British Journal of Nutrition (2015), **114**, 1294–1303
doi:10.1017/S0007114515002706

Prevalence and characteristics of misreporting of energy intake in US adults: NHANES 2003–2012

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(Submitted 18 February 2015 – Final revision received 1 June 2015 – Accepted 22 June 2015 – First published online 24 August 2015)

Abstract

Using data from the National Health and Nutrition Examination Survey (NHANES) 2003–2012, we investigated the prevalence and characteristics of under-reporting and over-reporting of energy intake (EI) among 19 693 US adults ≥20 years of age. For the assessment of EI, two 24-h dietary recalls were conducted using the US Department of Agriculture Automated Multiple-Pass Method. Under-reporters, acceptable reporters and over-reporters of EI were identified by two methods based on the 95 % confidence limits: (1) for agreement between the ratio of EI to BMR and a physical activity level for sedentary lifestyle (1·55) and (2) of the expected ratio of EI to estimated energy requirement (EER) of 1·0. BMR was calculated using Schofield's equations. EER was calculated using equations from the US Dietary Reference Intakes, assuming 'low active' level of physical activity. The risk of being an under-reporter or over-reporter compared with an acceptable reporter was analysed using multiple logistic regression. Percentages of under-reporters, acceptable reporters and over-reporters were 25·1, 73·5 and 1·4 %, respectively, based on EI:BMR, and 25·7, 71·8 and 2·5 %, respectively, based on EI:EER. Under-reporting was associated with female sex, older age, non-Hispanic blacks (compared with non-Hispanic whites), lower education, lower family poverty income ratio and overweight and obesity. Over-reporting was associated with male sex, younger age, lower family poverty income ratio, current smoking (compared with never smoking) and underweight. Similar findings were obtained when analysing only the first 24-h recall data from NHANES 1999–2012 (*n* 28 794). In conclusion, we found that misreporting of EI, particularly under-reporting, remains prevalent and differential in US adults.

Key words: **Energy intake: Misreporting: Adults: National Health and Nutrition Examination Survey**

Misreporting of dietary intake is a universal phenomenon that appears to occur both randomly and non-randomly[1–3]. Furthermore, it may be selective for different kinds of foods and nutrients[4–6], although without biomarkers for each food or nutrient of interest this is hard to articulate with absolute certainty, and may differ by population. Biases inherent in the use of self-reported dietary data make it complicated to interpret studies on diet and health, which may distort or obscure the associations between diet and health or even create spurious ones[1,3,5]. To better understand this issue, it is essential to identify the characteristics associated with misreporting (under-reporting and over-reporting) of dietary intake.

As all nutrients must be provided within the quantity of food needed to fulfil the energy requirement, energy intake (EI) is the foundation of the diet[1]. Unfortunately, under-reporting of EI has long been a serious problem in almost all dietary surveys[1,6]. In particular, overweight and obese subjects tend to under-report EI to a greater extent than normal-weight subjects[1–6]. Moreover, recent studies have shown that, in addition to under-reporting, over-reporting of EI also needs to be taken into account, in some populations at least, such as those with low BMI[3,7,8]. Investigation of dietary misreporting should be conducted in each country, as it is conceivable that the way in which survey participants comply with dietary assessment procedures may differ from one country to another. Nevertheless, information on the whole picture of characteristics associated with dietary misreporting in a representative sample in each country is still limited[7–14].

In the continuous National Health and Nutrition Examination Survey (NHANES), the US Department of Agriculture (USDA) Automated Multiple-Pass Method is used for collecting 24-h dietary recall information. Although this method has been validated against total energy expenditure measured by doubly labelled water[15,16] and against observed actual intake[17,18] in highly selected populations, the validity in a representative sample of US adults remains largely unknown. In the present study, the prevalence and characteristics of under-reporting and over-reporting of EI among US adults were evaluated using data from the NHANES.

Abbreviations: EER, estimated energy requirement; EI, energy intake; NHANES, National Health and Nutrition Examination Survey; PAL, physical activity level; USDA, US Department of Agriculture.

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Methods

Survey design

The present cross-sectional analysis was based on public domain data from NHANES, a continuing population-based survey that uses a complex, stratified multi-stage probability sample design to create a representative sample of the non-institutionalised civilian US population[19,20]. Initiated in 1999, the survey examines about 5000 persons each year, and the data are released every 2 years. Each survey consists of questionnaires administered at home, followed by a standardised health examination, including an in-person 24-h dietary recall interview, in a mobile examination centre. Since 2002, a second 24-h dietary recall was also obtained by telephone; two 24-h dietary recall data are publicly available since 2003. The unweighted response rates for the examined persons for NHANES 1999–2000, 2001–2002, 2003–2004, 2005–2006, 2007–2008, 2009–2010 and 2011–2012 were 76, 80, 76, 77, 75, 77 and 70 %, respectively[21]. The documentation and data for each of these surveys can be downloaded from the NHANES website[22]. The NHANES was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by National Center for Health Statistics Research Ethics Review Board. Written informed consent was obtained from each subject.

Analytical sample

The analytical sample was limited to adults aged ≥20 years with two complete and reliable, self-reported, 24-h dietary recall data (*n* 21 921). After excluding pregnant (*n* 618) and lactating (*n* 153) respondents, as well as those with missing information on the variables of interest (*n* 1754), the final analytical sample included 19 396 respondents from NHANES 2003–2012. An additional analysis was also conducted using only the first dietary recall data in 28 794 respondents from NHANES 1999–2012.

