Original Article

Accuracy of Energy Intake Reporting: Comparison of Energy Intake and Resting Metabolic Rate and their Relation to Anthropometric and Sociodemographic Factors among Iranian Women

Mahboubeh Shaneshin MSc[1], Bahram Rashidkhani PhD•[1], Samira Rabiei MSc[1]

Abstract

Background: This study assesses the accuracy of energy intake (EI) reporting and its relation to anthropometric characteristics and sociodemographic factors. In addition, we attempt to identify foods for which under- or over-reporting is more prevalent.

Methods: EI was assessed for 187 women using a semi-quantitative 168-item food frequency questionnaire (FFQ). Resting metabolic rate (RMR) was measured with an indirect calorimeter. We calculated the EI/RMR ratio to assess the accuracy of EI reporting. This study defined under-reporters as those with an EI/RMR of ≤1.34 and over-reporters as those with an EI/RMR of ≥ 2.4. We measured anthropometric characteristics and collected sociodemographic information. The chi-square test, ANOVA and multiple linear regressions were used for statistical analyses.

Results: Among participants, the under-reporting rate was 35.5% and the over-reporting rate was 7.5%. The EI/RMR ratio was significantly higher for younger women compared to older women ($P < 0.04$). Under-reporters had higher weight, waist circumference (WC), body mass index (BMI) and resting metabolism compared to accurate reporters ($P < 0.05$). Resting metabolism was significantly lower among over-reporters than accurate reporters. After adjusting for energy, the consumption of fish, high-fat dairy products, hydrogenated oil, sweets and coffee was lower, whereas consumption of unsaturated oils, tea, salt and yellow vegetables was higher among under-reporters compared to accurate reporters.

Conclusion: Under-reporting of EI is more frequent than over-reporting among Iranian women. Among various factors that may affect the accuracy of EI reporting, age and anthropometric characteristics might have a significant effect.

Keywords: Anthropometric characteristics, energy intake, energy reporting, resting metabolism, sociodemographic factors.

Cite this article as: Shaneshin M, Rashidkhani B, Rabiei S. Accuracy of energy intake reporting: comparison of energy intake and resting metabolic rate and their relation to anthropometric and sociodemographic factors among Iranian women. *Arch Iran Med*. 2012; **15(11):** 681 – 687.

Introduction

Bias of reporting energy intake (EI) in relation to energy expenditure (EE) is a common problem in dietary surveys.[1] Inaccurate estimates of energy consumption might lead to inaccurate estimates of food consumption and EI.[2] Inaccurate EI reporting represents a challenge in investigations of the association between dietary factors and health outcomes.[3,4] It is important to detect the degree and distribution of misreported EI because of its relevance in evaluating relations between diet and health.[5]

The doubly labeled water (DLW) method can be used to measure EE with good accuracy.[6] However, this method is costly and unsuitable for large samples.[1] The ratio of EI to the resting metabolic rate (RMR) can be used to calculate the degree of under- or over-reporting of EI.[7] EI/RMR, as suggested by Black in in 1999, is used to estimate the accuracy of EI reports in epidemiologic studies.[7] The ratio is positively correlated with the EI/EE ratio as measured by the DLW method.[8,9] EI/RMR ratios have revealed that most dietary surveys underestimate habitual EI; however, little information is available on over-reporting of EI.[1]

Most studies have found a high prevalence of EI under-reporting among women and among older compared to younger subjects.[1,5] Although under-reporting has been found among underweight subjects,[10] it is more prevalent among obese individuals.[11] There has only been one study of EI under-reporting in Iran. In this study, Mirmiran observed that under-reporting of 24 hr dietary recall was more frequent in women (41%) than in men (19%).[12] According to a study by Johansson in 1998, under-reporting in a food frequency questionnaire (FFQ) was 45% and over-reporting was 5% among women.[5]

It seems that reporting of food intake and EI may be biased by factors such as age, sex, educational level, health consciousness, dieting,[13] degree of obesity,[14,15] body image, percent of body fat, waist circumference (WC), physical activity and income level.[2,11] However, the results are controversial.

Many studies have shown that under- or over-reporting exists for selected food items.[5] If this bias is non-randomly distributed among a population, it could lead to distortion of assessments of the correlation between dietary intake and health outcomes.

The precise use of FFQs in nutritional studies to assess EI has not been evaluated among Iranian women. Considering the importance of accurate EI reporting in epidemiological surveys, the aim of this study was to evaluate the accuracy of EI reporting and to assess some of the related factors among Iranian women. In ad-

Authors' Affiliations: [1]Community Nutrition Department, Faculty of Nutrition Sciences and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences and Health Services, Tehran, Iran.

•**Corresponding author and reprints:** Bahram Rashidkhani PhD, National Nutrition and Food Technology Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Tel: +98 21 22360658, Fax: +98-2122360657,
E-mail: b_rashidkhani@sbmu.ac.ir.
Accepted for publication: 11 July 2012

dition, we wanted to identify the foods for which under- or over-reporting was more prevalent in our study population.

Materials and Methods

In this cross-sectional study, 232 women (18 – 45 years old) were selected according to population weight by stratified random sampling from 18 health service centers (8 in the north and 10 in the east) among the eight regions serviced by the Shahid Beheshti University of Medical Sciences in the north and east of Tehran. Some 210 women (90%) signed a written consent form. All participants were referred to the National Nutrition and Food Technology Research Institute of Shahid Beheshti University of Medical Sciences.

