



## ORIGINAL ARTICLE

# Under-reporting of Energy Intake from 24-hour Dietary Recalls in the Korean National Health and Nutrition Examination Survey

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**Abstract**

**Objectives:** Chronic degenerative diseases are closely related to daily eating habits, nutritional status, and, in particular, energy intake. In clarifying these relationships it is very important for dietary surveys to report accurate information about energy intake. This study attempted to identify the prevalence of the under-reporting of energy intake and its related characteristics based on the Korean National Health and Nutrition Examination Survey conducted in the years 2007–2009.

**Methods:** The present study analyzed dietary intake data from 15,133 adults aged  $\geq 19$  years using 24-hour dietary recalls. Basal metabolic rates were calculated from the age- and gender-specific equations of Schofield and under-reporting was defined as an energy intake  $< 0.9$ , represented by the ratio of energy intake to estimated basal metabolic rate.

**Results:** Under-reporters (URs) accounted for 14.4% of men and 23.0% of women and the under-reporting rate was higher in the age group 30–49 years for both men and women. The results from an analysis of the age-specific socioeconomic characteristics of participants classified as URs showed that under-reporting was high in women living alone and in women with only elementary school education or no education. The results from an analysis of the health-specific characteristics of URs showed that a large proportion of URs had poor self-rated health or were obese, or both, compared with non-URs. The proportion of participants who

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consumed less than the estimated average requirements for nutrients was significantly higher in URs compared with non-URs.

**Conclusion:** The under-reporting of energy intake was associated with age, gender, education level, income level, household status (single-person or multi-person), self-rated health, physical activity, and obesity.

## 1. Introduction

It is very important to assess dietary intake accurately in nutrition surveys. Many studies have pointed out the under-reporting of energy intake from dietary surveys [1–8]. As the importance of a proper calorie intake has recently been emphasized, especially in association with chronic diseases, it has become very important to assess energy intake accurately. Overweight and obesity have been reported as major factors influencing under-reporting [3–7]. There have been reports demonstrating that under-reporting is common in elderly people and women [2–4,6] and that it is associated with socioeconomic and psychological characteristics [3–7]. However, no clear conclusion has yet been reached. Most nutrition surveys or epidemiological studies investigating dietary intake have methodological limitations related to misreporting and measurement errors [8–11].

In general, under-reporting is less likely in 24-hour dietary recalls than in self-reporting surveys in which participants are asked to record their own food intake [12,13]. However, it is difficult to determine whether under-reporting is a result of the misreporting of the kinds and amounts of food consumed, or from other factors influencing the participants' actual food intake. The National Health and Nutrition Examination Survey (NHANES), which is conducted in Korea based on the National Health Promotion Act, provides critical data for monitoring the health and nutritional status of Korean populations. These data can be used to aid in selecting populations vulnerable to health problems. These populations should be given priority consideration in related policies and in developing new policies by evaluating whether the current health nutrition policies and programs are being effectively implemented.

Based on data from NHANES, this study attempted to analyze the prevalence of under-reporting of energy intake by age and to identify the socioeconomic characteristics and risk factors relating to health that influence such under-reporting.

## 2. Materials and methods

### 2.1. Study population and data sets

In Korea, NHANES is conducted nationwide to assess the health status, disease prevalence, and nutrient intake of Korean people and consists of questionnaires,

physical examinations, and health interviews. This study attempted to identify the prevalence of under-reporting and its related characteristics based on the NHANESs carried out in the period 2007–2009. This study analyzed daily dietary intake data from 15,133 men and women aged  $\geq 19$  years using 24-hour dietary recalls. The study referred to basic interviews for socioeconomic information on the participants and health questionnaires for their age, smoking status, alcohol consumption, health, and physical activity. Physical examinations were used to determine anthropometric data. Participants were classified into four levels of education: elementary school or no education; middle school graduate; high school graduate; and college graduate or higher. They were also stratified into quartiles according to household income level: lowest; medium–low; medium–high; and highest. On the basis of their body mass index, their weight was classified as underweight ( $< 18.5 \text{ kg/m}^2$ ), normal ( $18.5\text{--}25.0 \text{ kg/m}^2$ ), and obese ( $\geq 25.0 \text{ kg/m}^2$ ). Walking exercise was defined as walking for  $\geq 30$  minutes at a time at least five times per week, either indoors or outdoors. Physical activity was defined as moderate exercise for  $\geq 30$  minutes at a time at least five times per week, or as vigorous exercise for  $\geq 20$  minutes at a time at least three times per week.