Assessment of energy intake

All surveys collected dietary information using a 24-h dietary recall administered by a trained interviewer in the mobile examination centre. Beginning with 2002, a second 24-h dietary recall was also obtained via telephone 3–10 d after the first recall. The dietary recalls collected for the NHANES 1999–2000 and 2001 survey years used a computer-assisted interview that included a 4-step multiple pass approach. Since 2002, the dietary data were collected using an automated 5-step multiple pass approach – namely, the USDA Automated Multiple-Pass Method[15–18,22]. This method consists of (1) a quick list pass, in which the respondent is asked to list everything eaten or drunk the previous day; (2) a forgotten foods list pass, in which a standard list of foods or beverages, often forgotten, is read to prompt recall; (3) a time and occasion pass, in which the time of and the name for the eating occasion are collected; (4) a detail and review pass, in which detailed descriptions and portion sizes are collected and the time interval between meals is reviewed to check for additional food intake; and (5) the final probe pass, one last opportunity to remember foods consumed. Estimates of EI from all reported foods and beverages were calculated by using the USDA food composition databases. In 1999–2000, the USDA 1994–1998 Survey Nutrient Database was the food composition database used; in subsequent surveys, the USDA Food and Nutrient Database for Dietary Studies was used[22]. The average of EI over the 2 d for each participant was used for the present analysis.

Assessment of non-dietary variables

Consistent with NHANES sample-selection methods, age was categorised as 20–39, 40–59 and ≥60 years. Race/ethnicity was categorised as non-Hispanic white, non-Hispanic black, Mexican American and others. As indicators of socio-economic status, we considered family income as a percentage of the federal poverty threshold and years of education. The family poverty income ratio was categorised as <130, 130–349 and ≥350 %. The educational level was categorised as <12 years, 12 years, some college and college degree or more. Information on smoking status (never, former or current) and perceived weight status (underweight, about the right weight or overweight) was also collected. Based on self-report of either any moderate or vigorous activities lasting ≥10 min in the past 30 d (NHANES 1999–2006) or without a specified period (NHANES 2007–2012), any recreational physical activity (yes or no) was assessed. Body weight and height were measured by trained interviewers using standardised procedures with calibrated equipments. BMI (kg/m^2) was calculated as weight (kg) divided by height (m) squared. Weight status was defined based on BMI according to World Health Organization[23] recommendations as follows: underweight (<18·5 kg/m^2), normal (≥18·5 to <25 kg/m^2), overweight (≥25 to <30 kg/m^2) and obese (≥30 kg/m^2).

Evaluation of the accuracy of energy intake reporting

Misreporting of EI was evaluated based on the ratio of EI to BMR (the Goldberg cut-off)[24] and the ratio of EI to estimated energy requirement (EER) – namely, the procedure proposed by Huang *et al.*[25]. Subjects were identified as acceptable reporters, under-reporters and over-reporters of EI according to whether the individual's ratio was within, below or above the 95 % confidence limits for agreement between EI:BMR and the respective physical activity level (PAL) or of the expected EI:EER of 1·0. For the principles of the Goldberg cut-off, the PAL for sedentary lifestyle (i.e. 1·55)[24] was applied for all subjects, because of a lack of an objective measure of physical activity in the present study. BMR was estimated using Schofield sex- and age-specific equations based on body height and weight[26]. The 95 % confidence limits for agreement (upper and lower cut-off values) between EI:BMR and the PAL were calculated, taking into account CV in intakes and other components of energy balance (i.e. the within-subject variation in EI: 23 %; the precision of the estimated BMR relative to the measured BMR: 8·5 %; and the between-subject variation in PAL: 15 %)[24]. Consequently, under-reporters, acceptable reporters and over-reporters were defined as having EI:BMR < 0·96, 0·96–2·49 and >2·49 for 2-d data and <0·87, 0·87–2·75 and >2·75 for 1-d data, respectively.

EER was calculated using sex- and age-specific equations for use in populations with a range of weight statuses, published from the US Dietary Reference Intakes, based on sex, age, body height and weight and physical activity[27]. Because of a lack of

an objective measure of physical activity as mentioned above, we assumed 'low active' level of physical activity (i.e. PAL ≥ 1·4 to <1·6)[27] for all subjects during this calculation. The 95 % confidence limits of the expected EI:EER ratio of 0 on the natural log scale were calculated, taking into account CV in intakes and other components of energy balance (i.e. the within-subject variation in EI: 23 %; the error in the EER equations: 11 %; and the day-to-day variation in total energy expenditure: 8·2 %)[24,25,27]. Consequently, under-reporters, acceptable reporters and over-reporters were defined as having EI:EER < 0·65, 0·65–1·53 and >1·53 for 2-d data and <0·59, 0·59–1·71 and >1·71 for 1-d data, respectively.

Statistical analysis

Statistical analyses were performed using SAS statistical software (version 9.2, SAS Institute). All reported *P* values are two-tailed, and $P < 0{\cdot}05$ was considered to be statistically significant. All the analyses used the NHANES-provided sampling weights that were calculated to take into account unequal probabilities of selection, resulting from the sample design, non-response and planned over-sampling of selected sub-groups, so that the results are representative of the US community-dwelling population[20,28]. For EI, BMR, EER, EI:BMR and EI:EER, sample-weighted means (with their SE) were generated using the PROC SURVYMEANS procedure. Differences in these variables across categories of each of the characteristics were examined by Wald's *F* test using the PROC SURVEYREG procedure. Proportions (with their SE) of under-reporters, acceptable reporters and over-reporters of EI were calculated using the PROC SURVEYFREQ procedure. Differences in proportions of under-reporters, acceptable reporters and over-reporters across categories of each of the characteristics were examined by the χ^2 test using the PROC SURVEYFREQ procedure.

The risk of being classified as an under-reporter of EI, compared with being an acceptable reporter, or as an over-reporter, compared with being an acceptable reporter, was estimated using logistic regression. First, using the PROC SURVEYLOGISTIC procedure, crude OR and 95 % CI for the risk of being classified as an under-reporter or over-reporter were calculated for each category of factors, which are possibly associated with EI misreporting – namely, sex (reference: men), age group (reference: 20–39 years), race/ethnicity (reference: non-Hispanic white), years of education (reference: <12 years), family poverty income ratio (reference: <130 %), weight status (reference: normal), perceived weight status (reference: about the right weight), smoking status (reference: never), any recreational physical activity (reference: yes) and survey cycle (reference: 2003–2004). Multivariate-adjusted OR and 95 % CI were then calculated by entering all the variables simultaneously into the regression model in order to assess the independent associations.

These analyses were conducted separately for men and women. The results on the association between EI reporting and the variables examined were essentially the same in men and women, although the percentage of under-reporters was higher in women but that of over-reporters was higher in men, as shown below. The present report, therefore, presents the results for men and women combined.

