Nutrition Research and Practice (2007), 1(3), 231-236

Underreporting of dietary intake by body mass index in premenopausal women participating in the Healthy Women Study*

Hyun Ah Park[1§], Jung Sun Lee[2] and Lewis H. Kuller[3]
[1] *Department of Family Medicine, Seoul Paik Hospital, University of Inje, College of Medicine, Seoul 100-032, Korea*
[2] *Department of Foods and Nutrition, University of Georgia, Athens, GA, USA*
[3] *Department of Epidemiology, Graduate School of Public Heath, University of Pittsburgh, Pittsburgh, PA, USA*

Received June 18, 2007; Revised July 22, 2007; Accepted August 24, 2007

Abstract

Underreporting patterns by the level of obesity have not been fully assessed yet. The purpose of this study was to examine the differential underreporting patterns on cardiovascular risk factor, macronutrient, and food group intakes by the level of Body Mass Index (BMI). We analyzed cross-sectional baseline nutritional survey data from the population-based longitudinal study, the Healthy Women Study (HWS) cohort. Study subjects included 538 healthy premenopausal women participating in the HWS. Nutrient and food group intakes were assessed by the one-day 24-hour dietary recall and a semi-quantitative food frequency questionnaire, respectively. The ratio of reported energy intake (EI) to estimated basal metabolic rate (BMR) was used as a measure of relative energy reporting status and categorized into tertiles. Overweight group ($BMI \geq 25kg/m^2$) had a higher ratio of EI to BMR (EI/BMR) than normal weight group ($BMI<25kg/m^2$). Normal weight and overweight groups showed similar patterns in cardiovascular risk factors, nutrient intake, and food group intake by the EI/BMR. Fat and saturated fat intakes as a nutrient density were positively associated with the EI/BMR. Proportion of women who reported higher consumption (≥4 times/wk) of sugar/candy, cream and red meat groups was greater in higher tertiles of the EI/BMR in both BMI groups. Our findings suggest similar patterns of underreporting of cardiovascular risk factors, and macronutrient and food group intakes in both normal and overweight women.

Key Words: Underreporting, body mass index, nutrient intake, food group intake, cardiovascular risk factor

Introduction

Underreporting of dietary intake has been a frequently recognized problem in nutrition research using the self-reported dietary assessment methodology. The doubly labeled water (DLW) technique is the most widely accepted method to validate reported energy intake (Goris *et al.*, 2000). However, high cost and technical difficulties of DLW made its use less feasible in large sample dietary surveys. Goldberg suggested that reported energy intake could be used to evaluate reported energy intake against presumed energy requirement. Reported energy intake (EI) is expressed as multiples of the estimated basal metabolic rate (BMR) (Lichtman *et al.*, 1992), and the ratio of EI to BMR (EI/BMR) would indicate relative energy reporting status. For example, individuals reporting a lower EI/BMR would report relatively lower energy intake compared to their energy requirements. The WHO defined EI/BMR ratio of 1.55 as a sedentary level of energy expenditure and 1.27 as the 'minimum survival requirement' (Prentice *et al.*, 1986).

Many studies have been done to assess various factors associated with lower EI/BMR ratio. Among them, obesity has been the consistently reported risk factor for dietary underreporting (Goris *et al.*, 2000). Overweight individuals tend to underreport their dietary intake by about 20-50% depending on the population studied and assessment methods used (FAO/WHO/UNO, 1985; Goldberg *et al.*, 1991; Kretsch *et al.*, 199; Livingstone & Black, 2003). However, many important aspects of underreporting patterns by the level of obesity have not been fully assessed yet, especially the types of nutrient and food that are likely to be underreported and health-related characteristics of individuals who underreport dietary intake.

In this study, we examined the underreporting patterns using the EI/BMR by the level of obesity in the Healthy Women Study (HWS), a community-based longitudinal study (Pennsylvania, USA) to understand the changes in cardiovascular risk factors in healthy premenopausal women as they go through menopause. We were particularly interested in the following questions; 1) if obesity measured by body mass index (BMI) is related to the relative underreporting of energy intake, 2) if the relative energy reporting status is associated with cardiovascular risk factors, and macronutrient and specific food group intake, and 3) if the underreporting pattern is different by the level of obesity.