### 2.2. Estimation of energy requirements

The under-reporting of energy intake was evaluated by determining the ratio of reported energy intake to estimated basal metabolic rate, or EI:BMRest. The basal metabolic rate was estimated from the age- and gender-specific equations proposed by Schofield [14]. A cutoff value of 0.9 was used to define the under-reporting of energy intake in terms of the EI:BMRest ratio [15]. The participants were divided between under-reporters (URs) ( $< 0.9$ ) and non-under-reporters (non-URs) ( $\geq 0.9$ ).

### 2.3. Statistical analysis

All statistical analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC, USA). The statistics presented included the distributions (%) of sociodemographic and health-related variables for URs and non-URs and the means and standard deviations of nutrient and food group intakes. A Chi-square test was used to verify the differences in distributions of categorical variables by UR status (i.e., sociodemographic and health-related variables) and a *t* test was used to test for the difference in means of a continuous variable (i.e., food group intake).

**Table 1.** Percentages of under-reporters and non-under-reporters by gender in the Korean National Health and Nutrition Examination Survey 2007–2009

Age group (y)	Men ( <i>n</i> = 6029)			Women ( <i>n</i> = 9104)		
	Non-URs ( <i>n</i> = 5158)	URs ( <i>n</i> = 871)	<i>p</i>	Non-URs ( <i>n</i> = 7010)	URs ( <i>n</i> = 2094)	<i>p</i>
All	85.6	14.4		77.0	23.0	
19–29	10.9	20.4	<0.0001	11.6	13.1	<0.0001
30–49	37.8	33.6		41.5	36.4	
50–64	26.8	23.0		24.2	23.1	
≥65	24.5	23.0		22.7	27.4	

Data are given as %. Non-UR = non-under-reporter; UR = under-reporter.

**Table 2.** Sociodemographic characteristics of under-reporters and non-under-reporters in the Korean National Health and Nutrition Examination Survey 2007–2009

	Men ( <i>n</i> = 6029)			Women ( <i>n</i> = 9104)		
	Non-URs ( <i>n</i> = 5158)	URs ( <i>n</i> = 871)	<i>p</i> <sup>a</sup>	Non-URs ( <i>n</i> = 7010)	URs ( <i>n</i> = 2094)	<i>p</i> <sup>a</sup>
EI:BMRest	1.49 ± 0.48	0.72 ± 0.15	<0.0001	1.41 ± 0.42	0.69 ± 0.16	<0.0001
Living alone	4.8	6.2	0.077	8.6	12.7	<0.0001
Education						
Elementary school or less	22.5	22.1	0.008	34.1	40.8	<0.0001
Middle school	13.1	13.9		10.3	10.7	
High school	35.3	40.0		32.2	33.2	
College or higher	29.2	24.0		23.5	15.4	
Income						
Lowest	24.0	32.0	<0.0001	23.1	29.9	<0.0001
Medium–low	25.3	22.2		25.0	24.9	
Medium–high	25.1	22.7		26.1	23.0	
Highest	25.6	23.1		25.9	22.2	

<sup>a</sup>Obtained from Chi-square tests for categorical variables and from *t* tests for continuous variables. Data are presented as mean ± SD or %. EI:BMRest = ratio of energy intake to estimated basal metabolic rate; Non-UR = non-under-reporter; UR = under-reporter.

**Table 3.** Risk factors relating to health of under-reporters and non-under-reporters by gender in the Korean National Health and Nutrition Examination Survey 2007–2009

	Men ( <i>n</i> = 6029)			Women ( <i>n</i> = 9104)		
	Non-URs ( <i>n</i> = 5158)	URs ( <i>n</i> = 871)	<i>p</i> <sup>a</sup>	Non-URs ( <i>n</i> = 7010)	URs ( <i>n</i> = 2094)	<i>p</i> <sup>a</sup>
BMI ≥25.0 kg/m <sup>2</sup>	33.1	42.2	<0.0001	27.0	37.9	<0.0001
Current smoker	78.4	77.9	0.746	8.8	12.1	<0.0001
Alcohol consumer	71.3	68.4	0.079	37.4	36.8	0.624
Self-rated health						
Very good/good	45.4	39.5	<0.0001	37.1	32.5	<0.0001
Fair	35.4	34.9		35.9	32.8	
Very poor/poor	19.2	25.6		27.0	34.7	
Change of body weight in the past year						
No change	68.7	61.5	<0.0001	65.7	60.7	0.000
Weight loss	16.5	18.0		13.8	16.1	
Weight gain	14.8	20.5		20.5	23.2	
Physical activity <sup>b</sup>						
Walking	50.1	47.2	0.123	44.3	43.4	0.509
Moderate	15.4	12.3	0.019	14.3	13.6	0.411
Vigorous	19.7	16.2	0.014	13.7	13.2	0.595

