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UNDER-REPORTING OF ENERGY INTAKE IN ELDERLY AUSTRALIAN WOMEN IS ASSOCIATED WITH A HIGHER BODY MASS INDEX

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Abstract: *Objectives:* Identify the extent of under-reporting of energy intake and the characteristics associated with implausible intakes in elderly women. *Design:* Dietary intake was assessed using a 3-day weighed food record. Protein intake was validated by 24-hour urinary nitrogen. To examine under-reporting, participants were grouped according to their energy intake and compared to the Goldberg cut-off equation. Logistic regression was performed to assess the influence of body mass index (BMI) and social-demographic factors on under-reporting. *Setting:* Community dwelling elderly women from Perth, Western Australia. *Participants:* 217 elderly women aged 70-80 years. *Results:* Under-reporters had a higher physical activity level ($p<0.001$) compared with acceptable-reporters. The under-reporters also had a higher body weight ($p=0.006$), body mass index (BMI) ($p=0.001$), waist ($p=0.011$), hip circumference ($p<0.001$), whole body fat mass ($p<0.001$) and percentage body fat ($p<0.001$) than acceptable-reporters. Under-reporters had a significantly lower intakes of protein, fat, carbohydrate and alcohol ($p<0.001$) and fewer reported food items, compared with acceptable reporters. However, 24-hour urinary nitrogen was only marginally different between the two groups ($p=0.053$). Participants with a higher BMI were more likely to under-report their energy intake (BMI=25-29.9: odds ratio=2.98[95% CI=1.46-6.09]; BMI≥30: 5.84[2.41-14.14]). *Conclusion:* Under-reporting energy intake in elderly women was associated with a higher BMI, body fat and higher self-reported physical activity levels. A higher BMI (≥25) appears to be most significant factor in determining if elderly women will underreport their food intake and may be related to body image. These results have implications for undertaking surveys of food intake in elderly women.

Key words: Under-reporting, energy intake, protein intake, urinary nitrogen, elderly women.

Introduction

In Australian the population is aging therefore maintaining health and function in older adults is a priority and diet is likely to play an integral part towards increasing life expectancy (1). A poor diet, in combination with physical inactivity increases an individual's risk of developing chronic diseases, such as obesity, some cancers, cardiovascular disease or diabetes (2). Dietary assessment is a key tool used in the prevention and management of these chronic conditions and to assess the risk of poor nutritional status in the elderly.

Capturing food intake is difficult as it relies on self-reported food intake and underreporting can occur regardless of the dietary assessment method used (3, 4). Studies have reported varying degrees of under-reporting (UR) of energy intake, from 8-81% (5-8). A number of factors have been associated with underreporting of which weight status appears to be one of most significant variables (9). Body weight, percentage body fat and BMI have all shown positive associations with under-reporting (5, 8, 10, 11). In elderly women, under-reporting has also been observed using a number of different dietary assessment methods (12-15). It has been suggested that other explanations such as their health status may account for low energy intakes in some elderly individuals (14). In addition, some elderly may be under-eaters rather than under-reporters (16). Assessing the characteristics of under-reporters in the elderly is therefore important as measurement error can conceal effects of food and nutrient intake on health outcomes (17, 18). To characterise the effects of under-reporting it's important that body composition is assessed by criterion methods such as dual energy x-ray absorptiometry (DXA) and the health status is also assessed.

There are a variety of dietary assessment methods available for use in the elderly but the food record can provide more detail on quantities of foods consumed and can reduce the risk of food omissions if recorded at the time of consumption (18). The main limitation of food records is the underreporting or misreporting of energy intake and representativeness of the overall diet (19). Food records require the participant to record all food and drinks consumed for a specified number of days. This task may result in participants under eating or simplifying their food choices to ease the reporting burden (9). As the number of days of recording increases the risk of incomplete records appear to be greater (20). The purpose of this study was to identify the socio-demographic and physical characteristics of under-reporters in elderly women who had completed a 3-day food record. Urinary nitrogen was used to verify the dietary protein intake. To the best of our knowledge this is one of few studies which has assessed underreporting using a three day food record and assessed body composition using DXA in a

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large sample of older women recruited from the general population.