Women with histories of chronic diseases (e.g., cardiovascular disease, diabetes mellitus, cancer) or of thyroid disorders or factors that affected their metabolism (mainly steroid or thyroid drugs) were excluded from the study. We also excluded women who dieted to increase or decrease weight in the month before the study. After exclusions according to these criteria, 187 women were recruited. The study protocols and procedures were approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences.

General information assessment

The participants completed a general information form that included questions on age, marital status and education level for themselves and their husbands.

Food intake assessment

To collect dietary data, we used a 168-item semi-quantitative FFQ validated for the Iranian population.[12] The FFQ was a Willet format questionnaire[16] modified for Iranian food items that contained questions about average consumption and frequency for 168 food items during the past year. Food items were chosen according to the most frequently consumed items in a national food consumption survey in Iran. Because different recipes were used for food preparation, the FFQ was based on food items rather than dishes (e.g., beans, different meats and oils, and rice). Subjects indicated their food intake frequency on a daily, weekly, monthly and yearly basis. The questionnaire included 168 food items with the standard serving size for each item. It was designed according to the Willet method[16,17] and was used in previous studies by Esmaillzadeh and Azadbakht to determine dietary patterns.[18] Because the only Iranian Food Composition Table (FCT) available[19] analyzes a very limited number of raw food items and nutrients, we used the United States Department of Agriculture (USDA) FCT[20] as the main tool. In addition, we used the Iranian FCT as an alternative for traditional Iranian food items, such as kashk. Trained interviewers asked participants to report the foods they currently consumed and the dietary intake data were then converted into daily grams of food intake using household measures.[21] We calculated the EI of each food item for each person. SPSS version 13 (SPSS Inc., Chicago, IL) was used to calculate the mean daily EI for each participant.

Food items included in the FFQ were divided into 39 predefined food groups[22] based on similarity of nutrient profile or culinary usage.

Anthropometric measurements

Trained certified dietitians conducted all anthropometric measurements. Body weight was measured to the nearest 100 g using digital scales (Soehnle, Germany) with participants minimally clothed and without shoes. Height was measured in a standing position without shoes with the shoulders in a normal position using a non-stretch tape measure that was attached to a wall. Height was recorded to the nearest 0.5 cm. The body mass index (BMI) was calculated by dividing weight (kg) by height (m^2). Women with BMI ≤ 25 kg/m^2 were considered of normal weight. BMI between 25 and 29.9 kg/m^2 was considered as overweight and BMI ≥ 30 kg/m^2 was considered obese.[17] WC was measured at the end of normal exhalation. For some subjects whose minimal WC was not easily determined because of obesity or wasting, we measured the circumference at the last vertebra, since the minimal WC is located in this area for the most people.[23] We measured the greatest circumference of the hip as the hip circumference.

Measurement of resting metabolic rate (RMR)

Since accurate measurement of RMR typically requires trained technicians and involves costly methodologies, its application is impractical in most clinical and community settings.[10] Prediction equations for RMR use typical variables such as age, sex, height and body mass, but they can only predict 50% – 75% of the variability in RMR.[17] New portable devices for RMR measurement are less expensive and easier to use compared to traditional metabolic systems. Cosmed developed a small (20 cm × 24 cm) metabolic analyzer (FitMate™) to assess oxygen and energy consumption during rest and exercise.[10] In a previous study, RMR was measured simultaneously using a Douglas bag and the FitMate™ system with no significant differences observed in RMR results.[10] A FitMate™ calorimeter (Cosmed, Rome, Italy) was used by trained nutritionists to measure RMR according to a standard protocol.

We measured RMR during the first 10 days of the follicular phase to control for possible fluctuations in resting metabolism.[24] Tests were conducted at 08:00 h after 12 hr of overnight fasting; subjects were instructed to ingest a standard evening meal between 19:30 and 20:00 hr on the previous day. During the 24 h before the study, subjects abstained from exercise. Participants also refrained from smoking and consumption of alcohol, caffeine or drugs for 12 h before the study. Before RMR measurements, subjects remained supine for 25 ± 30 min in a quiet room at a temperature between 22°C and 24°C.

During the procedure, subjects were relaxed and stable, and a mask covered their nose and mouth to measure oxygen consumption (VO_2) for 15 min. Ventilation was measured using a flow meter and the fraction of oxygen in expired gases was assessed using a galvanic fuel-cell oxygen sensor. RMR was calculated from oxygen consumption using a fixed respiratory quotient (RQ) of 0.85 and estimated grams of urinary nitrogen according to a modified Weir equation:[16]

$$\text{REE} = [O_2 \text{ consumed (L)} \times 3.941\ CO_2 \text{ produced (L)} \times 1.11] \times 1440 \text{ min/day}$$

Calculation of the EI/RMR ratio

We used the Goldberg cutoff to identify the accuracy for EI reporting. This ratio is also beneficial in assessing the precision of FFQ reporting. According to this cutoff, a subject is considered an under-reporter when EI/RMR is ≤ 1.34 and an over-reporter when

EI/RMR is ≥ 2.4. Subjects with an EI/RMR ratio between 1.35 and 2.39 are considered to be accurate reporters.[1]

Statistical analysis

SPSS version 13 was used for statistical analysis. We used the Kolmogorov-Smirnov test to determine if variables showed a normal distribution. We calculated daily intakes of food groups in grams per 1000 kcal. This correction for EI prevents overeaters from exerting undue influence on the resulting patterns.[25] Unstandardized variables were used to give more frequently consumed foods additional influence on analysis formation.[26] One-way ANOVA was used to compare quantitative variables among the reporting groups and Bonferroni correction was applied if the results were statistically significant. Mann-Whitney and Kruskal-Wallis tests were used for the two variables (age and education level) that did not show a normal distribution. We used a chi-square or Fisher test to compare the mean of qualitative variables among EI reporting groups.