Results

Among 19 396 subjects with 2-d dietary data, the sample-weighted mean EI:BMR was 1·28, whereas the corresponding value for EI:EER was 0·85 (Table 1). Men had a higher mean EI:BMR than women. Mean EI:BMR differed significantly among age groups, with the highest in the youngest group (20–39 years) and the lowest in the oldest group (≥60 years); among race/ethnicity groups, with the highest in non-Hispanic whites and Mexican Americans and the lowest in non-Hispanic blacks; among smoking status groups, with the highest in current smokers; and among survey cycles, with the highest in 2003–2004 and the lowest in 2007–2008. Years of education and family poverty income ratio were positively associated with EI:BMR. Mean EI:BMR in obese and overweight subjects was lower compared with normal-weight and underweight subjects. Mean EI:BMR similarly differed according to perceived weight status, with the highest in those who considered themselves underweight and the lowest in those who considered themselves overweight. Subjects with any recreational physical activity had a higher mean EI:BMR than those without any activity. Similar associations of these characteristics with EI:EER were also observed.

The sample-weighted percentages of under-reporters, acceptable reporters and over-reporters of EI were 25·1, 73·5 and 1·4 %, respectively, based on EI:BMR, and 25·7, 71·8 and 2·5 %, respectively, based on EI:EER (Table 2). Using EI:BMR, the percentage of under-reporters was higher in women but that of over-reporters was higher in men. With regard to age, there were more under-reporters among the oldest group, whereas there were more over-reporters among the youngest group. For race/ethnicity, there were more under-reporters among non-Hispanic blacks. Years of education and family poverty income ratio were inversely associated with the percentages of both under-reporters and over-reporters. There were more under-reporters and fewer over-reporters among overweight and obese subjects. For perceived weight status, there were more under-reporters among those who considered themselves overweight and more over-reporters among those who considered themselves underweight. Current smokers had a higher percentage of over-reporters, whereas those with any recreational physical activity had a lower percentage of under-reporters. The proportion of under-reporters and over-reporters differed among survey cycles, with more under-reporters in 2007–2008 and more over-reporters in 2005–2006. The results were similar based on using EI:EER to estimate misreporters, except for no difference according to the survey cycle.

Odds ratios and 95 % confidence intervals for the risk of being an under-reporter compared with an acceptable reporter are shown in Table 3. The results for the crude and multivariate-adjusted models were generally similar except for any recreational physical activity. In the multivariate analyses, based on EI:BMR and EI:EER, a higher risk of being an under-reporter was associated with the female sex, age ≥60 years (EI:BMR only)

Table 1. Characteristics of the subjects: National Health and Nutrition Examination Survey (NHANES) 2003–2012 (n 19 396)*
(Mean values with their standard errors)

				EI (kJ/d)†		BMR (kJ/d)‡		EER (kJ/d)§		EI:BMR		EI:EER	
	n	%	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
All	19 396	100	0	8884	44	7015	15	10 469	21	1·28	0·005	0·85	0·004
Sex													
Men	9575	48·5	0·4	10 463	62	8021	18	11 824	24	1·32	0·008	0·89	0·005
Women	9821	51·5	0·4	7399	37	6070	16	9195	22	1·23	0·006	0·81	0·004
P‖				<0·0001		<0·0001		<0·0001		<0·0001		<0·0001	
Age group (years)													
20–39	6250	36·7	0·8	9573	73	7233	25	11 117	33	1·34	0·010	0·86	0·006
40–59	6492	39·1	0·5	9039	71	7056	23	10 492	34	1·29	0·009	0·86	0·006
≥60	6654	24·2	0·6	7591	62	6619	24	9451	33	1·17	0·008	0·81	0·006
P‖				<0·0001		<0·0001		<0·0001		<0·0001		<0·0001	
Race/ethnicity													
Non-Hispanic white	9674	71·6	1·5	8977	50	7004	18	10 441	26	1·29	0·006	0·86	0·004
Non-Hispanic black	4055	11·0	0·8	8565	99	7269	30	10 863	41	1·20	0·013	0·80	0·008
Mexican American	3090	7·6	0·8	9017	117	7049	29	10 535	37	1·29	0·016	0·86	0·010
Others	2577	9·7	0·6	8462	99	6785	37	10 178	55	1·25	0·013	0·83	0·009
P‖				<0·0001		<0·0001		<0·0001		<0·0001		<0·0001	
Years of education													
<12 years	4952	16·7	0·8	8333	97	6922	37	10 210	51	1·21	0·012	0·82	0·008
12 years	4552	23·7	0·7	8875	86	7062	30	10 499	44	1·27	0·011	0·85	0·007
Some college	5616	31·3	0·6	9014	68	7088	30	10 622	42	1·28	0·009	0·85	0·006
≥College	4276	28·3	1·0	9072	63	6951	23	10 428	34	1·31	0·008	0·87	0·005
P‖				<0·0001		0·0002		<0·0001		<0·0001		<0·0001	
Family poverty income ratio (%)													
<130	5741	20·5	0·8	8631	84	6950	28	10 396	43	1·25	0·011	0·83	0·007
130–349	7387	35·6	0·8	8657	81	6982	24	10 387	37	1·25	0·011	0·84	0·007
≥ 350	6268	43·9	1·1	9187	59	7073	25	10 570	35	1·31	0·007	0·87	0·005
P‖				<0·0001		0·004		<0·0001		<0·0001		<0·0001	
Weight status¶													
Underweight	284	1·5	0·1	8704	301	5400	55	8458	104	1·60	0·050	1·03	0·030
Normal	5348	30·4	0·7	8967	81	6177	18	9405	31	1·44	0·011	0·94	0·007
Overweight	6577	33·4	0·6	8959	63	6988	19	10387	31	1·27	0·008	0·86	0·005
Obese	7187	34·8	0·6	8774	72	7842	25	11564	34	1·12	0·008	0·76	0·005
P‖				0·11		<0·0001		<0·0001		<0·0001		<0·0001	
Perceived weight status													
Underweight	935	4·4	0·2	10 010	242	6354	42	9656	70	1·57	0·034	1·03	0·022
About the right weight	7642	38·5	0·6	9177	69	6675	18	10 033	29	1·38	0·009	0·91	0·006
Overweight	10 819	57·2	0·7	8601	52	7295	21	10 825	30	1·19	0·006	0·80	0·004
P‖				<0·0001		<0·0001		<0·0001		<0·0001		<0·0001	
Smoking status													
Never	10 206	52·9	0·8	8698	52	6936	20	10 407	29	1·26	0·006	0·84	0·004
Former	5046	25·0	0·6	8870	82	7135	31	10 450	44	1·25	0·011	0·85	0·007
Current	4144	22·1	0·6	9347	95	7070	27	10 640	37	1·34	0·013	0·88	0·009
P‖				<0·0001		<0·0001		<0·0001		<0·0001		<0·0001	
Any recreational physical activity													
Yes	10 205	59·8	1·0	9085	53	7035	20	10 546	29	1·30	0·007	0·86	0·004
No	9191	40·2	1·0	8585	67	6986	23	10 355	31	1·24	0·008	0·83	0·006
P‖				<0·0001		0·12		<0·0001		<0·0001		<0·0001	
Survey cycle													
2003–2004	3577	19·1	1·3	9089	82	6970	37	10 411	51	1·31	0·008	0·87	0·005
2005–2006	3504	19·9	1·1	8924	124	7014	42	10 478	59	1·28	0·015	0·85	0·009
2007–2008	4065	19·8	1·1	8702	112	7012	28	10 460	35	1·25	0·013	0·84	0·009
2009–2010	4414	20·1	1·1	8811	101	7043	25	10 510	35	1·26	0·013	0·84	0·009
2011–2012	3836	21·0	1·2	8902	69	7034	29	10 484	48	1·28	0·008	0·85	0·006
P‖				0·06		0·56		0·60		0·001		0·005	