Materials and methods

Subjects

Ambulant community-dwelling women (219) aged between 70 and 80 years were recruited from the Electoral Roll in 2007 for a two-year randomised controlled protein intervention trial related to musculoskeletal health (21). During recruitment participants were excluded if they were taking medications or had the conditions known to affect bone metabolism, diagnosed with osteoporosis or a previous osteoporotic fracture; currently or within last year taking medication for osteoporosis apart from calcium or vitamin D; lactose intolerance; cognitive impairment (MMSE -Mini Mental State Exam<24); BMI>35 kg/m2; clinical diagnosis of diabetes and renal insufficiency (creatinine more than twofold the upper limit of normal). Two participants were excluded from the study (one participant did not complete the food record and another was classified as an over-reporter). The study was approved by the Human Research Ethics Committees of Sir Charles Gardiner Hospital and Curtin University.

Dietary intake

Dietary intake was assessed by a 3-day food record (two week days, one weekend day). Participants were asked to record everything they ate and drank for three consecutive days using either the electronic food scales provided or household measures. They watched a training video on how to complete their food record prior to undertaking the study. When the food record was returned one week later, the participant was interviewed to clarify types and amounts of food or beverages recorded. The food record was analysed using the AUSNUT99 database (Foodworks Professional edition version 3.02), by nutritionists trained in dietary assessment.

24-hour urinary nitrogen

Urine nitrogen (24-hour) was used as a biomarker for the validation of dietary protein intake. The participants collected a 24 hour urine sample on the third day of the food recording period in a 5 L plastic collection bottle which contained 20 ml of 1M HCL. They discarded the first urine specimen of the morning and collected all specimens for 24 hours. The urine sample was weighed and a five mL sample was stored at -20 Celsius until analysed. The urine nitrogen concentration was measured by the Kjeldahl method (22). The estimated dietary protein intake in grams (g) equals 6.25 x (N + 2), where N is the number of grams of total urinary nitrogen in the 24 hour urine, and 2 (g) is the estimated nitrogen excretion by routes other than urine (i.e. faeces and sweat) (23).

Body composition

Body composition was measured by a whole body dual energy x-ray absorptiometry (DXA) scan (Hologic Discovery A, Hologic Corp., Boston, MA, USA). The CVs for total body lean mass and total body fat mass were 1.1% and 1.6% respectively. The head was excluded from all analyses and lean mass refers to bone-free lean mass. Anthropometric measurements were taken prior to the DXA scan according to a standard protocol (24, 25). A tape (Lufkin, Executive Thinline, W606PM) was used to measure waist and hip girth to the nearest 0.1 cm. Standing height was measured using a wall-mounted stadiometer (Veeder-Root, Elizabethown, N.C., USA) to the nearest 0.1 cm. Body weight was measured using an electronic scale (August Sauter GmbH D-7470 Albstadt 1 Ebingen, West Germany) to the nearest 0.1 kg.

Physical activity

Physical activity level (PAL) was assessed by the International Physical Activity Questionnaire (IPAQ) short form (www.ipaq.ki.se) (25). Participants were asked to indicate the time they spent in vigorous activities such as aerobics or fast bicycling, moderate activities such as carrying light loads or bicycling at a regular pace, and walking and sitting in the previous 7 days. The MET-minutes/weeks (METs) was calculated with the following equations and used as the continuous score for total PAL. One MET (metabolic energy turnover) equals one kcal per kg body mass per hour (26).

Walking METs/week=3.3 x walking minutes x walking days

Moderate METs/week=4.0 x moderate-intensity activity minutes x moderate days

Vigorous METs/week=8.0 x vigorous-intensity activity minutes x vigorous-intensity days

Total physical activity METs/week=sum of Walking + Moderate + Vigorous METs

Physical activity was then categorized as low, moderate and high following the IPAQ user instruction (http:www.ipaq.ki.se/scoring.pdf). Low was defined as the total physical activity less than 600 METs/week, moderate 600-3000 METs/week and high ≥ 3000 METs/week.