<sup>a</sup>Obtained from Chi-square tests for categorical variables; <sup>b</sup>Walking exercise was defined as walking for ≥30 minutes at a time at least five times per week, either indoors or outdoors. Physical activity was defined as moderate exercise for ≥30 minutes at a time at least five times per week, or in vigorous exercise for ≥20 minutes at a time at least three times per week. Data are presented as %.

### 3. Results

Table 1 shows the rates of under-reporting by gender and age. Under-reporting was higher in women (23.0%) than in men (14.4%) and higher in the age group 30–49 years for both men and women.

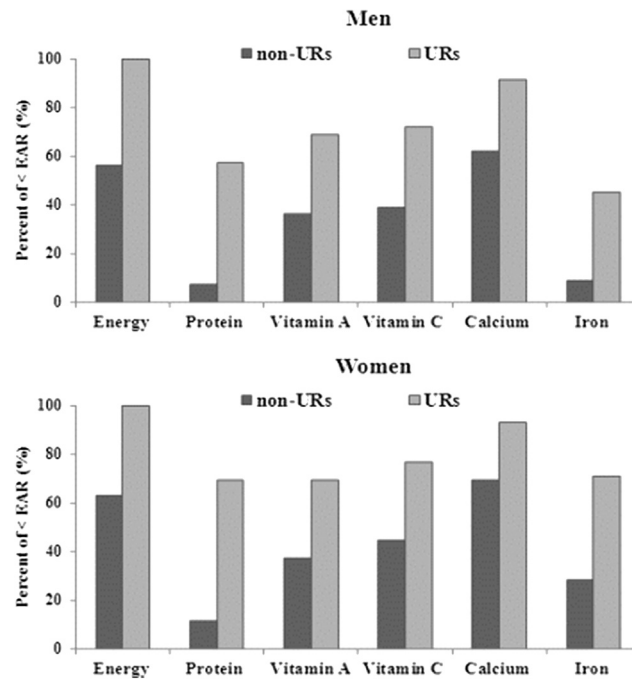
Table 2 shows the results from our analysis of indicators that represent the household status, education level, and income level of URs and non-URs. Odd ratios

were used to estimate the probability for under-reporting. Under-reporting was high in women living alone. Under-reporting by final education level was higher in men with a high school diploma and in women with elementary school education or no education. Both men and women showed the highest under-reporting rate at the lowest income level.

The percentage of individuals classified as obese (body mass index  $\geq 25$ ) was higher in URs than in non-

**Table 4.** Multivariate analysis of factors for predicting of under-reporting status by gender

	Men		Women	
	OR (95% CI)	<i>p</i> for trend	OR (95% CI)	<i>p</i> for trend
Age (y)				
19–29	1.00	0.001	1.00	<0.0001
30–49	0.84 (0.72–0.98)		0.46 (0.67–1.01)	
50–64	0.65 (0.53–0.81)		0.39 (0.30–0.51)	
$\geq 65$	0.70 (0.55–0.89)		0.40 (0.30–0.54)	
Living status				
Together	1.00	0.002	1.00	0.931
Alone	1.31 (1.10–1.56)		1.02 (0.73–1.41)	
Education				
$\leq$ Middle school	1.00	0.026	1.00	0.068
>High school	0.84 (0.72–0.98)		0.83 (0.67–1.01)	
Income level				
Lowest	1.00	0.000	1.00	0.001
Medium–low	0.80 (0.70–0.92)		0.68 (0.55–0.83)	
Medium–high	0.74 (0.64–0.86)		0.72 (0.59–0.89)	
Highest	0.77 (0.66–0.86)		0.73 (0.59–0.91)	
Weight status				
Under weight	1.00	<0.0001	1.00	<0.0001
Normal	1.26 (0.98–1.63)		0.92 (0.62–1.36)	
Obese	1.96 (1.50–2.55)		1.43 (0.96–2.13)	
Current smoker				
No	1.00	0.002	1.00	0.454
Yes	1.29 (1.10–1.63)		1.07 (0.89–1.30)	
Alcohol consumer				
No	1.00	0.576	1.00	0.110
Yes	1.03 (0.92–1.15)		0.87 (0.74–1.03)	
Self-rated health				
Very good/good	1.00	0.000	1.00	0.001
Fair	1.01 (0.89–1.14)		0.92 (0.62–1.36)	
Very poor/poor	1.28 (1.12–1.46)		1.46 (1.19–1.79)	
Change of body weight in last year				
No change	1.00	0.025	1.00	0.291
Reducing body weight	1.20 (1.04–1.39)		1.10 (0.86–1.34)	
Increasing body weight	1.12 (0.98–1.28)		1.17 (0.95–1.45)	
Physical activity				
High activity				
No	1.00	0.901	1.00	0.069
Yes	0.99 (0.85–1.15)		0.83 (0.67–1.02)	
Medium activity				
No	1.00	0.473	1.00	0.099
Yes	0.95 (0.81–1.10)		0.82 (0.65–1.04)	
Walking activity				
No	1.00	0.547	1.00	0.122
Yes	0.97 (0.87–1.08)		0.89 (0.76–1.03)	