EI, energy intake; EER, estimated energy requirement.
* All % and mean values are weighted to reflect the survey design characteristics. Analyses are based on subjects with complete data on two 24-h dietary recalls as well as complete information on the variables of interest.
† Based on average values of the two 24-h dietary recalls.
‡ Estimated using Schofield's sex- and age-specific equations based on body height and weight[26].
§ Calculated using sex- and age-specific equations for use in populations with a range of weight statuses published from the US Dietary Reference Intakes based on sex, age and body height and weight assuming 'low active' level of physical activity for all subjects[27].
‖ Based on Wald's *F* test.
¶ Defined based on BMI (kg/m^2) according to World Health Organization[23] recommendations: <18·5 for underweight, ≥25 to <30 for normal, ≥25 to <30 for overweight and ≥30 for obese subjects.

https://doi.org/10.1017/S0007114515002706 Published online by Cambridge University Press

Table 2. Numbers and percentages of under-reporters, acceptable reporters and over-reporters of energy intake (EI): National Health and Nutrition Examination Survey (NHANES) 2003–2012 (*n* 19 396)* (Percentages with their standard errors)

	Based on EI:BMR†										Based on EI:EER‡									
	Under-reporters			Acceptable reporters			Over-reporters				Under-reporters			Acceptable reporters			Over-reporters			
	n	%	SE	*n*	%	SE	*n*	%	SE	*P*§	*n*	%	SE	*n*	%	SE	*n*	%	SE	*P*§
All	5633	25·1	0·5	13 490	73·5	0·5	273	1·4	0·1		5560	25·7	0·5	13 358	71·8	0·5	478	2·5	0·2	
Sex										<0·0001										<0·0001
Men	2692	22·8	0·6	6710	75·4	0·6	173	1·8	0·2		2420	21·7	0·7	6851	75·0	0·7	304	3·3	0·3	
Women	2941	27·2	0·6	6780	71·8	0·7	100	1·0	0·2		3140	29·4	0·7	6507	68·9	0·7	174	1·7	0·2	
Age group (years)										<0·0001										<0·0001
20–39	1493	22·5	0·8	4612	75·4	0·9	145	2·1	0·2		1685	25·6	0·9	4361	71·4	0·9	204	3·0	0·3	
40–59	1724	23·7	0·8	4666	74·8	0·8	102	1·5	0·2		1740	24·4	0·8	4575	72·9	0·8	177	2·7	0·3	
≥60	2416	31·1	0·9	4212	68·6	0·9	26	0·3	0·1		2135	27·9	0·9	4422	70·8	0·9	97	1·3	0·2	
Race/ethnicity										<0·0001										<0·0001
Non-Hispanic white	2504	23·5	0·6	7035	75·2	0·6	135	1·3	0·1		2446	24·1	0·6	6986	73·5	0·6	242	2·4	0·2	
Non-Hispanic black	1467	34·9	1·1	2528	63·3	1·1	60	1·7	0·3		1468	35·8	1·2	2489	61·5	1·2	98	2·8	0·4	
Mexican American	906	25·5	1·3	2139	72·8	1·2	45	1·6	0·3		907	26·4	1·4	2103	70·9	1·3	80	2·7	0·5	
Others	756	25·1	1·4	1788	73·4	1·5	33	1·4	0·4		739	25·6	1·5	1780	71·8	1·6	58	2·6	0·5	
Years of education										<0·0001										<0·0001
<12 years	1823	33·3	1·2	3055	64·8	1·2	74	1·9	0·3		1732	32·7	1·3	3090	64·3	1·3	130	3·0	0·4	
12 years	1357	26·7	1·0	3135	71·9	1·0	60	1·4	0·2		1340	27·4	1·0	3092	69·9	1·0	120	2·7	0·3	
Some college	1538	25·1	0·8	3975	73·3	0·8	103	1·7	0·2		1570	26·3	0·8	3894	71·2	0·8	152	2·6	0·3	
≥College	915	18·9	0·7	3325	80·3	0·8	36	0·9	0·2		918	19·5	0·8	3282	78·6	0·9	76	1·9	0·3	
Family poverty income ratio (%)										<0·0001										<0·0001
<130	1958	31·6	1·0	3661	65·9	1·0	122	2·5	0·3		1935	32·1	1·1	3610	64·3	1·0	196	3·7	0·3	
130–349	2244	27·5	0·8	5047	71·0	0·8	96	1·5	0·2		2198	27·8	0·8	5022	69·5	0·8	167	2·7	0·3	
≥350	1431	20·0	0·7	4782	79·2	0·8	55	0·8	0·1		1427	21·0	0·8	4726	77·2	0·8	115	1·8	0·2	
Weight status‖										<0·0001										<0·0001