Under-reporting of energy intake assessment method

The analysis of UR was conducted using the mean energy intake assessed by the 3-day food record which was examined using the Goldberg EI:BMR 'cut-off' method (27). The reported energy intake (EI) was compared to the estimated energy expenditure (EE) which was calculated from the adjusted basal metabolic rate (BMR) and the PAL. Firstly, BMR for women aged over 60 years was calculated using the Schofield Equation (28) as used in the 1985 FAO/WHO/UNU report (29): BMR = 0.038 x weight + 2.755. BMR megajoule/day (MJ/day) and weight in kg. The individual PAL assessed by IPAQ was used to obtain the EE for each participant: EE (kJ) = BMR x 1000 x PAL. The PAL was classified as low (1.56), moderate (1.64) and high (1.95) according to the FAQ/WHO/UNU 1985 recommendations (29). Using the IPAQ total METs/week, low, moderate and high level PAL were <600 METs/week, 600-3000 METs/week and ≥3000 METs/week, respectively. The final equation is EI:EE = Energy intake (kJ)/((0.038 x weight + 2.755) x 1000 x PAL) (kJ) for females age over 60 years (28). Participants were divided into three groups using the Black method (30), which defines under-reporting (UR) and acceptable-reporting (AR) and over-reporting (OR) as EI:EE<0.76, 0.76-1.24 and >1.24 respectively.

General health status

General health status was assessed using the SF-36 questionnaire, International Quality of Life Assessment (IQOLA), English (Australia), version 1.0 (Medical Outcomes Trust http://www.outcomes-trust.org/instruments.htm) (31). The data was analysed with Stata software (Intercooled 9.0) using a custom designed program for calculation of summary statistics for SF-36 (32). The results gave the country-weighted (for Australia) two summary scores (physical health and mental health scores). In Australia, the Stata program uses zero to represent the worst health status and 100 to represent the best health status. The standard population health score has a mean of 50 (SD 10).

Statistical analysis

Statistical analyses were made using Stata Statistical Software (IC 11.1, College Station, TX). A two sample t test and Chi-square test were used to detect the differences between the groups when appropriate. Binary logistic regression (backward stepwise) was performed to assess the influence of body mass index (BMI) and other social-demographic factors on UR energy intake in elderly women. In the model, the under-reporters were compared to the acceptable- reporters. The full model includes age groups, BMI category, country of origin, current living arrangement, education level, income, PAL, and self-reported physical and mental health score. The likelihood ratio test was used during the model selection process. Wald's chi-square test was used to exam if a categorical variable was equal across the categories. Variables with Wald's test p values < 0.20 were retained in the final model. A P value < 0.05 is considered as statistically significant.

Results

Two hundred and eighteen participants who had completed a 3-day food record were included in the original analysis. Using the Goldberg cut-off technique (27), the preliminary analysis showed that 110 participants were categorized as under-reporters (URs), 107 participants were categorized as acceptable-reporters (ARs), and only one participant was categorized as an over-reporter and was excluded from analyses resulting in a final sample of 217 participants with mean age 74.3 (SD 2.7) years. Demographic and lifestyle factors, including age, country of origin, education level, living arrangement and self-reported health status did not differ between groups (Table 1). However, significantly more URs (50%) reported having a higher physical activity level compared to ARs (23%). The mean score of MMSE was 28.2 ranging from 24 to 30, and URs had a higher MMSE score than the ARs (p=0.03, Table 1). As shown in Table 2, the URs had a significantly higher body weight (p=0.006), BMI (p=0.001), waist (p=0.011) and hip circumference (p<0.001) when compared to the ARs. The URs also had a significantly higher total body fat mass and percentage body fat mass and lower percentage of total body lean mass than the ARs (all p values <0.001 in two sample t test) (Table 2). There were significantly more overweight or obese participants classified as URs (overweight 47%, obese 29%) than ARs (overweight 40%, obese 17%) and the difference between the two groups was significant (chi2 = 10.289, df=2, p value=0.006).