---

* This study was supported by the National Institute of Health, Grant-28266.
[§] **Corresponding Author:** Hyun-Ah Park, Tel. 82-2-2270-0097, Fax. 82-2-2270-2030, Email. parkhyunah@hanafos.com

Subjects and Methods

Study participants included 538 healthy premenopausal women from the HWS. The study eligibility criteria included the following: age 42-50 years; menstrual bleeding within the last 3 months; diastolic blood pressure less than 100 mmHg; no medication use known to influence cardiovascular risk factors (e.g., estrogen, insulin, lipid-lowering drugs, thyroid, anti-hypertensive, and psychotropic medication). Details of the HWS study had been reported previously (Matthews *et al.*, 1989; Sutton-Tyrrell *et al.*, 2002).

Data from the baseline examination were used, which included dietary intake, anthropometry, and cardiovascular risk factors.

Nutrient and food group intake

Dietary intake was evaluated by the one-day 24-hour dietary recall and a semi-quantitative food frequency questionnaire (FFQ). The dietary recall interview was done by a trained nutritionist using three-dimensional models of food portions in a clinical setting. Nutrient intake was calculated using a computerized nutrient database, which was a compilation of nutrient data mainly from the U.S. Department of Agriculture, Revised Handbook No.8 (Human Nutrition Information Service, 1976-87), and the Multiple Risk Factor Intervention Trial (MRFIT) data (Dolecek *et al.*, 1997). Keys score was calculated from dietary intake of cholesterol, saturated fat and polyunsaturated fat as a composite indicator of fat intake. Higher score indicates higher projected changes in serum cholesterol (mg/dl) (Keys & Parlin, 1966).

The semi-quantitative FFQ was originally developed for the MRFIT as a qualitative measure of fat intake. The interviewer asked the participants about weekly consumption frequency of items from 22 food groups. There were four response categories: "never", "1-3 times per month", "1-3 times per week", and "4 or more times per week."

Relative energy reporting status (EI/BMR)

In a weight-stable person, the reported EI should be equal to total energy expenditure which mainly consists of BMR (60%) and energy for physical activity (30%) (Horton, 1983). BMR was calculated with the equation made by Schofield and adopted in the 1985 FAO/WHO/UNU reports (Voss *et al.*, 1998).

BMR (kcal) = (8.7* wt in kilogram) − (25* ht in meter) + 865

Most of the inter-individual variance arising from differences in physical characteristics (weight, height, and age) is automatically removed by the use of BMR as the denominator. EI/BMR could be considered as a measure of relative energy reporting status after adjusting for the physical activity level (Schofield, 1985).

Body mass index

Height was recorded to the nearest 0.5 centimeter, and weight was recorded to the nearest 0.1 kilogram using a balance beam scale. Body Mass Index (BMI) was computed as body weight divided by height squared and stratified into 2 groups: normal weight group (BMI<25 kg/m^2) and overweight group (BMI≥25 kg/m^2).

Cardiovascular risk factors

Fasting blood was drawn to measure insulin, glucose, and serum lipids. Blood pressure was measured. A questionnaire was used to assess alcohol consumption and smoking status. Physical activity, expressed as kilocalories expended per week, was measured using the Paffenbarger Physical Activity Questionnaire (Paffenbarger and Wing, 1978).

Statistical analysis

Student t-test was used to compare EI/BMR between the two BMI groups. Then, analyses were conducted separately for normal weight and overweight groups. The EI/BMR ratio was categorized by the tertile groups. The associations between the baseline cardiovascular risk factors and the tertiles of EI/BMR were examined using analysis of variance (ANOVA) and chi-square test. Multivariate regression was used to examine the associations between EI/BMR and macronutrient intake expressed as both absolute nutrients intake and nutrients density (percentage of total energy intake) after controlling for age, BMI, physical activity, and smoking status. The association between the food group intake and the EI/BMR was compared by chi-square test.