Underweight	49	17·2	2·8	217	75·0	3·5	18	7·8	2·3		51	18·8	2·7	206	70·9	3·5	27	10·3	2·5	
Normal	909	14·2	0·7	4275	83·0	0·7	164	2·9	0·3		938	16·1	0·8	4155	79·5	0·8	255	4·4	0·4	
Overweight	1737	22·8	0·8	4778	76·3	0·8	62	0·9	0·1		1672	23·3	0·8	4782	74·7	0·8	123	2·0	0·3	
Obese	2938	37·1	0·9	4220	62·6	0·9	29	0·4	0·1		2899	36·7	0·9	4215	62·4	0·9	73	0·9	0·2	
Perceived weight status										<0·0001										<0·0001
Underweight	167	15·7	2·2	714	78·1	2·1	54	6·3	1·0		158	15·5	2·1	696	75·9	2·0	81	8·6	1·1	
About the right weight	1761	18·5	0·7	5716	79·3	0·7	165	2·2	0·2		1700	19·3	0·7	5670	76·9	0·7	272	3·9	0·3	
Overweight	3705	30·2	0·6	7060	69·3	0·7	54	0·5	0·1		3702	30·8	0·7	6992	68·1	0·7	125	1·1	0·1	
Smoking status										<0·0001										<0·0001
Never	2972	25·0	0·6	7127	74·0	0·6	107	1·0	0·1		3022	26·2	0·6	6994	72·0	0·7	190	1·8	0·2	
Former	1541	25·3	0·9	3469	73·8	0·9	36	0·8	0·2		1401	23·9	0·8	3553	73·7	0·8	92	2·3	0·4	
Current	1120	24·9	0·9	2894	72·0	0·9	130	3·1	0·4		1137	26·4	1·0	2811	69·2	1·0	196	4·4	0·4	
Any recreational physical activity										<0·0001										<0·0001
Yes	2649	23·0	0·6	7404	75·5	0·6	152	1·5	0·2		2661	24·0	0·6	7279	73·4	0·6	265	2·6	0·3	
No	2984	28·1	0·8	6086	70·6	0·8	121	1·3	0·2		2899	28·2	0·8	6079	69·5	0·8	213	2·3	0·2	
Survey cycle										0·008										0·10
2003–2004	985	23·5	0·8	2542	74·8	0·9	50	1·6	0·3		958	24·2	0·8	2534	73·2	0·9	85	2·7	0·4	
2005–2006	982	24·7	1·0	2474	73·5	0·9	48	1·8	0·3		961	25·2	1·0	2459	71·9	1·1	84	2·9	0·4	
2007–2008	1272	27·2	1·3	2727	71·4	1·2	66	1·4	0·2		1270	28·0	1·5	2684	69·7	1·5	111	2·3	0·3	
2009–2010	1340	26·4	1·0	3011	72·0	1·0	63	1·5	0·3		1317	26·9	1·0	2991	70·5	1·0	106	2·6	0·5	
2011–2012	1054	23·4	1·1	2736	75·8	1·2	46	0·8	0·2		1054	24·3	1·1	2690	73·8	1·2	92	2·0	0·3	

EER, estimated energy requirement.

* All % values are weighted to reflect the survey design characteristics. Analyses are based on subjects with complete data on two 24-h dietary recalls as well as complete information on the variables of interest. Average EI values of the two 24-h dietary recalls were used.

† Under-reporters were defined as subjects with EI:BMR < 0·96; acceptable reporters as subjects with EI:BMR 0·96–2·49; and over-reporters as subjects with EI:BMR > 2·49. BMR was estimated using Schofield's sex- and age-specific equations based on body height and weight[26].

‡ Under-reporters were defined as subjects with EI:EER < 0·65; acceptable reporters as subjects with EI:EER 0·65–1·53; and over-reporters as subjects with EI:EER > 1·53. EER was calculated using sex- and age-specific equations for use in populations with a range of weight statuses published from the US Dietary Reference Intakes based on sex, age and body height and weight assuming 'low active' level of physical activity for all subjects[27].

§ Based on χ^2 test.

‖ Defined based on BMI (kg/m^2) according to World Health Organization[23] recommendations: <18·5 for underweight, ≥25 to <30 for normal, ≥25 to <30 for overweight and ≥30 for obese subjects.

https://doi.org/10.1017/S0007114515002706 Published online by Cambridge University Press

Table 3. Risk of being an under-reporter of energy intake (EI) compared with being an acceptable reporter of EI: National Health and Nutrition Examination Survey (NHANES) 2003–2012* (Odds ratios and 95 % confidence intervals)