**Figure 1.** Percentages of under-reporters (URs) and non-URs by gender who consumed less nutrients than the estimated average requirement (EAR) for each nutrient. All percentages were significantly different at  $p < 0.001$ .

URs (42.2% vs. 33.1% for men; 37.9% vs. 27.0% for women) and in those who reported poor or very poor self-rated health (25.6% vs. 19.2% for men; 34.7% vs. 27.0% for women; Table 3). As shown in Table 4, higher odds ratios were found for individuals who were classified as obese and who reported poor or very poor self-rated health. This indicates that obesity and poor health influenced under-reporting. Current women smokers were associated with higher under-reporting, as indicated by the odds ratio (1.29 for smoking vs. 1.0 for nonsmoking; Table 4).

Figure 1 shows the proportions of participants who did not meet the estimated average requirements for nutrients by gender and UR status. For every nutrient, the proportion of participants who consumed less than the estimated average requirement was significantly higher in URs than in non-URs.

Figure 2 shows food group intakes expressed as percentages of the total food intake. Food groups whose intake accounted for a high percentage of the total food intake in URs compared with non-URs included cereals, vegetables, and seaweeds. Food groups consumed at a lower percentage were potatoes and starches, sugars and sweeteners (for men), nuts, mushrooms, fruits, meats, fish and shellfish, oil and fats, and beverages.