Table 1. General characteristics and reported energy intake of 538 HWS participants

Mean ± SD	BMI<25 kg/m^2 [1)] (n=342)	BMI≥25 kg/m^2 [1)] (n=196)	Total (n=438)
Age (year)*	47.5 ± 1.5	47.8 ± 1.8	47.6 ± 1.6
White (%)*	93.0	86.2	90.5
College graduate, n (%)**	54.4	40.8	49.4
Married, n (%)	72.2	73.0	72.5
Current smoker, n (%)	32.5	25.0	29.7
Physical activity, n (%)**			
<1000 kcal/week	46.9	61.7	52.3
1000-1999 kcal/week	25.8	19.9	23.6
≥2000 kcal/week	27.3	18.4	24.0
Height (m)	1.64 ± 0.06	1.63 ± 0.06	1.63 ± 0.06
Weight (kg)***	59.3 ± 6.2	78.7 ± 12.7	66.4 ± 13.0
Body mass index (BMI, kg/m^2)***	22.2 ± 1.7	29.5 ± 4.3	24.8 ± 4.6
Reported energy intake (EI, kcal/day)	1763 ± 620	1747 ± 624	1757 ± 621
Basal metabolic rate (BMR, kcal/day)***	1340 ± 53	1509 ± 109	1402 ± 113
EI/BMR [1)] ***	1.32 ± 0.47	1.16 ± 0.41	1.26 ± 0.45

[1)] EI, energy intake; BMR, basal metabolic rate; BMI, body mass index

* Significantly different between normal weight (<25 kg/m^2) and overweight groups (≥25 kg/m^2) at $p<0.05$ (*), $P<0.01$ (**), and $P<0.001$ (***) by Student t- test for continuous variables and chi-square test for categorical variables.

Table 2. Baseline cardiovascular risk factors by tertiles of the EI/BMR, by BMI categories of 538 HWS participants

	BMI<25 kg/m^2 (n=342)[1]				BMI≥25 kg/m^2 (n=196)[1]			
EI/BMR tertiles[1]	T1 (114)	T2 (114)	T3 (114)		T1 (65)	T2 (66)	T3 (65)	
EI/BMR range[1]	<1.10	1.10-1.46	>1.46	p[2]	<0.96	0.96-1.28	>1.28	p[2]
Age (year)	47 ± 2	47 ± 2	48 ± 1	0.460	48 ± 2	48 ± 2	48 ± 2	0.942
White (%)	93	94	92	0.796	85	89	85	1.000
College graduate (%)	49	53	61	0.063	37	41	45	0.373
Married (%)	76	70	70	0.301	77	71	71	0.431
BMI (wt/ht^2)[1]	22.3 ± 1.7	22.3 ± 1.7	21.9 ± 1.8	0.043	30.5 ± 4.8	29.2 ± 4.0	28.8 ± 4.0	0.023
Physical activity≥1000 kcal/week (%)	59	49	51	0.261	46	26	43	0.719
Smoker (%)	33	32	33	0.880	25	21	29	0.544
Fasting glucose (mg/dl)	85 ± 10	85 ± 11	85 ± 9	0.862	91 ± 21	94 ± 39	90 ± 11	0.937
Fasting insulin (uU/l)	6.1 ± 2.4	7.2 ± 3.6	6.1 ± 2.6	0.951	11.9 ± 9.5	11.9 ± 8.8	11.4 ± 6.0	0.762
Systolic BP (mmHg)[1]	106 ± 12	109 ± 13	107 ± 11	0.585	114 ± 12	113 ± 12	114 ± 12	0.994
Cholesterol (mg/dl)	177 ± 29	184 ± 35	183 ± 30	0.220	185 ± 41	190 ± 36	191 ± 33	0.334
LDL-C (mg/dl)[1]	101 ± 28	106 ± 29	105 ± 27	0.299	112 ± 35	116 ± 33	119 ± 30	0.222
HDL-C (mg/dl)[1]	64 ± 13	62 ± 13	64 ± 14	0.927	53 ± 14	52 ± 12	52 ± 11	0.464
Triglyceride (mg/dl)	66 ± 23	76 ± 42	73 ± 33	0.119	99 ± 56	110 ± 72	103 ± 50	0.707

[1] EI, energy intake; BMR, basal metabolic rate; BMI, body mass index; BP, blood pressure; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol

[2] P for EI/BMR ratio tertiles within each BMI category. Analysis of variance (ANOVA) was used for continuous variables and the chi-square test was used for categorical variables.