	Based on EI:BMR (*n* 19 123)†					Based on EI:EER (*n* 18 918)‡				
		Crude model§		Multivariate model‖			Crude model§		Multivariate model‖	
	Under-reporters/acceptable reporters (*n*)	OR	95 % CI	OR	95 % CI	Under-reporters/acceptable reporters (*n*)	OR	95 % CI	OR	95 % CI
Sex										
Men	2692/6710	1	Reference	1	Reference	2420/6851	1	Reference	1	Reference
Women	2941/6780	1·26	1·15, 1·37	1·20	1·09, 1·33	3140/6507	1·48	1·34, 1·63	1·44	1·29, 1·61
Age group (years)										
20–39	1493/4612	1	Reference	1	Reference	1685/4361	1	Reference	1	Reference
40–59	1724/4666	1·06	0·93, 1·21	1·03	0·91, 1·17	1740/4575	0·93	0·83, 1·06	0·89	0·79, 1·01
≥60	2416/4212	1·52	1·32, 1·74	1·47	1·26, 1·71	2135/4422	1·10	0·97, 1·26	1·04	0·90, 1·21
Race/ethnicity										
Non-Hispanic white	2504/7035	1	Reference	1	Reference	2446/6986	1	Reference	1	Reference
Non-Hispanic black	1467/2528	1·77	1·57, 1·98	1·41	1·24, 1·59	1468/2489	1·78	1·58, 2·01	1·40	1·23, 1·59
Mexican American	906/2139	1·12	0·97, 1·30	0·85	0·74, 0·99	907/2103	1·14	0·98, 1·32	0·84	0·73, 0·98
Others	756/1788	1·10	0·93, 1·29	1·11	0·96, 1·30	739/1780	1·09	0·92, 1·29	1·05	0·90, 1·24
Years of education										
<12 years	1823/3055	1	Reference	1	Reference	1732/3090	1	Reference	1	Reference
12 years	1357/3135	0·72	0·63, 0·82	0·77	0·66, 0·89	1340/3092	0·77	0·67, 0·88	0·80	0·69, 0·93
Some college	1538/3975	0·67	0·59, 0·75	0·77	0·67, 0·88	1570/3894	0·73	0·64, 0·83	0·78	0·67, 0·91
≥College	915/3325	0·46	0·40, 0·53	0·64	0·55, 0·75	918/3282	0·49	0·42, 0·57	0·63	0·53, 0·75
Family poverty income ratio (%)										
<130	1958/3661	1	Reference	1	Reference	1935/3610	1	Reference	1	Reference
130–349	2244/5047	0·81	0·71, 0·92	0·83	0·72, 0·96	2198/5022	0·80	0·70, 0·91	0·86	0·74, 0·99
≥350	1431/4782	0·53	0·46, 0·61	0·63	0·55, 0·73	1427/4726	0·54	0·47, 0·63	0·68	0·58, 0·80
Weight status¶										
Underweight	49/217	1·34	0·88, 2·05	1·28	0·83, 2·00	51/206	1·31	0·88, 1·94	1·28	0·86, 1·91
Normal	909/4275	1	Reference	1	Reference	938/4155	1	Reference	1	Reference
Overweight	1737/4778	1·75	1·53, 2·01	1·65	1·40, 1·94	1672/4782	1·54	1·34, 1·77	1·50	1·28, 1·76
Obese	2938/4220	3·47	3·03, 3·98	2·97	2·48, 3·56	2899/4215	2·91	2·55, 3·32	2·51	2·11, 2·99
Perceived weight status										
Underweight	167/714	0·86	0·61, 1·21	0·87	0·60, 1·26	158/696	0·81	0·58, 1·14	0·80	0·56, 1·13
About the right weight	1761/5716	1	Reference	1	Reference	1700/5670	1	Reference	1	Reference
Overweight	3705/7060	1·87	1·69, 2·06	1·14	0·999, 1·31	3702/6992	1·81	1·63, 2·00	1·18	1·03, 1·35
Smoking status										
Never	2972/7127	1	Reference	1	Reference	3022/6994	1	Reference	1	Reference
Former	1541/3469	1·02	0·92, 1·13	0·94	0·84, 1·05	1401/3553	0·89	0·81, 0·98	0·89	0·81, 0·99
Current	1120/2894	1·02	0·91, 1·15	1·02	0·92, 1·13	1137/2811	1·05	0·94, 1·17	1·04	0·94, 1·15
Any recreational physical activity										
Yes	2649/7404	1	Reference	1	Reference	2661/7279	1	Reference	1	Reference
No	2984/6086	1·31	1·19, 1·44	0·94	0·86, 1·03	2899/6079	1·24	1·13, 1·37	0·94	0·86, 1·04
Survey cycle										
2003–2004	985/2542	1	Reference	1	Reference	958/2534	1	Reference	1	Reference
2005–2006	982/2474	1·07	0·93, 1·23	1·06	0·92, 1·22	961/2459	1·06	0·92, 1·22	1·05	0·91, 1·21
2007–2008	1272/2727	1·21	1·04, 1·41	1·20	1·02, 1·42	1270/2684	1·22	1·02, 1·45	1·20	1·01, 1·43
2009–2010	1340/3011	1·17	1·02, 1·34	1·11	0·95, 1·30	1317/2991	1·15	1·01, 1·32	1·11	0·97, 1·28
2011–2012	1054/2736	0·98	0·84, 1·14	0·96	0·81, 1·13	1054/2690	1·00	0·85, 1·16	0·99	0·84, 1·16

EER, estimated energy requirement.

* Analyses are based on subjects with complete data on two 24-h dietary recalls as well as complete information on the variables of interest. Average EI values of the two 24-h dietary recalls were used.

† Under-reporters were defined as subjects with EI:BMR < 0·96; acceptable reporters as subjects with EI:BMR 0·96–2·49. Over-reporters (subjects with EI:BMR > 2·49; *n* 273) were excluded from the analysis. BMR was estimated using Schofield's sex- and age-specific equations based on body height and weight[26].

‡ Under-reporters were defined as subjects with EI:EER < 0·65; acceptable reporters as subjects with EI:EER 0·65–1·53. Over-reporters (subjects with EI:EER > 1·53; *n* 478) were excluded from the analysis. EER was calculated using sex- and age-specific equations for use in populations with a range of weight statuses published from the US Dietary Reference Intakes based on sex, age and body height and weight assuming 'low active' level of physical activity for all subjects[27].

§ Each of the variables listed was entered into the model separately.

‖ All the variables listed were entered into the model simultaneously.

¶ Defined based on BMI (kg/m^2) according to World Health Organization[23] recommendations: <18·5 for underweight, ≥25 to <30 for normal, ≥25 to <30 for overweight and ≥30 for obese subjects.

(compared with age 20–39 years), non-Hispanic blacks (compared with non-Hispanic white), overweight and obesity (compared with normal weight), perceived overweight (EI:EER only) (compared with about the right weight) and survey cycle 2007–2008 (compared with 2003–2004). A lower risk of being an under-reporter was associated with higher years of education (compared with the lowest), higher family poverty income ratio (compared with the lowest), Mexican Americans and former smoking (EI:EER only) (compared with never smoking).