Table 1
Demographic and lifestyle data of under- and acceptable-reporters (n=217).

	Overall n = 217	Under-reporters n = 110	Acceptable-reporters n = 107	P value
Age (year)				
< 75	135 (62%)	39 (62%)	67 (63%)	0.90
≥ 75	82 (38%)	42 (38%)	40 (37%)	
Country origin				
Australia	145 (67%)	78 (71%)	67 (63%)	0.10
United Kingdom	33 (15%)	11 (10%)	22 (20%)	
Others	39 (18%)	21 (19%)	18 (17%)	
Education level				
Primary school	17 (8%)	12 (11%)	5 (5%)	0.23
High school or equivalent	157 (72%)	77 (70%)	80 (75%)	
Tertiary degree	43 (20%)	21 (19%)	22 (21%)	
Living arrangement				
Live alone	94 (43%)	46 (42%)	48 (45%)	0.87
Live with husband/partner	101 (47%)	52 (47%)	49 (46%)	
Live with relative or others	22 (10%)	12 (11%)	10 (9%)	
Physical activity (METs/week)				
Low	33 (15%)	15 (14%)	18 (17%)	
Moderate	104 (48%)	40 (36%)	64 (60%)	<0.001
High	80 (37%)	55 (50%)	25 (23%)	
SF-36 Self-reported health status				
Physical health score (0-100)	46 (10)	46 (10)	46 (10)	0.95
Mental health score (0-100)	54 (8)	55 (8)	53 (9)	0.08
Mini Mental State	28.2 (1.5)	28.4 (1.4)	28.0 (1.5)	0.03
Examination (0-32)	n=216	n=110	n=106	

Results are number (percentage) of participants, except for self-report health status and Mini Mental State Examination which are mean (SD). P values were derived from two-sample t test for continuous variables and from Pearson Chi-square test for the categorical variables. The under- and acceptable-reporters were defined by ratio of energy intake assessed by 3-day food record and energy expenditure assessed by equations, and the details can be found in the methodology section.

Compared to the ARs, the URs had significantly lower total energy (p<0.001), protein, (p<0.001), fat (p<0.001), carbohydrate (p<0.001) and alcohol intake (p<0.001) and recorded significantly fewer food items (p<0.001). In addition, the URs had significantly lower percentage of energy intake derived from fat (p=0.001) than ARs (Table 3). The 24-hour urinary nitrogen showed no differences between the ARs and the URs (p=0.150) (Table 3).

Table 2
Anthropometry and body composition of under- and acceptable-reporters (n=217)

	Overall n = 217	Under-reporters n = 110	Acceptable-reporters n = 107	P value
Height (cm)	159.8 (6.0)	160.0 (6.7)	160.0 (6.0)	0.655
Weight (kg)	68.5 (11.3)	70.6 (11.8)	66.4 (10.4)	0.006
BMI (kg/m^2)	26.8 (3.9)	27.6 (3.8)	25.9 (3.8)	0.001
< 25	72 (33%)	26 (24%)	46 (43%)	0.006
25-29	95 (44%)	52 (47%)	43 (40%)	
> 30	50 (23%)	32 (29%)	18 (17%)	
Waist girth (cm)	88.8 (9.6)	90.4 (9.6)	87.1 (9.4)	0.011
Hip girth (cm)	104.6 (9.1)	106.7 (9.3)	102.6 (8.4)	<0.001
Waist-to-hip ratio	0.85 (0.06)	0.85 (0.05)	0.85 (0.06)	0.850
Body composition				
Whole body lean mass (kg)	37.4 (4.7)	37.8 (4.9)	37.1 (4.4)	0.281
% of whole body lean mass	58.2 (5.6)	56.8 (5.1)	59.6 (5.7)	<0.001
Whole body fat mass (kg)	26.1 (7.5)	27.9 (7.6)	24.3 (7.0)	<0.001
% of whole body fat mass	39.5 (5.7)	40.9 (5.2)	38.0 (5.9)	<0.001
Ratio of fat mass to lean mass	0.69 (0.16)	0.73 (0.15)	0.65 (0.16)	<0.001

Results are mean (SD) except for BMI category which is number (percentage) of participants. P values were derived from two-sample t test for continuous variables and from Pearson Chi-square test for the categorical variables. The under- and acceptable-reporters were defined by ratio of energy intake assessed by 3-day food record and energy expenditure assessed by equations, and the details can be found in the methodology section.