In this study, the EI/RMR ratio was the dependent variable and food groups were the independent variables; we considered their effects simultaneously. In analyses, we used baseline data on age. Age was classified into three categories: < 32, 32 – 40 and > 40 years. Multivariate linear regression was used to determine the correlation between food groups and EI reporting. We considered a P-value of < 0.05 as significant.

Results

Of the 185 participants, 35.3% were under-reporters (EI/BMR <1.35) and 7.4% were over-reporters (EI/BMR ratio of ≥ 2.4). The mean age of participants was 35 years and the average ratio of EI/BMR was 1.6 ± 0.6 (SD). The mean BMI was 27.7 kg/m^{2}and EI was 2281 kcal. The numbers of women who were of normal weight were 33.7%, overweight comprised 30.5% and obese were 35.8%. Educational status of participants were as follows: primary school (15%), guidance school (38.8%), diploma (19%) and university education (27.2%).

As shown in Table 1 resting metabolism as measured using a FitMate™ calorimeter was significantly lower in younger women compared to the other age groups (P < 0.01). The EI/RMR ratio was significantly higher in subjects < 32 years of age compared to those > 40 years (P < 0.04). Body weight, WC, hip circumference and BMI were significantly lower in the youngest age group compared to the other groups (P < 0.01). Variables of marital status, tendency for weight change and educational level did not significantly differ among the age groups. There were also no significant differences for BMI among the age groups.

Table 2 shows characteristics according to EI reporting. Under-reporters (EI/RMR ≤ 1.34) were older and had higher weight, WC, BMI and resting metabolism compared with accurate reporters (P < 0.05). Resting metabolism was significantly lower among over-reporters (EI/RMR ≥ 2.4) compared to accurate reporters. The percentage of women with normal BMI was significantly higher among over-reporters (P < 0.05). After including age and BMI in multiple linear regressions to evaluate the accuracy of EI reporting, a negative correlation was noted between BMI and EI/RMR (P < 0.01, β = 0.1999; Table 3).

As shown in Table 4, under- and over-reporters had lower and higher total food intake (g/day), respectively, than accurate reporters. After adjustments for energy it was noted that the consump-

Table 1. Distribution of energy intake (EI), estimated resting metabolic rate (RMR), EI/RMR ratio, anthropometric and sociodemographic factors in three age groups.*

	Age (years)			
	<32 (n=60)	**32-40 (n=55)**	**≥40 (n=72)**	***P*-value #**
Energy intake (EI; kcal/day)	2319±700.1	2361±848.9	2188±652.1	0.37
Resting metabolic rate (RMR; kcal/day)	¥1368±313.8€	1522±296.6	1510±256.1	<0.01
EI/RMR	1.8±0.6 €	1.6±0.7	1.5±0.5	<0.05
Weight (kg)	61±17.1 ℓ	72±13.9	72±8.7	<0.01
Height (cm)	158±6.8	158±6.0	156±5.7	0.05
Waist circumference (WC; cm)	75±13.6 ℓ	83±12.4	88±10.4	<0.01
Hip circumference (cm)	101.3±11.4 ℓ	108.5±10.1	108.6±8.3	<0.01
BMI (kg/m²)	25±6.0 ℓ	29±6.1	29±4.1	<0.01
Marital status (%)				
Single	12 (20)	5 (9.1)	16 (22.2)	0.05
Married	48 (80)	50 (90.9)	53 (73.6)	
Divorced/widow	---	----	3 (4.2)	
BMI (%)				
Normal (≤25)	25 (41.7)	16 (29.1)	22 (30.6)	0.6
Overweight (25< BMI <30)	15 (25)	18 (32.7)	24 (33.3)	
Obese (≥30)	20 (33.3)	21 (38.2)	26 (36.1)	
Intent to change body weight (%)				
To decrease	49 (81.7)	38 (69.1)	57 (79.2)	0.6
To increase	3 (5.0)	5 (9.1)	5 (6.9)	
Unchanged	8 (13.3)	12 (21.8)	10 (13.9)	
Educational level (%)				
Primary school	7 (11.7)	5 (9.1)	4 (5.6)	0.7
Guidance school	20 (33.3)	17 (30.9)	28 (38.9)	
High school	17 (28.3)	21 (38.2)	20 (27.8)	
University/College	16 (26.7)	12 (21.8)	20 (27.8)	

* Values are expressed as mean ± SD, unless specified otherwise; # P value is calculated by ANOVA or Kruskal-Wallis for qualitative variables and by chi-square or Fisher for qualitative variables; ¥ P<0.05 compared with the second age group; € P<0.05 compared with the third age group; ℓ P<0.05 compared with the other groups.