Table 4 lists the OR and 95 % CI for the risk of being an over-reporter compared with an acceptable reporter. The results for the crude and multivariate-adjusted models were again generally similar except for years of education. In the multivariate analyses, a lower risk of being an over-reporter was associated with the female sex (EI:EER only), age ≥60 years, higher family poverty income ratio, overweight and obese, perceived overweight and survey cycle 2011–2012 (EI:BMR only). A higher risk of being an over-reporter was associated with underweight (EI:EER only) and current smoking.

We repeated all the analyses using 28 794 subjects with the first dietary recall data. The sample-weighted mean EI:BMR was 1·31, whereas the corresponding value for EI:EER was 0·87 (online Supplementary Table S1). The sample-weighted percentages of under-reporters, acceptable reporters and over-reporters of EI were 20·5, 77·5 and 2·0 %, respectively, based on EI:BMR, and 21·0, 76·4 and 2·6 %, respectively, based on EI:EER (online Supplementary Table S2). Factors significantly associated with the risk of being an under-reporter or being an over-reporter compared with being an acceptable reporter were generally similar (online Supplementary Tables S3 and S4, respectively), except for no association of survey year with both under-reporting and over-reporting and an inverse association between years of education and over-reporting.

Discussion

Using two 24-h dietary recalls from NHANES 2003–2012, we found that misreporting, particularly under-reporting, of EI remains prevalent and differential in US adults aged ≥20 years. Percentages of under-reporters and over-reporters of EI were 25·1 and 1·4 %, respectively, based on EI:BMR, and 25·7 and 2·5 %, respectively, based on EI:EER. A higher risk of being an under-reporter of EI compared with being an acceptable reporter was associated with female sex, older age, non-Hispanic blacks (compared with non-Hispanic whites), lower education, lower family poverty income ratio and overweight and obesity. A higher risk of being an over-reporter compared with being an acceptable reporter was associated with male sex, younger age, lower family poverty income ratio, current smoking (compared with never smoking) and underweight. Similar findings were observed when analysing based on the first 24-h dietary recall only (NHANES 1999–2012). To our knowledge, this is the first study to examine the prevalence and characteristics of misreporting of EI in a representative sample of US adults from the continuous NHANES.

Only a few recent national studies have examined misreporting of EI among adults. Among 1487 adults in Britain, EI assessed by a 7-d weighed dietary record was evaluated according to EI:EER[9]. The prevalence of under-reporters and over-reporters was 63 and 0·4 %, respectively, for men, and 55 and 0 %, respectively, for women. A French study evaluated EI assessed by a 7-d diet record among 1567 adults based on the Goldberg principles[10]. The prevalence of under-reporters was 24 % in men and 21 % in women (over-reporters not defined). EI estimated by a 24-h dietary recall was similarly evaluated in 3919 adults in New Zealand, and the prevalence of under-reporters was 21 % for men and 25 % for women (over-reporters not defined)[11]. Similar prevalence of under-reporting of EI (obtained from a 24-h dietary recall) was also observed in Korean adults: 14 % for men and 23 % for women (over-reporters not defined)[12]. A study in Ireland investigated EI estimated by a FFQ using the Goldberg principles (*n* 7521), and the prevalence of under-reporting and over-reporting was 33 and 12 %, respectively[7]. Similar findings have been observed in a study among Norwegians where EI was assessed by a FFQ; prevalence of under-reporting was 20 % for men and 25 % for women, with prevalence of over-reporting being 7 % for men and 5 % for women[8]. In the previous NHANES III (1988–1991), 18 % of the men and 28 % of the women were classified as under-reporters[13]. In the present analysis, the prevalence of under-reporting both using two 24-h recall data (25·1 % based on EI:BMR and 25·7 % based on EI:EER in NHANES 2003–2012) and using one 24-h recall data (20·5 % based on EI:BMR and 21·0 % based on EI:EER in NHANES 1999–2012) was relatively similar to those observed in other countries. Although it is difficult to determine whether the difference in the prevalence among countries reflects the true difference in the accuracy of reporting or is merely due to differences in the criteria used to identify misreporters, dietary assessment instruments, food composition databases and population characteristics, these national studies clearly show that misreporting of EI remains a serious problem in dietary surveys among adults.

In this study, overweight and obese subjects were more likely to under-report EI, which has been consistently observed in many studies[1–14]. The association between weight status and EI under-reporting should be carefully considered in any relevant analysis based on continuous NHANES, given that there has been an increase in the prevalence of obesity and extreme obesity (BMI ≥ 40 kg/m^2) since previous NHANES III[29]. In addition, female sex and older age were associated with under-reporting of EI, although the associations of sex and age with under-reporting are not consistent in the literature[1,6,7,10]. For other correlates of misreporting, research is limited or the results are generally inconsistent[1]. For race/ethnicity, we found that a higher risk of under-reporting was associated with non-Hispanic blacks (compared with non-Hispanic whites), which has also been observed among US adults from previous NHANES 1988–1991[13]. Lower education and lower family poverty income ratio were associated with a higher risk of under-reporting. Both low[3,10,13] and high[2,6,7] socio-economic statuses have been shown to be associated with under-reporting. Characteristics associated with over-reporting of EI are less understood. We found that over-reporting was associated with male sex, younger age, lower family poverty income ratio, current smoking and underweight. In an analysis of Irish

Table 4. Risk of being an over-reporter of energy intake (EI) compared with being an acceptable reporter of EI: National Health and Nutrition Examination Survey (NHANES) 2003–2012* (Odds ratios and 95 % confidence intervals)