For all participants, the energy intake significantly increased from the first to the third day of food recording (6832 kJ; 7024 kJ; 7398 kJ, p<0.001 in a Linear regression model), and the difference between day one, day two and day three was significant (p=0.006 in Wald's chi-square test). The ARs significantly increased their energy intake from the first day of recording through to the third day (7697 kJ; 8134 kJ; 8547 kJ, p<0.001) but this pattern was not observed in the URs (5990 kJ; 5944 kJ; 6270 kJ), p=0.23).

In the binary logistic regression (backward stepwise) for predicting characteristics of under-reporters, age, mental health status, income, country of birth and living arrangement were not predictors of URs and were not included in the final model. The final regression model (Table 4) showed that participants with a higher BMI (BMI 25-29.9: odds ratio=2.98, [95%CI=1.46-6.09]; BMI > 30: 5.84 [2.41-14.14]) and who were reported a higher physical activity level (2.90 [1.14-7.39]) were significantly more likely to under-report their energy intake than those whose BMI < 25 and had low physical activity level.

Table 3
Dietary intake and 24-hour urinary nitrogen of under- and acceptable-reporters (n=217)

	Overall n = 217	Under-reporters n = 110	Acceptable-reporters n = 107	P value
Dietary intake assessed by 3-day weighed food record				
Energy intake (kJ/day)	7068 (1450)	6031 (1074)	8134 (913)	<0.001
Protein intake (g/day)	75.4 (15.1)	67.5 (15.4)	83.5 (15.1)	<0.001
Protein intake (g/kg body wt/day)	1.13 (0.31)	0.97 (0.24)	1.29 (0.29)	<0.001
Fat intake (g/day)	61.9 (18.8)	50.7 (14.0)	73.5 (16.0)	<0.001
Carbohydrate intake (g/day)	186.5(43.0)	163.0 (34.5)	210.7(37.2)	<0.001
Alcohol (g/day)	7.0 (10.5)	4.5 (7.0)	9.5 (12.7)	<0.001
% energy from protein	18.7 (3.4)	19.6 (3.7)	17.8 (2.8)	<0.001
% energy from fat	32.7 (5.6)	31.5 (5.4)	33.9 (5.5)	0.001
% energy from carbohydrate	45.8 (6.6)	46.8 (6.5)	44.8 (6.6)	0.021
% energy from alcohol	2.8 (4.1)	2.1 (3.2)	3.5 (4.8)	0.013
Number of food item recorded	78 (19)	74 (17)	83 (20)	<0.001
24-hour urinary nitrogen				
24-hour urinary nitrogen (g/day)	8.58 (3.03)	8.18 (2.73)	8.98 (3.27)	0.053
Protein intake estimated by urinary nitrogen (g/day)	66.1 (18.9)	63.7 (17.1)	68.6 (20.5)	0.053
Ratio of protein intake †	1.22 (0.40)	1.14 (0.39)	1.31 (0.40)	0.001

Results are mean (SD). P values were derived from two-sample t test for continuous variables and from Pearson Chi-square test for the categorical variables. † The ratio of estimated protein intake: by 3-day food record versus estimated by 24 hour urinary nitrogen. The under- and acceptable-reporters were defined by ratio of energy intake assessed by 3-day food record and energy expenditure assessed by equations, and the details can be found in the methodology section.