Table 2. Characteristics of under-, over-, and accurate reporters: Energy intake (EI), resting metabolism, anthropometric characteristics and sociodemographic factors. *

	Under-reporting [ɣ] (n=66)	Accurate reporting [ɣ] (n=107)	Over-reporting [ɣ] (n=14)	*P*-value [#]
Age (years)	36±8 [€]	35±10	29±9	0.01
Energy intake (EI; kcal/day)	1774±463[¥]	2406±472	3711±1049[¥]	<0.01
Resting metabolism rate (RMR; kcal/day)	1652±293[¥]	1393±238	1171±179[£]	<0.01
Weight (kg)	73±17[¥]	66±15	61±8	<0.01
Height (cm)	155±20	155±21	157±7	0.87
Waist circumference (WC; cm)	84±16[£]	79±18	76±6	0.01
BMI (kg/m²)	29±6 [€]	27±6	25±5	<0.01
Marital status (%)				0.27
Single	7 (11)	23 (21)	3 (21)	
Married	57 (86)	83 (78)	11 (79)	
Divorced/widow	2 (3)	1 (1)	---	
BMI (%)				<0.05
Normal (≤25)	15 (23)	40 (37)	8 (58)	
Overweight (25< BMI <30)	19 (29)	35 (33)	3 (21)	
Obese (≥30)	32 (48)	32 (30)	3 (21)	
Intent to change body weight (%)				0.43
To decrease	54 (82)	80 (75)	10 (72)	
To increase	2 (3)	9 (8)	2 (14)	
Unchanged	10 (15)	18 (17)	2 (14)	
Educational level (%)				0.06
Primary school	6 (4)	10 (9)	2 (14)	
Guidance school	32 (48)	31 (29)	2 (14)	
High school	19 (29)	33 (31)	6 (43)	
University/college	11 (17)	33 (31)	4 (29)	
Husband's educational level (%)				0.26
Primary school	7 (12)	14 (18)	1 (9)	
Guidance school	24 (44)	32 (39)	1 (9)	
High school	11 (20)	13 (16)	4 (36)	
University/college	13 (24)	22 (27)	5 (46)	
Age (years; %)				<0.05
<32	17 (26)	34 (32)	9 (64)	
32–40	21 (32)	31 (29)	3 (22)	
≥40	28 (42)	42 (39)	2 (14)	

* Values are expressed as mean ± SE, unless specified otherwise; # *P*-value is calculated by ANOVA or Kruskal-Wallis for qualitative variables and by chi-square or Fisher for qualitative variables; ¥ *P*<0.001 compared with accurate reporters; £ *P*<0.01 compared with accurate reporters; € *P*<0.05 compared with accurate reporters; ɣ, Under-reporters: EI/ RMR ≤1.34; Accurate reporters: 1.34< EI/RMR <2.4; Over-reporters: EI/RMR ≥2.4.

Table 3. Correlation of report accuracy with age and BMI using multiple linear regression.*

	β[#]	SE[¥]	95% CI [€]	*P*-value
Age	-0.094	0.006	(-0.004, 0.019)	0.22
BMI	-0.199	0.008	(-0.037, -0.005)	<0.01

* Adjusted for age and BMI; # Regression coefficient; ¥ Standard error of the regression coefficient;
€ Confidence interval.

tion of fish, high-fat dairy products, hydrogenated oil, sweets and coffee was lower among under-reporters compared to accurate reporters, whereas consumption of unsaturated oils, tea, salt and yellow vegetables was higher among under-reporters compared to accurate reporters.

Table 5 shows the Pearson coefficient for correlation between energy reporting and anthropometric characteristics for all participants and separately for accurate reporters. There were no significant correlations among all participants. The correlation between energy reporting and body weight, WC and hip circumference was significant when we considered only accurate reporters.

Discussion

Our study showed that under-reporting of EI was more frequent than over-reporting among Iranian women. Under-reporting was accompanied by higher weight, WC, BMI and resting metabolism, and older age. Among various factors that may affect the accuracy of EI reporting, age and anthropometric characteristics have a significant negative effect.

The mean EI/RMR ratio was 1.6. According to 37 previous studies, this ratio varied from 1.09 to 1.57.[2] Our results were consistent with those of Black et al., who reported a ratio of 1.6.[1] Our results were also similar to those of Johansson; in both studies the mean EI/RMR ratios for women of < 30, 30 – 40 and > 40 years were 1.8, 1.6 and 1.5, respectively.[5] Samaras et al. found that 52% of their study population were under-reporters.[27] Mirmiran et al. observed that 41% of 20 to 50-year-old women reported an EI less than their actual intake.[12] Their study differed from ours in two aspects. First, they measured EI using 24 hr dietary recall, while we used the FFQ. They used the Harris-Benedict formula to calculate RMR, while we used an indirect calorimeter.

All methods used for nutritional assessment have both advantages and limitations. In a survey by Black, an FFQ, food recording and 24 h dietary recall estimated EI values that were 25%, 64% and 88% less than the acceptable cutoff of 1.34, respectively.[7]

Approximately 7% of our sample had an EI/RMR ratio > 2.4, thus we classified them as over-reporters. Previous studies using DLW measured EI over-reporting in soldiers, athletes and subjects who performed strenuous physical activity, but not enough information about other subjects has been reported.[7]

Over-reporting of EI in women was 5% in a survey by Johans-

Table 4. Intake of food in accurate, under-, and over-reporters*,**.

