Married	275	50	197	82	78	26
Widowed	263	48	42	17	221	72
Other	9	2	2	1	7	2
Family income per month	(n = 333)		(n = 157)		(n = 176)	
(won) ≤ 500,000	78	24	29	19	49	28
510,000 – 1,000,000	84	25	43	27	41	23
1,010,000 – 2,000,000	94	28	49	31	45	26
2,010,000 – 3,000,000	46	4	21	13	25	14
≥ 3,010,000	31	9	15	10	16	9
Enough money to buy foods*	(n = 548)		(n = 239)		(n = 309)	
Always enough	305	56	154	64	151	49
Just enough	152	28	68	29	84	27
Never enough	91	16	17	7	74	24
Education*	(n = 548)		(n = 240)		(n = 308)	
No formal education	185	34	38	16	147	48
Elementary school	178	32	83	35	95	31
Middle school	66	12	45	19	21	7
High school	80	15	39	16	41	13
Undergraduate or higher	39	7	35	14	4	1
Members of household*	(n = 550)		(n = 241)		(n = 309)	
Living alone	77	14	8	3	69	22
With spouse	135	25	93	39	42	14
With children	63	11	40	17	23	7
With married son	230	42	84	35	146	47
With married daughter	20	4	5	2	15	5
Others	25	4	11	4	14	5
Perceived health status*#	(n = 549)		(n = 240)		(n = 309)	
Very good	203	37	116	48	87	28
Good	160	29	68	28	92	30
Not good	159	29	52	22	107	35
Poor	27	5	4	2	23	7

*Significantly different between male and female, as judged by χ^2-test #Perceived by each subject

mass index (BMI). Underweight subjects were classified as having BMI < 20.0, normal as $20.0 \leq$ BMI ≤ 25.0, and overweight as BMI > 25.0.

3. 24-hour recall

For each subject, 24-hour recall data were collected by graduate students majoring in food and nutrition, all of whom were trained by researchers at the Korea Health Industry Development Institute (formerly the Korea Institute of Food Hygiene). Both interviewers and subjects used small booklet including pictures of portion size to estimate food intake (KFRI, 1988). Energy and nutrient intakes were calculated using Korean Food Composition Tables (KRNI, 1996).

4. Estimation of energy requirements

To evaluate the underreporting of dietary intake, we used reported body weights to estimate ratios reported energy intake (EI) to estimated basal metabolic rate (BMRest), using age-and sex-specific formulas derived by Schofield (1985) (Table 1.) The cutoff value of 0.9 was used to classify individuals on the basis of one-day intake (Goldberg et al, 1991.) Participants with an EI: BMRest value of less than 0.9 were considered to be underreporters, whereas those with an EI: BMRest value of 0.9 or greater were considered to be adequate reporters.

5. Data analyses

A χ^2-test was used to determine gender differences in subject characteristics and to compare difference of characteristics and risk factors between underreporters and adequate reporters. Two-way ANOVA was used to find differences of EI : BMRest between men and women across age, weight status, family income, education, and members of household. Student's t-test was used to compare difference of EI : BMRest, age and nutrient intake for under- and adequate reporters according to gender. Stepwise regression analyses were also performed to predict EI : BMRest values using separate models for men and women. Variables included in the models were age, weight status, marital status, family income, education, members of household, perceived health status, alcohol consumption, and smoking habit.

RESULTS

1. Characteristics of the subjects

Subject characteristics are shown in Table 2. There were no significant differences between men and women for age or family income. It was found that 82% of men and 26% of women were married; 72% of women and 17% of men were widowed. Sixty percent of men and 49% of women reported always having enough money to buy foods. Only 16% of men reported no formal school education whereas 48% of women did so. Women were more likely to live alone, but 50% of men and 60% of women lived in households with children, including married children. Thirty seven percent of respondents reported that their perceived health condition was good.