Table 3. Macronutrients and food group intake by tertiles of the EI/BMI in normal weight and overweight women

	BMI<25 kg/m^2 (N=342)[1]				BMI≥25 kg/m^2 (N=196)[1]			
EI/BMR[1]	T1 (114)	T2 (114)	T3 (114)		T1 (65)	T2 (66)	T3 (65)	
EI/BMR range[1]	<1.10	1.10-1.46	>1.46	p[2]	<0.96	0.96-1.28	>1.28	p[2]
Total energy (kcal)[3]	1148 ± 262	1705 ± 148	2437 ± 477	<0.001	1124 ± 269	1680 ± 169	2438 ± 449	<0.001
Absolute intake[3]								
Protein (g)	54 ± 20	66 ± 19	89 ± 27	<0.001	56 ± 19	71 ± 18	90 ± 25	<0.001
Carbohydrate (g)	127 ± 44	185 ± 44	260 ± 79	<0.001	131 ± 47	185 ± 48	252 ± 68	<0.001
Fat (g)	45 ± 16	72 ± 18	105 ± 38	<0.001	43 ± 15	72 ± 16	112 ± 30	<0.001
Saturated fat (g)	15 ± 7	25 ± 9	36 ± 17	<0.001	14 ± 8	24 ± 8	39 ± 13	<0.001
Cholesterol (mg)	227 ± 193	288 ± 203	390 ± 232	<0.001	238 ± 182	281 ± 162	428 ± 268	<0.001
Keys score[4]	44 ± 19	45 ± 18	46 ± 16	0.368	44 ± 19	45 ± 13	49 ± 13	0.028
Alcohol (g)	9 ± 9	9 ± 11	12 ± 12	0.051	5 ± 6	6 ± 7	7 ± 10	0.234
Nutrient density[3],[6]								
Protein (%)	19 ± 6	16 ± 4	15 ± 4	<0.001	20 ± 7	17 ± 42	15 ± 4	<0.001
Carbohydrate (%)	44 ± 12	43 ± 10	43 ± 11	0.243	46 ± 12	44 ± 9	42 ± 9	0.021
Fat (%)	35 ± 10	38 ± 9	38 ± 10	0.012	34 ± 10	39 ± 8	41 ± 7	<0.001
Saturated fat (%)	12 ± 5	13 ± 5	13 ± 5	0.009	11 ± 5	13 ± 4	14 ± 4	<0.001
Cholesterol (mg/1000kcal)	208 ± 195	170 ± 119	160 ± 89	0.009	229 ± 212	167 ± 93	173 ± 94	0.037
Alcohol (%)	6 ± 6	4 ± 4	4 ± 3	<0.001	3 ± 4	2 ± 3	2 ± 3	0.016
Food group intake[5]								
Vegetable	71%	59%	62%	0.168	65%	64%	62%	0.717
Fruit	76%	75%	77%	0.876	77%	64%	71%	0.443
Whole grain cereals/bread	50%	51%	52%	0.791	48%	52%	55%	0.381
Red meat	21%	28%	33%	0.038	19%	41%	31%	0.127
Poultry/fish	25%	24%	24%	0.877	42%	19%	29%	0.126
Whole milk	3%	11%	12%	0.016	5%	14.%	16%	0.049
Low fat/skim milk	45%	40%	33%	0.079	46%	36%	43%	0.723
Butter	29%	28%	36%	0.234	14%	23%	26%	0.086
Sugar/candy	13%	30%	35%	<0.001	20%	30%	31%	0.168
Cream	3%	12%	13%	0.006	6%	9%	15.%	0.083
Artificially sweetened beverage	30%	22%	18%	0.031	39%	32%	37%	0.855