Table 4
Binary logistic regression describing social-demographic and lifestyle predictors of a participant being an under-reporters compared to acceptable-reporters

	Odds ratio (95% confidence interval)	P values
BMI		<0.001
< 25	1.00	
25-29.9	2.98 [1.46, 6.09]	
≥ 30	5.84 [2.41, 14.14]	
Education		0.116
Primary	1.00	
Secondary	0.27 [0.08, 0.98]	
Tertiary	0.24 [0.06, 0.97]	
Physical activity level		<0.001
Low	1.00	
Moderate	0.64 [0.27, 1.54]	
High	2.90 [1.14, 7.39]	
SF-36 physical health score	1.03 [0.99, 1.06]	0.119
SF-36 mental health score	1.03 [0.99, 1.07]	0.168

The backward stepwise regression analysis was performed. P values were derived from the Wald's chi-square test. The following variables with Wald's chi-square test p value >0.20 were excluded from the final model: age group, mental health status, income, country of birth and living arrangement. P value < 0.05 is considered as statistically significant.

Discussion

The results of this study showed that underreporting is more likely to occur in overweight elderly women and those reporting to be more physically active. The prevalence of UR has ranged from 18-54% in large nutritional surveys and has been reported as high as 70% in some subgroups, such as overweight women (33). In the current study, the prevalence of UR was 49%. Differences in the study population, the methods used to assess dietary intake and the cut-off point used all contribute to the differences in the prevalence of UR between studies. The general health of the participants in the current study was similar to the normal health level of Australians, as the participants' mean score of the two summary score of the SF-36 was above or similar to the normal health level (34).

This study found URs had a higher weight, BMI, body fat mass, waist and hip girth, than acceptable-reporters. Women with a BMI between 25-29.9 were three times more likely to under-report their energy intake compared with those with a BMI < 25. For those who were obese they were 5.8 times more likely to underreport compared to those with a BMI < 25. These findings are consistent with previous studies in elderly women (15) and in general adult populations (5, 8, 10, 35-37) which have shown overweight women are more likely to under-report. In the current study body composition was assessed by dual energy X-ray absorptiometry (DXA) and found percentage body fat was significantly higher in the under-reporters compared with the acceptable reporters. This finding differs from the study by Samaras and colleagues (38) who also measured body composition using DXA and found in middle-aged women that BMI but not percentage body fat was related to UR. The DXA is a more accurate way to measure body composition and our findings would support that the UR is related to higher body fat rather than body size as the authors had suggested (38).

Accurate assessment of dietary intake in the elderly is important to be able to establish the relationship between dietary intake and health outcomes. When examining energy intakes in the elderly it is important to identify implausible records due to inaccurate reporting so that relationship between diet and disease is not obscured. Doubly labelled water, accurately measures energy expenditure and is used to check the validity of dietary intake methods, which assess energy intake such as food records (9). The assumption of this approach is that energy intake is equal to energy expenditure when weight is stable (39). However, the high cost and the expertise required for analysis make it impractical for routine use_ENREF_36. The Goldberg method allows a checking of the energy intake for implausible results when DLW is not undertaken, as in the current study (27).

Black (30) has stated that a major limitation of the Goldberg approach is that the calculation of EI:BMR requires knowledge of the energy requirements or expenditure and suggested data on physical activity should be included routinely in all dietary surveys. The current study of elderly women used the individual PAL self-assessed by the IPAQ questionnaire as an attempt to improve the estimation of energy expenditure. URs were more likely to report a higher level of physical activity than ARs. The findings suggest that URs may also be overestimating their physical activity and highlights the issue with self-report methods. A study by Tooze et al. (40) compared the Golberg method with doubly labelled water in 451 men and women and found the Goldberg method had high predictive value for food frequency and 24 hour recall methods of dietary assessment. The authors also highlighted the issue of expenditure-related bias and questioned whether self-reported PAL could improve energy estimation. Future studies should include objective measures of PAL such as activity monitors in an attempt to improve the estimation of energy expenditure.

Age, self-reported health status, education level and whether they were living with a partner was not found to be associated with UR in the current study. In a study of 238 females and 105 males aged 60 to 89 years the under-reporters had a lower educational level, greater body weight and were more likely to want to lose weight compared with adequate reporters (41). The study which used 3-day food diaries found only 7.6% of the females under-reported their food intake. The authors suggested this was due to the older females being more motivated. This level of under-reporting was lower than in other studies (12, 38) and that observed in the current study which found 49% of elderly women under-reported. The differences may be due to differences in factors such as education levels and body image concerns between populations.