We calculated mean EI : BMRest rates by gender according to age, weight status, family income per month, education, and members of household. Mean EI : BMRest rates tended to increase with higher family income in women and decreasing weight in men (Table 3). Mean ratios were significantly different with respect to weight status ($p < 0.01$). In women, the mean EI : BMRest rate

Table 3. Mean ratio of reported energy intake to estimated basal metabolic rate (EI : BMRest) by gender according to age, weight status, family income, education, and members of household

Characteristics	All	Men	Women
Age 60 – 69	1.38 (216)+	1.39 (89)	1.38 (127)
70 – 79	1.37 (226)	1.44 (111)	1.31 (115)
≥ 80	1.29 (54)	1.25 (25)	1.32 (29)
Weight status # **			
Underweight	1.40 (92)	1.49 (44)	1.30 (48)
Normal weight	1.41 (307)	1.41 (144)	1.41 (163)
Overweight	1.23 (97)	1.27 (37)	1.21 (60)
Family income per month*			
(won) ≤ 500,000	1.24 (62)	1.33 (26)	1.18 (36)
510,000 – 1,000,000	1.38 (78)	1.42 (40)	1.33 (38)
1,010,000 – 2,000,000	1.39 (92)	1.43 (48)	1.33 (44)
2,010,000 – 3,000,000	1.42 (45)	1.34 (21)	1.50 (24)
≥ 3,010,000	1.54 (31)	1.36 (15)	1.70 (16)
Education***			
No formal education	1.23 (145)	1.28 (29)	1.22 (116)
Elementary school	1.38 (168)	1.41 (80)	1.35 (88)
Middle school	1.45 (64)	1.38 (43)	1.59 (21)
High school	1.51 (78)	1.50 (37)	1.51 (41)
Undergraduate or higher	1.41 (39)	1.39 (35)	1.60 (4)
Members of household			
Living alone	1.30 (65)	1.33 (7)	1.30 (58)
With spouse	1.41 (130)	1.43 (92)	1.38 (38)
With children	1.36 (58)	1.39 (36)	1.32 (22)
With married son or married daughter	1.35 (218)	1.37 (79)	1.34 (139)
Others	1.44 (25)	1.43 (11)	1.45 (14)

+N (%)
#Criteria of BMI: Underweight: < 20.0, Normal weight: $20.0 - 25.0$, Overweight: > 25.0
*There were significant differences in EI : BMRest by family income level at $p < 0.05$
**There were significant differences in EI : BMRest by weight status at $p < 0.01$
***There were significant differences in EI : BMRest by education level at $p < 0.001$

was more likely to decrease with lower education.

Characteristics and risk factors of underreporters and adequate reporters of energy intake are shown in Table 4 and 5, respectively. About 14% of respondents were classified as underreporters (Table 5). The overall mean ratio for adequate reporters was significantly higher than that of underreporters (1.45 vs. 0.73, data not shown). There were significant differences between underreporters and adequate reporters in terms of education. Only 28% of adequate reporters reported no formal school education whereas 43% of underreporters did so. The prevalence of overweightness was significantly higher in female underreporters than adequate reporters, as judged by χ^2-test. Thirty-nine percent of underreporters were overweight compared to 20% of adequate reporters. The prevalence of alcohol consumption was lower in underreporters than in adequate reporters but the difference was not significant. Likewise, the higher prevalence of smoking in underreporters than in male adequate reporters was not significant. The prevalence of perceived poor health was also not significantly different between groups.

Table 4. Characteristics of underreporters and adequate reporters of energy intake in Korean elderly

	Underreporters	Adequate reporters
Age 60 - 69	23 (35)+	204 (42)
70 - 79	32 (48)	220 (46)
≥ 80	11 (17)	60 (12)
Family income per month		
(won) ≤ 500,000	10 (30)	52 (19)
510,000 - 1,000,000	8 (23)	70 (25)
1,010,000 - 2,000,000	8 (23)	84 (31)
2,010,000 - 3,000,000	5 (15)	40 (15)
≥ 3,010,000	3 (9)	28 (10)
Education*		
No formal education	25 (43)	120 (28)
Elementary school	19 (33)	149 (34)
Middle school	7 (12)	57 (13)
High school	5 (9)	73 (17)
Undergraduate or higher	2 (3)	37 (8)
Members of household		
Living alone	9 (15)	56 (13)
With spouse	11 (19)	119 (27)
With children	8 (14)	50 (11)
With married son or married daughter	27 (47)	191 (44)
Others	3 (5)	22 (5)