[1] EI, energy intake; BMR, basal metabolic rate; BMI, body mass index

[2] P for EI/BMR ratio tertiles within each BMI category controlling for age (continuous), BMI (continuous), smoking status (yes or no), and physical activity (<1000kcal/week, 1000–1999kcal/week, >2000kcal/week)

[3] Mean ± SD

[4] Keys score=1.26(2S–P)+1.5 root C, where S and P are the percentages of total energy from saturated and polyunsaturated fats, respectively, and C is the daily cholesterol intake in mg/1000 kcal.

[5] Proportions of women reporting on FFQ consuming each food group four or more times per week. P values were from the chi-square test.

[6] Percentages of total energy intake except for cholesterol

To examine if the underreporting pattern is different by the level of obesity, we made cross product terms of the EI/BMR ratio and BMI categories and examined their significance in the multivariate regression models.

All statistical analyses were conducted using the SPSS 11.5 statistical packages, and statistical significance was set at $p<0.05$. All p values were 2-tailed.

Results

Table 1 shows general characteristics and reported energy intake of the study participants by the level of obesity. About 36% (196 women) of the study population was either overweight (BMI≥25 kg/m^2, 25.1%) or obese (BMI≥30 kg/m^2, 11.3%). Normal weight women are more likely to be a white, a college graduate and physically active than overweight women. Mean reported EI and estimated BMR (mean ± SD) of the study population were 1757 ± 621 kcal and 1402 ± 113 kcal, respectively. Mean EI/BMR (mean ± SD) was 1.26 ± 0.45. While the estimated BMR was greater among overweight women than that of normal weight women, the reported EI was not significantly different by the level of BMI, which resulted in a significantly lower EI/BMR in overweight women.

Table 2 shows baseline cardiovascular risk factors by BMI category-specific tertiles of the EI/BMR ratio. The proportion of college graduates increased from the lowest to the highest tertile of the EI/BMR in both BMI groups. A non-significant increasing trend was seen for cholesterol and LDL cholesterol across EI/BMR tertiles. The lowest tertile groups of the EI/BMR ratio in both normal weight and overweight groups reported the lowest total energy intake (table 3) while having the highest BMI and not being less physically active.

The associations of EI/BMR with macronutrient and food group intake are presented in Table 3. Total energy intake increased by the EI/BMR tertiles. Accordingly, all macronutrient intakes and Keys score increased (all $p<0.001$ except Keys score). The macronutrient composition of the diets varied by relative energy reporting status. The increasing trend of nutrient density for fat and saturated fat and the decreasing trend of carbohydrate and protein were more prominent in the overweight group. Normal weight women in the higher tertiles of EI/BMR were more likely to report consuming ≥ 4 times/wk of sugar/candy, cream and red meat groups than the lower tertile groups. This pattern was also observed in the overweight women group, but did not reach statistical significance. The consumption of other food groups like vegetables, fruit, poultry/fish, and whole grain foods were reported similarly across the EI/BMR tertiles.

There was no significant interaction between EI/BMR and BMI categories on macronutrient and specific food group intake (data not shown).

Discussion

The findings of this study showed the selective underreporting of nutrient and food group intake by relative energy reporting status in healthy premenopausal women; furthermore, this pattern was not modified by the level of obesity.

The consumption of sugar, cream, baked goods, and red meat groups, which are generally considered unhealthy or fattening, were reported significantly differently across the EI/BMR tertiles. This relationship was observed in both normal weight and overweight women. Although we were not able to directly compare such reporting patterns with actual dietary intake, this pattern may be in part due to participants' disinclinations to report socially undesirable foods. Indeed, HWS participants were relatively well educated, highly-motivated and might have been more conscious of health issues than the general population. These results suggest that measurement and evaluation of dietary intake in a free living population is complex. Selective underreporting may occur when relatively well validated dietary methodologies are used to estimate total energy intake (Black *et al.*, 1991). Therefore, simple adjustment of total energy intake as used in Stallone *et al.* (Stallone *et al.*, 1997) might be limited to completely correct the bias in self-reported nutrient and food group intakes.