Food groups (gr/1000 kcal)	Accurate reporters (n=107)	Under-reporters (n=66)	Over-reporters (n=14)
Processed meat	11.2 (9.6,12.8)	11.1 (8.8,13.4)	9.2 (4.0,14.2)
Red meat	11.2 (9.7,13.8)	15.7 (11.6,19.8)	15.3 (1.1,29.6)
By-products	0.8 (0.6,1.0)	1.3 (0.4,2.1)	0.8 (0.1,1.5)
Fish	4.3 (3.6,5.1)	3.1 (2.1,4.0) #	2.9 (2.0,3.8)
Poultry	6.3 (5.6,7.3)	7.6 (6.1,9.2)	7.2 (3.1,11.2)
Eggs	8.7 (7.2,10.1)	9.0 (7.4, 10.6)	8.4 (5.8,11.2)
Butter	1.8 (0.9,2.8)	1.1 (0.6,1.6)	2.6 (0.3,4.9)
Margarine	0.02 (0.006,0.04)	0.16 (0.04,0.36)	0.3 (0.14,0.6)
Low-fat dairy products	101.5 (85.1,117.9)	136.5 (100.6, 172.4)	39.9 (15.5,64.0) #
High-fat dairy products	37.9 (26.1,49.7)	24.7 (9.3,40.0) #	52.0 (4.5, 99.5)
Tea	288.0 (252.7, 323.3)	390.0 (321.0,459.0) #	108.8 (63.6,154.1) #
Coffee	10.4 (6.6,14.2)	4.6 (2.3, 6.9) #	6.3 (0.6,11.9)
Fruits	215.2 (192.2,238.2)	222.5 (180.1,264.9)	179.0 (127.8,230.1)
Fruit juices	12.4 (9.1,15.7)	8.4 (5.8,11.1)	12.5 (5.3,19.6)
Cabbage	1.5 (1.0,2.0)	2.1 (1.0,3.1)	3.2 (0.1,6.4)
Yellow vegetables	8.6 (6.3,11.0)	13.3 (10.0,16.6) #	5.5 (2.5,8.6)
Tomatoes	67.7 (57.4,77.9)	75.6 (57.8,93.4)	46.3 (29.2,63.4)
Green leafy vegetables	9.3 (7.5,11.1)	14.7 (9.8,19.6)	9.1 (5.7,12.4)
Other vegetables	98.8 (89.2,108.4)	112.9 (94.9,130.9)	85.6 (64.4,106.9)
Legumes	13.5 (11.1,16.0)	15.5 (11.7,19.3)	14.8 (9.2,20.4)
Garlic	0.2 (0.1,0.3)	0.2 (0.1,0.3)	0.1 (0.04,0.3)
Potatoes, total	10.1 (7.8,12.4)	12.6 (9.4,15.7)	8.3 (3.0,13.5)
Potato chips	3.4 (2.5,4.4)	2.4 (1.6,3.1)	3.3 (0.4,7.2)
Whole cereal	48.5 (40.2,56.8)	58.2 (45.7,70.7)	50.2 (3.7,104.1)
Refined cereal	100.7 (88.7,112.7)	108.2 (93.7,122.8)	145.6 (86.5,204.7)
Snacks	8.4 (6.8,9.9)	7.0 (4.8,9.2)	9.5 (3.1,15.7)
Nuts	3.2 (2.5,3.8)	3.5 (2.2,4.8)	2.5 (1.3,3.6)
Mayonnaise	1.4 (1.1,1.7)	1.3 (0.8,1.7)	2.0 (0.7,3.3)
Dried fruits	7.2 (5.7,8.7)	6.3 (4.2,8.3)	5.7 (2.6,8.8)
Olives	1.5 (0.8,2.2)	1.6 (0.7,2.6)	0.9 (0.2,1.6)
Sweets and desserts	5.5 (4.4,6.6)	4.0 (2.6,5.6) #	4.5 (2.5,6.6)
Pickles	14.6 (11.6,17.5)	15.8 (9.3,22.4)	9.6 (2.6,16.6)
Hydrogenated oil	7.0 (5.6,8.4)	5.1 (3.3,7.0) #	3.3 (1.2,5.4)
Unsaturated oil	3.2 (2.5,3.8)	4.4 (3.4,5.5) #	6.6 (1.3,14.5)
Sugar	11.2 (9.6,12.8)	11.1 (8.8,13.4)	9.2 (4.0,14.3)
Commercial juice	2.4 (1.6,3.2)	2.8 (1.7,4.0)	3.6 (1.7,5.6)
Coke	19.4 (14.2,24.6)	16.7 (9.0,24.4)	20.1 (4.4,36.1)
Yogurt drink	58.9 (45.0,72.9)	56.2 (32.7,79.7)	78.4 (14.6,142.2)
Salt	2.2 (1.9,2.6)	2.8 (2.4,3.4) #	1.7 (0.7,2.6)

* Accurate reporters: 1.34< EI/RMR <2.4; Under-reporters: EI/RMR ≤1.34; Over-reporters: EI/RMR ≥2.4; #Significantly different from category 1.34< EI/RMR <2.4; *P*<0.05 (Mann-Whitney U test). **Values are expressed as mean (95% CI).

Table 5. Pearson coefficient correlation between energy reporting and anthropometric characteristics among all subjects and accurate reporters.

	Body weight (kg)	Height (cm)	BMI (kg/m²)	Waist circumference (WC; cm)	Hip circumference (cm)
All reporters	0.068	0.084	-0.084	0.108	0.101
Accurate reporters*	0.363#	0.120	0.025	0.339#	0.334#

* 1.34< EI/RMR <2.4; # *P*<0.01

son[5] and 16% in a study by Mendez.[28] It should be noted that EI/RMR is only a ratio and might not accurately reflect energy consumption.