+ N (% in column)
*Significantly different between under- and adequate reporters by χ^2-test

Table 6. Results of multiple-regression analyses in predicting the ratio of energy intake to estimated basal metabolic rate (EI : BMRest) in men and women

Variables	Partial R^2	Total R^2
Men		
Weight status	0.0261	0.0261
Members of household	0.0249	0.0510
Alcohol consumption	0.0166	0.0676
Age	0.0143	0.0819
Women		
Family income	0.0859	0.0859
Education	0.0150	0.1008

Table 5. Risk factors relating to health of underreporters and adequate reporters by gender

	Men		Women	
	Underreporters	Adequate reporters	Underreporters	Adequate reporters
n (%)	30 (14)	208 (87)	35 (14)	259 (88)
EI : BMRest +	0.78±0.12#	1.47±0.34***	0.68±0.14	1.41±0.41***
Age (y)	72.33±8.25	71.18±6.28	74.26±5.89	70.48±6.50**
Weight status(%)				
Underweight	16	20	9	19*
Normal	52	66	52	61
Overweight	32	14	39	20
Smoking(%)				
Smokers	53	37	9	9
Non-smokers	47	63	91	91
Drinking alcohol(%)				
Alcohol consumer	30	46	8	19
Non-consumer	70	54	92	81
Perceived health status(%)				
Very good	40	50	17	30
Good	23	29	31	30
Not good	34	20	44	33
Poor	3	1	8	7

+Ratio of energy intake to estimated basal metabolic rate
#Mean ± S.D.
***Significantly different from underreporters at $p < 0.001$ by t-test
*Significantly different from underreporters at $p < 0.05$ by χ^2-test
**Significantly different from underreporters at $p < 0.01$ by t-test

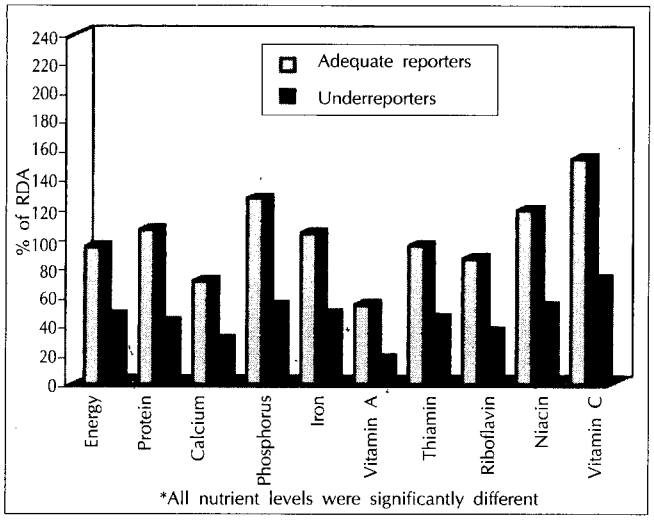

Fig. 1. Nutrient intake as % of RDA for male under- and adequate reporters*.

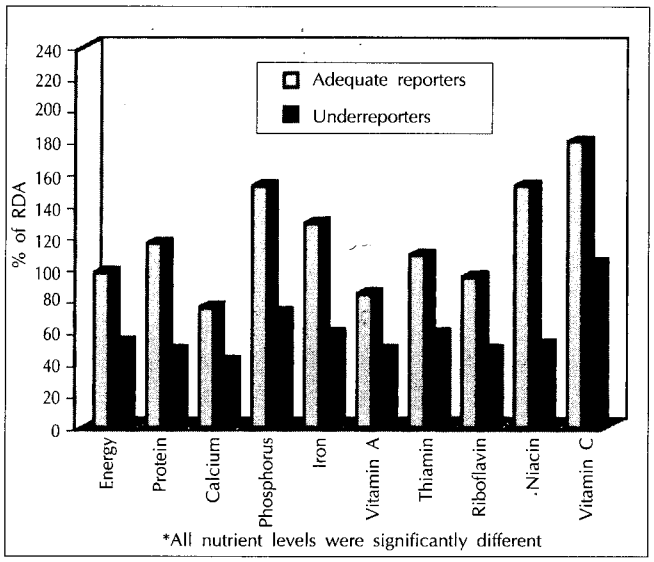

Fig. 2. Nutrient intake as % of RDA for female under- and adequate reporters*.