Another issue related to the effect of BMI-related underreporting lies on understanding of the relationship between dietary intake and diseases. The selective reporting bias might weaken the associations of specific nutrient intake with diseases. Prentice (Prentice, 1996) suggested the possible role of BMI-related underreporting of fat intake on the observed null association between fat intake and breast cancer in case-control and cohort study. McCrory, *et al.* also demonstrated the relationships of low fiber intake and high fat intake with the degree of obesity could be underestimated by dietary underreporting (McCrory, 2002). Underreporting might also affect the mediatory variables in dietary intervention studies aiming at modifying nutrient composition of diets (for example, reducing fat intake). This issue is currently being evaluated in the Women Health Initiative (Anderson *et al.*, 2003).

In this study, 28% of women reported their EI less than their estimated BMR (data not shown). This pattern has been also reported in other large population based epidemiologic studies such as the British Whitehall Study (Stallone *et al.*, 1997) and the Ontario Healthy Study (Pomerleau *et al.*, 1999). Our mean EI/BMR ratio of 1.26 is very similar to that of middle aged women (30-59 years old) from the Third National Health and Nutrition Examination Survey (1988-1991) (Kant *et al.* 2002). These universal findings of dietary underrerporting suggest more efforts are needed to elucidate the nature of dietary underreporting.

Because underreporting might exist at all the levels of the EI/BMR, we used the tertiles of EI/BMR instead of using pre-established the Goldberg Cutoff Value to identify relatively low energy reporters. The Goldberg Cutoff may be limited by low sensitivity to identify inaccurate intake reports (Black, 2000) and be only able to identify extremely inaccurate reporting (McCrory, 2002).

Interestingly, the lowest tertile of the EI/BMR ratio in normal weight and overweight groups had lower total cholesterol and LDL cholesterol, which was consistent with reported lower saturated fat and Keys score. This finding may indicate the lower reported fat intake of the lowest tertile group was partly caused by the dietary restriction of fat and saturated fat intake.

Our study has limitations. One-day 24-hour dietary recall is limited to reflect an individual's usual intake and to provide information on day-to-day within-individual variation in dietary intake. It has been estimated that dietary intake measurements are required for between 7 and 32 days to correctly assess an individual's energy intake with 90% confidence (Marr, 1986; Nelson, 1989). Therefore, some respondents classified in the lowest tertile group may have reported accurate intakes for the day while some in the highest tertile group might have underreported their intake. However, we were unable to ascertain to what extent the reported dietary intake were biased or valid. Also, due to the relatively small sample size and homogenous characteristics of the study population, the distribution and range of BMI and EI/BMR were limited to fully examine the effects of the BMI levels on underreporting patterns.

In conclusion, our study showed that underreporting is related to BMI even in normal weight women, the relative energy reporting status is associated with cardiovascular risk factors, macro-nutrients and foods group intake, and the underreporting pattern is not modified by weight status. Caution should be taken into account to assess the consequences of underreporting patterns in self-reported dietary intake in both normal weight and overweight women. More efforts should be given to improve dietary assessment methods.

Literature cited

Anderson GL, Manson J, Wallace R, Lund B, Hall D & Davis S (2003). Implementation of the Women's Health Initiative study design. *Ann Epidemiol* 13:5-17.

Black AE, Goldberg GR, Jebb SA, Livingstone MB, Cole TJ & Prentice AM (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *Eur J Clin Nutr* 45:583-599.

Black AE (2000). The sensitivity and specificity of the Goldberg cut-off for EI:BMR for identifying diet reports of poor validity. *Eur J Clin Nutr* 54:395-404.

Dolecek TA, Stamler J, Caggiula AW, Tillotson JL & Buzzard IM (1997). Methods of dietary and nutritional assessment and intervention and other methods in the Multiple Risk Factor Intervention Trial. *Am J Clin Nutr* 65:196-210.