FAO/WHO/UNU formulas have shown that the mean energy consumption of women is 1.56 times BMR for mild, 1.64 times BMR for moderate, and 1.82 times BMR for strenuous physical activity levels.[29] Therefore, considering the EI/RMR ratio of ≤ 1.34 (which was used in current study as under-reporting), we found that all of our participants had sedentary lifestyles. However the assessment of physical activity level (PAL) to precisely identify an accurate reporter has been suggested. There are some limitations to assess PAL because of the difficulties numerous people have with estimating their activity levels. On the other hand, some people report ideal activity level rather than their actual PAL, which may lead to over-reporting for people who have sedentary lifestyles. It may also not precisely identify under-reporters.[8]

We also assessed the correlation between accurate EI reporting and factors that included anthropometric indices, lifestyle and sociodemographic factors (e.g., age, marital status, educational level) and compared the results to previous studies.[11]

In the present study, under-reporting was more frequent by obese women than other subjects. The negative correlation between EI/RMR and obesity remained unchanged after adjustment for age. This finding was consistent with numerous previous studies.[30] While Lissner and Novotny found no correlation between under-reporting and obesity,[31,32] Livingstone et al. suggested that weight was the independent variable that had the greatest effect on under-reporting.[2] Some studies have shown a relation between EI reporting and the attitude of subjects to their own body weight. Johansson suggested that under-reporting was more common in obese than in lean subjects.[5] In the present study, the mean BMI was 27 kg/m^2, which corresponded to moderately overweight. More than 50% of our subjects reported that they wanted to change their weight (data not shown). Some investigators have shown that concern about body weight may lead to under-reporting of food intake.[5] Others have suggested that people on a restricted calorie diet tend to under-report consumption of certain foods, including high-calorie and high-fat foods, sweets and salty foods that make people feel guilty following consumption.[33,34]

In our study, the proportion of under-reporters increased with age; however, this relation disappeared after adjusting for BMI. A positive relation between under-reporting and age has been observed in other studies. For instance, in the National Health and Nutrition Examination Survey (NHANES) the mean age of female under-reporters was four years greater than for females who were accurate reporters (49 vs. 45 years).[33] However, Okubo and coworkers observed a negative relation between under-reporting and age in their Japanese sample. This has suggested that factors related to the accuracy of EI reporting may depend on population characteristics.[35] Furthermore, it is not clear if this positive relation is actually due to age or the result of using a high EI/RMR ratio as acceptable. Authors who used the DLW method have shown that young people consume more energy compared to older people. Thus, use of the same ratio for all samples may inevitably lead to identification of older subjects as under-reporters.[2] However, Johansson and Vries found no relation between under-reporting and age.[36] Therefore, this possible relationship needs to be investigated in further studies.

There are controversial findings about correlation between the accuracy of EI reporting and educational levels.[2] Johnson has observed significant correlation between these two variables,[37] but this was not the case in the present study.

We also identified foods for which under- or over-reporting was more prevalent. Consumption of fish, high-fat dairy products, hydrogenated oil, sweets and coffee was lower among under-reporters than among accurate reporters, whereas consumption of unsaturated oils, tea, salt and yellow vegetables was higher compared to accurate reporters. This meant that under-reporters tended to under-report consumption of foods generally perceived as unhealthy (e.g., margarine, coffee, sweets and hydrogenated oils) but over-report consumption of healthy foods (e.g., low-fat dairy products, tea, yellow vegetables and unsaturated oils). Fish was an exception because it was mainly categorized as a healthy food, but we found it among the under-reported foods. This finding was consistent with results reported by Scagliusi.[38] Conversely, Goris found that snack consumption was reported accurately, whereas consumption of main courses was under-reported[4] and NHANES III participants under-reported consumption of both main courses and snacks.[34] Poppitt observed under-reporting for snacks but not for main courses,[39] which suggested that people tended to remember their main courses better than their snacks. Johansson et al. have shown that consumption of high-fat and -sugar foods such as cake, chips, chocolate, cookies and sweet beverages is under-reported, whereas consumption of potatoes, meat, fish and soft drinks is over-reported.[5] Overall, people tend to over-report consumption of healthy foods, whereas the opposite is true for unhealthy foods.[2]

Only one study has suggested that exclusion of under-reporters might lead to an increase in the percentage of energy obtained from snacks and a decrease in the percentage obtained from fruits.[2] No other study has investigated portion size, although Drummond et al. believe that people usually under-report the number of meals they consume.[40]

In the present study there was no significant correlation between anthropometric measures and EI for the total sample. When only accurate reporters were considered, there was a significant correlation between EI and body weight, WC and hip circumference. This was consistent with previous studies.[5,41] Obese people generally report their EI inaccurately, which can lead to problems in assessing relations between food intake and anthropometric characteristics. This leads to significant bias in assessment of the etiology of obesity.

Although the FFQ used here has been validated in a previous study in Iran by Esmaillzadeh,[18] some of the natural features of the FFQ could lead to inaccurate results. There were some possible reasons for EI under-reporting: lack of motivation, inability to respond and a tendency to hide dietary intake might be among the most important reasons. Other factors may play a role when an investigator is estimating the frequency or portion size. Moreover, some food items are recognized as unhealthy (e.g., snacks rich in fat and sugar), so consumption of these is regarded as an undesirable behavior and under-reporting of these food items may occur.