Energy, protein, vitamins, minerals, and macro- and micro-nutrient intakes were significantly lower in underreporters, naturally due to underreporting. In men, average intakes of adequate reporters were greater than recommended levels except for energy, calcium, vitamin A, and riboflavin ; average intakes of underreporters were less than recommended levels for all nutrients but vitamin C (Fig. 1). In women, underreporters had deficient intakes of all nutrients compared with Korean RDA whereas adequate reporters were deficient in energy, calcium, vitamin A, thiamin, and riboflavin (Fig. 2).

It was found by stepwise regression analysis that the most significant variables in men to predict the ratio of energy intake to estimated basal metabolic rate (EI : BMRest) were weight status, members of household, alcohol consumption, and age. Family income and education level were most significant in women (Table 6).

DISCUSSION

In the literature, underreporting has been reported to occur to a greater degree among obese than normal-weight subjects (Briefel et al., 1997; Lafay et al., 1997; Lansky and Brownell, 1982; Lichtman et al., 1992; Rothenbreg et al., 1997), older than younger subjects (Briefel, 1997), and women than men (Briefel, 1997; Johnson et al., 1994).

We found that mean EI : BMRest values were lower in both overweight men and women. These result are consistent with other findings that underreporting of energy occurs most often in overweight persons and weight-conscious respondents (Black et al., 1991; Black et al., 1993; Bingham, 1994; de Vries et al., 1994; Johnson et al., 1994; Mertz et al., 1991; Scholler 1990).

Weight status in men and income in women were the strongest independent predictors of underreporting, even though they accounted for only 3% of the variability in underreporting.

Lichtman et al. (1992) reported that young, obese subjects underreported their actual food intake by 47%. Johnson et al. (1994) reported that in normal-weight older women, adiposity was a strong predictor of underreporting of energy intake.

In this study, mean age was significantly higher in female underreporters than in adequate reporters. This result seems to agree with the general assumption that elderly women tend to underreport. In our sample, overweight older women were more likely to underreport their energy intake than were the overweight older men. Although the basis for this difference is not known, it could be speculated that the socio-cultural pressure placed on women to be slim induced alterations in their recording of food intake, making them appear to be smaller eaters.

Johnson et al. (1994) found that a higher level (24%) of underreporting in women was associated with adiposity in older women. The underreporting error in older women of our samples was lower than reported by Johnson (12% vs 24%). This result might be associated with lower prevalence of overweightness and inclination for dieting among the subjects. Thus, the bias toward energy intake underreporting is unlikely to be an overestimate of the actual amount of underreporting that exists among ov-

erweight subjects. With respect to the possible underreporting of total energy intake in the Third National Health and Nutrition Examination Survey (NHANES III) (Briefel et al, 1997), higher education and recreational physical activity were associated with higher EI : BMRest rates.

Nutrient intakes paralleled energy intake and any differences in mean nutrient intakes between underreporters and adequate reporters appeared to be energy-driven. The implications for measurement of specific nutrient intake depend on the still-unknown cause of the underreporting. Schoeller (1990) reported that if the underreporting of habitual energy intake by obese subjects was due to an inability to measure portion size, then it is likely that all nutrients would be underreported by similar amounts. And if the underreporting was due to the omission of nutrient-dilute snack foods, then many micro-nutrient intakes would be close to the reported values, while intakes of saturated fats, salt, and refined sugar would be even less accurate than energy intakes (Schoeller, 1990). Unfortunately however, it was not possible to distinguish between these two possibilities from our data. Therefore, more survey analyses are necessary to determine whether certain foods and beverages are more likely to be underreported.

Improved calculations for estimating BMR and energy requirements, or the development of adjustments that could be applied to the calculations, would enhance the study of factors associated with underreporting. Additional research is needed to evaluate the validity and applicability of existing formulas in Asian population groups such as the elderly and persons with various levels of physical activity. Apparent changes in energy intake are likely to be, at least in part, artifacts of the methods used. This is difficult to assess in detail, however, because physical activity expenditures were not measured in this study.

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