FAO/WHO/UNU (1985). *Energy and Protein Requirements.* (Report of a Joint FAO/WHO/UNU Experts Consultation. Technical Report Series No 724). World Health Organization, Geneva. Switzerland

Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR & Coward WA (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *Eur J Clin Nutr* 45: 569-581.

Goris AH, Westerterp-Plantenga MS & Westerterp KR (2000). Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake. *Am J Clin Nutr* 71:130-134.

Horton ES (1983). Introduction: an overview of the assessment and regulation of energy balance in humans. *Am J Clin Nutr* 38:972-977.

Human Nutrition Information Service. US Department of Agriculture (1976-87). *Composition of Foods.* Agricultural Handbook 8-1 to 8-18, Hyattsville MD. USA

Kant AK (2002). Nature of dietary reporting by adults in the third National Health and Nutrition Examination Survey, 1988-1994. *J Am Coll Nutr* 21:315-327.

Keys A & Parlin RW (1966). Serum cholesterol response to changes in dietary lipids. *Am J Clin Nutr* 19:175-181.

Kretsch MJ, Fong AK & Green MW (1999). Behavioral and body size correlates of energy intake underreporting by obese and normal-weight women. *J Am Diet Assoc* 99:300-306.

Lichtman SW, Pisarska K, Berman ER, Pestone M, Dowling H & Offenbacher E (1992). Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. *N Engl J Med* 327:1893-1898.

Livingstone MB & Black AE (2003). Markers of the validity of reported energy intake. *J Nutr* 133:895-920.

Marr JW & Heady JA (1986). Within- and between-person variation in dietary surveys: number of days needed to classify individuals. *Hum Nutr Appl Nutr* 40:347-364.

Matthews KA, Meilahn E, Kuller LH, Kelsey SF, Caggiula AW & Wing RR (1989). Menopause and risk factors for coronary heart disease. *N Engl J Med* 321:641-646.

McCrory MA, Hajduk CL & Roberts SB (2002). Procedures for screening out inaccurate reports of dietary energy intake. *Public Health Nutr* 5:873-882.

Nelson M, Black AE, Morris JA & Cole TJ (1989). Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *Am J Clin Nutr* 50:155-167.

Paffenbarger RS, Jr., Wing AL & Hyde RT (1978). Physical activity as an index of heart attack risk in college alumni. *Am J Epidemiol* 108:161-175.

Pomerleau J, Ostbye T & Bright-See E (1999). Potential underreporting of energy intake in the Ontario Health Survey and its relationship with nutrient and food intakes. *Eur J Epidemiol* 15: 553-557.

Prentice AM, Black AE, Coward WA, Davies HL, Goldberg GR & Murgatroyd PR (1986). High levels of energy expenditure in obese women. *Br Med J (Clin Res Ed)* 292:983-987.

Prentice RL (1996). Measurement error and results from analytic epidemiology: dietary fat and breast cancer. *J Natl Cancer Inst* 88:1738-1747.

Schofield WN (1985). Predicting basal metabolic rate, new standards and review of previous work. *Hum Nutr Clin Nutr* 39:5-41.

Stallone DD, Brunner EJ, Bingham SA & Marmot MG (1997). Dietary assessment in Whitehall II: the influence of reporting bias on apparent socioeconomic variation in nutrient intakes. *Eur J Clin Nutr* 51:815-825.

Sutton-Tyrrell K, Kuller LH, Matthews KA, Holubkov R, Patel A & Edmundowicz D (2002). Subclinical atherosclerosis in multiple vascular beds: an index of atherosclerotic burden evaluated in postmenopausal women. *Atherosclerosis* 160:407-416.

Voss S, Kroke A, Klipstein-Grobusch K & Boeing H (1998). Is macronutrient composition of dietary intake data affected by underreporting? Results from the EPIC-Potsdam Study. European Prospective Investigation into Cancer and Nutrition. *Eur J Clin Nutr* 52:119-126.