FFQ precision depends on good memory, summarizing and mathematical calculations, and food recording requires good writing skills. If these instruments are used for poor populations, the possibility of inaccurate reporting because of shame about insufficient food intake should be taken into account. This could lead to inaccurate results. Conversely, for populations with a high income level, food reporting patterns might vary among different sections. These factors should be considered by investigators.

In summary, under-reporting of EI is more frequent than over-reporting among Iranian women. Among various factors that may affect the accuracy of EI reporting, age and anthropometric characteristics have a significant negative effect. More research should be carried out to investigate the prevalence and causes of EI under-reporting in developing countries.

Acknowledgments

The authors would like to thank the subjects for their enthusiastic support. We also thank the members of National Nutrition and Food Technology Research Institute for their kind collaboration. This work was supported by the National Nutrition and Food Technology Research Institute of Shahid Beheshti University of Medical Sciences. None of the authors had any personal or financial conflicts of interest. M.SH and B.R designed the study, collected and analyzed the data. S.R wrote the manuscript and provided consultation.

References

1. Black AE, Goldberg GR, Jebb SA, Livingstone MBE, Cole TJ, Prentice AM. Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *Eur J ClinNutr*. 1991; **45(12):** 583 – 599. PMID: 1810720.

2. Livingstone MBE, Black AE. Markers of the Validity of Reported Energy Intake 1. *J Nutr*.2003; 895 – 920. PMID: 12612176.
3. Heitmann BL, Lissner L. Dietary underreporting by obese individuals – is it specific or non-specific? *British Medical Journal*. 1995; **311:** 986 – 989. PMID: 7580640.
4. Goris AH, Westerterp-Plantenga MS, Westerterp KR. Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake. *American Journal of Clinical Nutrition*. 2000; **71:** 130 – 134. PMID: 10617957.
5. Johansson L, Solvoll K, Bjorneboe GE, Drevon CA. Under-and over-reporting of energy intake related to weight status and lifestyle in a nationwide sample. *Am J ClinNutr*. 1998; **68(2):** 266 – 274. PMID: 9701182.
6. International Dietary Energy Consultant Group. The doubly labeled water method for measuring energy expenditure: technical recommendations for use in humans. Vienna: *International Atomic Energy Agency*, 1990.
7. Black AE, Coward WA, Cole TJ, Prentice AM. Human energy expenditure in affluent societies: an analysis of 574 doubly-labelled water measurements. *Eur J ClinNutr*. 1996; **50(2):** 72 – 92. PMID: 8641250.
8. Bedard D, Shatenstein B, Nadon S. Underreporting of energy intake from a self-administered food-frequency questionnaire completed by adults in Montreal. *Public Health Nutr*. 2004; **7(5):** 675 – 681. PMID: 15251058.
9. Black AE, Bingham SA, Johansson G, Coward WA. Validation of dietary intakes of protein and energy against 24 hour urinary N and DLW energy expenditure in middle-aged women, retired men and post-obese subjects: comparisons with validation against presumed energy requirements. *Eur J ClinNutr*. 1997; **51(6):** 405 – 513. PMID: 9192200.
10. Asbeck I, Mast M, Bierwag A, Westenhöfer J, Acheson KJ, Müller MJ. Severe underreporting of energy intake in normal weight subjects: use of an appropriate standard and relation to restrained eating. *Public Health Nutr*. 2002; **5(5):** 683 – 690. PMID: 12372163.
11. Johansson G, Wikman Å, Åhrén AM, Hallmans G, Johansson I. Underreporting of energy intake in repeated 24-hour recalls related to gender, age, weight status, day of interview, educational level, reported food intake, smoking habits and area of living. *Public Health Nutr*. 2001; **4(4):** 919 – 927. PMID: 11527517.
12. Mirmiran P, Esmaillzadeh A, Azizi F. Under-reporting of energy intake affects estimates of nutrient intakes. *Asia Pac J ClinNutr*. 2006;**15(4):** 459 – 464. PMID: 17077060.
13. Ballard-Barbash R, Graubard I, Krebs-Smith SM, Schatzkin A, Thompson FE. Contribution of dieting to the inverse association between energy intake and body mass index. *Eur J ClinNutr*. 1996; **50:** 98 – 106. PMID:8641252
14. Livingstone MBE. Assessment of food intakes: are we measuring what people eat? *Br J Biomed Sci*. 1995; **52:** 58 – 67. PMID: 7549607.
15. Prentice AM, Black AE, Coward WA, Cole TJ. Energy expenditure in overweight and obese adults in affluent societies: an analysis of 319 doubly-labelled water measurements. *Eur J ClinNutr*. 1996; **50:** 93 – 97. PMID: 8641251.
16. Willett W. Nutritional epidemiology. *Oxford University Press*; USA, 1998.
17. Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. *New England Journal of Medicine*. 1999; **341(6):** 427.
18. Esmaillzadeh A, Azadbakht L. Major dietary patterns in relation to general obesity and central adiposity among Iranian women. *J Nutr*. 2008; **138(2):** 358 – 363. PMID: 18203904.