A number of factors have been shown to contribute to UR, including body-shape and body image concerns (42, 43), social desirability (44), or fear of negative evaluation (45). When asked to record their food intake, participants may also simplify food choices to ease the reporting burden (9) or under-report foods which they perceive as being unhealthy (12). The current study showed URs reported eating significantly less protein, fat, carbohydrate and alcohol and recorded less food items compared with ARs. This suggests that the URs ate less due to either a fear of negative evaluation.

The results in the current study were similar to a study of men and women aged 16-79 years which used a self-administered quantitative food-frequency questionnaire (5). The under-reporters consumed fewer foods rich in fat compared with the other subjects. Others have reported that recording dietary intake itself may alter eating behaviour even in lean women (46). However in the current study normal weight elderly women were less likely to under-report than their overweight or obese counterparts. These results suggest that factors related to body weight and body fat, such as body image concerns may be contributing to underreporting in this group of elderly women. Much of the research to date on body image has focused on adolescents and young adult populations. In a study by of 250 older women, the elderly women were found to show similar levels of body dissatisfaction to middle-aged women (47). The obese women reported a greater drive for thinness, body dissatisfaction and disinhibited eating. These results support the findings in the current study that body image issues persist into old age which can lead to implausible results with dietary assessment methods.

In the current study, 24-hour urinary nitrogen was used as the recovery biomarker representing accurate protein intake (23, 48). Obese participants (BMI ≥ 30) were found to have a similar protein intake to that of their reported food record (ratio of reported protein intake to protein intake estimated from 24-hour urinary nitrogen = 1.19 (0.35) (Table 3). One possible explanation is that women who under-reported simply ate less than their usual intakes during the 3-day recording period. The task of keeping a food record is known to influence food behaviour. Known as the 'Hawthorne' effect, subjects improve an aspect of their behaviour in response to the fact that they are being studied (49). The difference in protein intake between URs and ARs was 15 g/day when self reported, and 5 g/day when estimated from urinary nitrogen. Although eating less partly contributed to underreporting, it would appear the main factor associated with underreporting is people with a high BMI.

There are some limitations with the current study. The assumptions of using urinary nitrogen to estimate dietary protein intake are that subjects are in nitrogen balance and 24-hour urines are completely collected (50) which may not have been the case in this elderly population. Para-amino benzoic acid (PABA) can be used to verify the completeness of 24-hour urine collection (51). The concentration of PABA less than 85% is classified as an incomplete urine collection (52). A limitation of the current study was that the completeness of 24-hour urine collection was not verified using PABA and only a single 24-hour urine sample was collected. PABA is not approved for use with healthy volunteers in Australia (53). Therefore, the protein intake estimated from 24-hour urinary nitrogen may not represent an accurate protein intake in this study. Due to the systematic bias toward under-estimation of 24-hour urinary nitrogen, the true protein intake could be higher than we reported. However, as the purpose of this study was to identify the characteristics of URs by comparing URs to ARs, the incomplete urine collection was unlikely to affect the result from the regression analysis.

Conclusion

The findings of this study indicate that in elderly women, compared to those acceptable-reporters, underreporting is more likely to occur in those who are overweight or obese and have a higher percentage body fat and those reporting to be more physically active (≥ 3000 METS/week). Under-reporters also recorded significantly fewer food items. A higher BMI (≥ 25 kg/m2) appears to be most significant factor in determining if elderly women will underreport their food intake and this may be related to body image issues. These results have implications for future research that undertakes dietary intake surveys of elderly women and all dietary intake surveys.

Conflict of interest: We declare that we have no conflict of interest.

List of author contributions: All authors provided feedback on the overall design of the study, interpretation of results and provided feedback on the manuscript. XM and DK prepared the draft manuscript. XM, DK, KZ and AD analysed the dietary data, undertook the data analysis and interpretation.

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