#### 4. Discussion

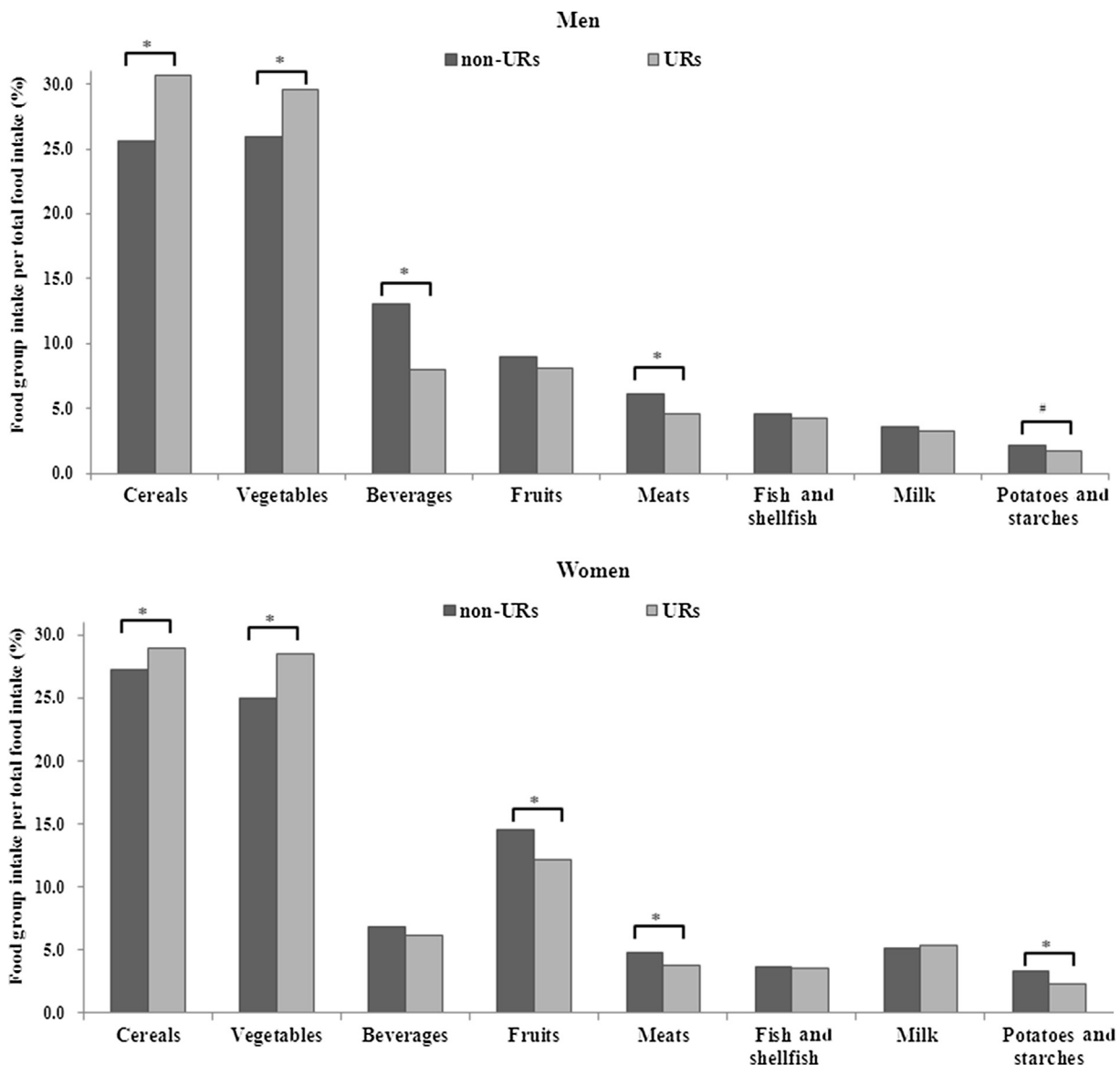
In a national survey, it is meaningful to identify under-reporting population groups and to determine the socioeconomic characteristics and health indicators that

help to predict under-reporting. The prevalence of obesity is increasing, especially in Korea, but the total energy intake is tending to decrease. There is a need to determine whether there is under-reporting of energy intake and other nutrients.

Previous studies showed that the under-reporting of energy intake is more common among obese or overweight people than among those of normal weight [3–7]. This study also found a higher under-reporting rate in participants who were obese.

Likewise, age was reported as a strong independent predictor of under-reporting [8]. In this study, the age groups 19–29 years for men and  $\geq 65$  years for women were associated with higher under-reporting in URs compared with non-URs. When the under-reporting status of overweight or obese people was compared by age (data not shown), under-reporting was found to be high in all age groups for women in the age group and in the 19–29 year and 30–49 year age groups for men (data not shown). These findings confirmed the association between under-reporting and obesity indicators. It has been reported that there is a tendency for under-reporting in women and older people. This study also found that women tended to under-report their energy intake more than men, but as middle-aged people (aged 30–49 years) displayed higher under-reporting than older people, we could not clarify the association between age and under-reporting.

Although a low level of household income is known to be associated with a poorer quality diet, Garriguet [1] reported in his analysis of data from the Canadian



**Figure 2.** Food group intake as a percentage of total food intake for under-reporters (URs) and non-URs by gender. Differences are statistically significant  $*p < 0.001$ .

Community Health Survey that there was no association between household income and under-reporting of energy intake. This study found a high proportion of under-reporters in the lowest income level. From this finding, it can be inferred that a low income led to a decreased food intake by affecting food purchasing power. This may cause dissatisfaction in the quality and quantity of the diet, but further analyses are needed to clarify the correlations.

The study results indicate that the proportion of women who completed elementary school education or no education is higher in URs than in non-URs. This is consistent with a previous report showing that an education level lower than middle school is associated with under-reporting [1].

The analysis of data on self-rated health status in this study showed that a larger portion of URs than non-URs

reported their self-rated health as poor or very poor. From the finding, it can be inferred that poor self-rated health is associated with an under-reporting of energy intake by reducing appetite and affecting food intake, but this is not clear.

It has been reported that a great deal of energy intake under-reporting is usually attributable to the under-reporting of unhealthy and energy-dense foods such as sugars, fats, sweets, and sugar-containing desserts [1]. This issue needs to be analyzed in depth in future Korean NHANESs.

### Conflicts of interest

All contributing authors declare no conflicts of interest.

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