19. Azar M, Sarkisian E. Food composition table of Iran. *National Nutrition and Food Research Institute of ShaheedBeheshti University (in Farsi).*
20. Ars.usda.gov (homepage on internet). WashingtonDC: United States Department of Agriculture, Agriculture of Research Service. Available from: URL: http://www.nal.usda.gov/fnic/foodcomp/. (Accessed Date: 27 April 2009).
21. Ghaffarpour M, Houshiar-Rad A, Kianfar H (1999): The Manual for Household Measures, Cooking Yields Factors and Edible Portion of Food. Tehran: Keshaverzi press.
22. Rezazadeh A, Rashidkhani B, Omidvar N. Association of major dietary patterns with socioeconomic and lifestyle factors of adult women living in Tehran, Iran. *Nutrition*. 2010; **26(3):** 337 – 341.
23. Wang J, Thornton JC, Bari S, Williamson B, Gallagher D, Heymsfield SB, et al. Comparisons of waist circumferences measured at 4 sites. *Am J ClinNutr*. 2003; **77(2):** 379 – 384. PMID: 12540397.
24. Forman JN, Miller WC, Szymanski LM, Fernhall B. Differences in resting metabolic rates of inactive obese African-American and Caucasian women. *Int J Obes Relat Metab Disord*. 1998; **22(3):** 215 – 221. PMID: 9539188.
25. Delisle HF, Vioque J, Gil A. Dietary patterns and quality in West-African immigrants in Madrid. *Nutr J*. 2009; **8:**3. PMID: 19166606.
26. Berg CM, Lappas G, Strandhagen E, Wolk A, Torén K, Rosengren A, et al. Food patterns and cardiovascular disease risk factors: the Swedish INTERGENE research program. *Am J Clin Nutr*. 2008; **88:** 289 – 297. PMID:18689363.
27. Samaras K, Kelly PJ, Campbell LV. Dietary underreporting is prevalent in middle-aged British women and is not related to adiposity (percentage body fat). *Int J Obes Relat Metab Disord*. 1999; **23(8):** 881 – 888. PMID: 10490791.
28. Mendez MA, Wynter S, Wilks R, Forrester T. Under-and overreporting of energy is related to obesity, lifestyle factors and food group intakes in Jamaican adults. *Public Health Nutr*. 2004; **7(1):** 9 – 19. PMID: 14972067.
29. Energy WHO. Protein requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. *WHO Technical Report Series*. 1985;**724**. PMID: 3937340
30. Harrison GG, Galal OM, Ibrahim N, Khorshid A, Stormer A, Leslie J, et al. Underreporting of Food Intake by Dietary Recall Is Not Universal: A Comparison of Data from Egyptian and American Women. *J Nutr*. 2000; **130(8):** 2049 – 2054. PMID: 10917924.
31. Lissner L, Habicht JP, Strupp BJ, Levitsky DA, Haas JD, Roe DA. Body composition and energy intake: do overweight women overeat and underreport? *Am J Clin Nutr*. 1989; **49(2):** 320 – 325.
32. Novotny JA, Rumpler WV, Riddick H, Hebert JR, Rhodes D, Judd JT, et al. Personality characteristics as predictors of underreporting of energy intake on 24-hour dietary recall interviews. *J Am Diet Assoc*. 2003; **103(9):** 1146 – 1151.
33. Lafay L, Mennen L, Basdevant A, Charles MA, Borys JM, Eschwege E, et al. Does energy intake underreporting involve all kinds of food or only specific food items? Results from the FleurbaixLaventie Ville Santé(FLVS) study. *Int J Obes Relat Metab Disord*. 2000; **24(11):** 1500 – 1506. PMID: 11126348.
34. Briefel RR, Sempos CT, McDowell MA, Chien S, Alaimo K. Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *Am J Clin Nutr*.1997; **65(4):** 1203 – 1209. PMID: 9094923.
35. Okubo H, Sasaki S, Hirota N, Notsu A, Todoriki H, Miura A, et al. The influence of age and body mass index on relative accuracy of energy intake among Japanese adults. *Public Health Nutr*. 2006; **9(5):** 651 – 657. PMID: 16923297.
36. De Vries JH, Zock PL, Mensink RP, Katan MB. Underestimation of energy intake by 3-d records compared with energy intake to maintain body weight in 269 nonobese adults. *Am J Clin Nutr*. 1994; **60(6):** 855 – 860.
37. Johnson RK, Soultanakis RP, Matthews DE. Literacy and body fatness are associated with underreporting of energy intake in US low-income women using the multiple-pass 24-hour recall A doubly labeled water study. *J Am Diet Assoc*. 1998; **98(10):** 1136 – 1140. PMID: 9787719.
38. Scagliusi FB, Ferriolli E, Pfrimer K, Laureano C, Cunha CSF, Gualano B, et al. Under-reporting of energy intake is more prevalent in a healthy dietary pattern cluster. *Br J Nutr*. 2008; **100(5):** 1060 – 1068. PMID: 18377688.
39. Poppitt SD, Swann D, Black AE, Prentice AM. Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. International journal of obesity and related metabolic disorders. *Int J Obes Relat Metab Disord*. 1998; **22(4):** 303 – 311. PMID: 9578234.
40. Drummond SE, Crombie NE, Cursiter MC, Kirk TR. Evidence that eating frequency is inversely related to body weight status in male, but not female, non-obese adults reporting valid dietary intakes. International journal of obesity and related metabolic disorders. *Int J Obes Relat Metab Disord*. 1998; **22(2):** 105 – 112.
41. Bailey RL, Mitchell DC, Miller C, Smiciklas-Wright H. Assessing the effect of underreporting energy intake on dietary patterns and weight status. *J Am Diet Assoc*. 2007; **107(1):** 64 – 71. PMID: 171972.