	Based on EI:BMR (*n* 13 763)†					Based on EI:EER (*n* 13 836)‡				
		Crude model§		Multivariate model‖			Crude model§		Multivariate model‖	
	Over-reporters/acceptable reporters (*n*)	OR	95 % CI	OR	95 % CI	Over-reporters/acceptable reporters (*n*)	OR	95 % CI	OR	95 % CI
Sex										
Men	173/6710	1	Reference	1	Reference	304/6851	1	Reference	1	Reference
Women	100/6780	0·61	0·43, 0·85	0·70	0·47, 1·04	174/6507	0·56	0·44, 0·72	0·61	0·46, 0·81
Age group (years)										
20–39	145/4612	1	Reference	1	Reference	204/4361	1	Reference	1	Reference
40–59	102/4666	0·72	0·51, 1·02	1·07	0·73, 1·57	177/4575	0·89	0·65, 1·21	1·23	0·88, 1·73
≥60	26/4212	0·16	0·10, 0·25	0·23	0·14, 0·39	97/4422	0·44	0·32, 0·59	0·57	0·40, 0·80
Race/ethnicity										
Non-Hispanic white	135/7035	1	Reference	1	Reference	242/6986	1	Reference	1	Reference
Non-Hispanic black	60/2528	1·54	1·02, 2·31	1·14	0·78, 1·66	98/2489	1·37	0·99, 1·91	1·15	0·84, 1·58
Mexican American	45/2139	1·26	0·80, 1·98	0·97	0·62, 1·53	80/2103	1·19	0·78, 1·82	0·99	0·64, 1·54
Others	33/1788	1·07	0·62, 1·84	0·91	0·52, 1·59	58/1780	1·12	0·72, 1·76	1·00	0·63, 1·58
Years of education										
<12 years	74/3055	1	Reference	1	Reference	130/3090	1	Reference	1	Reference
12 years	60/3135	0·67	0·41, 1·09	0·85	0·51, 1·42	120/3092	0·83	0·58, 1·21	1·02	0·68, 1·53
Some college	103/3975	0·78	0·52, 1·17	1·10	0·70, 1·72	152/3894	0·78	0·56, 1·09	1·01	0·69, 1·47
≥College	36/3325	0·38	0·22, 0·67	0·73	0·39, 1·37	76/3282	0·52	0·35, 0·78	0·80	0·50, 1·29
Family poverty income ratio (%)										
<130	122/3661	1	Reference	1	Reference	196/3610	1	Reference	1	Reference
130–349	96/5047	0·58	0·43, 0·79	0·73	0·54, 1·01	167/5022	0·68	0·52, 0·90	0·79	0·60, 1·05
≥350	55/4782	0·28	0·19, 0·41	0·40	0·25, 0·62	115/4726	0·40	0·30, 0·55	0·51	0·37, 0·71
Weight status¶										
Underweight	18/217	3·00	1·52, 5·92	1·95	0·85, 4·47	27/206	2·60	1·45, 4·68	1·97	1·02, 3·80
Normal	164/4275	1	Reference	1	Reference	255/4155	1	Reference	1	Reference
Overweight	62/4778	0·35	0·24, 0·50	0·50	0·35, 0·71	123/4782	0·48	0·35, 0·67	0·61	0·41, 0·90
Obese	29/4220	0·16	0·09, 0·31	0·30	0·14, 0·64	73/4215	0·26	0·17, 0·40	0·43	0·25, 0·75
Perceived weight status										
Underweight	54/714	2·84	1·97, 4·10	1·47	0·93, 2·32	81/696	2·27	1·67, 3·10	1·36	0·93, 1·98
About the right weight	165/5716	1	Reference	1	Reference	272/5670	1	Reference	1	Reference
Overweight	54/7060	0·25	0·17, 0·37	0·49	0·31, 0·78	125/6992	0·32	0·24, 0·43	0·53	0·36, 0·78
Smoking status										
Never	107/7127	1	Reference	1	Reference	190/6994	1	Reference	1	Reference
Former	36/3469	0·84	0·52, 1·37	1·04	0·61, 1·77	92/3553	1·30	0·88, 1·93	1·44	0·94, 2·20
Current	130/2894	3·29	2·19, 4·93	2·01	1·29, 3·14	196/2811	2·61	1·92, 3·56	1·74	1·26, 2·40
Any recreational physical activity										
Yes	152/7404	1	Reference	1	Reference	265/7279	1	Reference	1	Reference
No	121/6086	0·96	0·69, 1·34	0·84	0·57, 1·22	213/6079	0·91	0·70, 1·18	0·82	0·61, 1·10
Survey cycle										
2003–2004	50/2542	1	Reference	1	Reference	85/2534	1	Reference	1	Reference
2005–2006	48/2474	1·11	0·69, 1·78	1·22	0·75, 1·97	84/2459	1·10	0·75, 1·61	1·17	0·79, 1·72
2007–2008	66/2727	0·87	0·53, 1·41	0·92	0·56, 1·52	111/2684	0·89	0·62, 1·29	0·95	0·65, 1·38
2009–2010	63/3011	0·96	0·57, 1·63	1·09	0·63, 1·89	106/2991	1·01	0·63, 1·64	1·12	0·67, 1·86
2011–2012	46/2736	0·48	0·27, 0·85	0·51	0·30, 0·86	92/2690	0·73	0·48, 1·09	0·77	0·52, 1·13

EER, estimated energy requirement.

* Analyses are based on subjects with complete data on two 24-h dietary recalls as well as complete information on the variables of interest. Average EI values of the two 24-h dietary recalls were used.

† Over-reporters were defined as subjects with EI:BMR > 2·49; acceptable reporters as subjects with EI:BMR 0·96–2·49. Under-reporters (subjects with EI:BMR < 0·96; *n* 5633) were excluded from the analysis. BMR was estimated using Schofield's sex- and age-specific equations based on body height and weight[26].

‡ Over-reporters were defined as subjects with EI:EER > 1·53; acceptable reporters as subjects with EI:EER 0·65–1·53. Under-reporters (subjects with EI:EER < 0·65; *n* 5560) were excluded from the analysis. EER was calculated using sex- and age-specific equations for use in populations with a range of weight statuses published from the US Dietary Reference Intakes based on sex, age and body height and weight assuming 'low active' level of physical activity for all subjects[27].

§ Each of the variables listed was entered into the model separately.

‖ All the variables listed were entered into the model simultaneously.

¶ Defined based on BMI (kg/m^2) according to World Health Organization[23] recommendations: <18·5 for underweight, ≥25 to <30 for normal, ≥25 to <30 for overweight and ≥30 for obese subjects.

adults, younger age, lower social class and underweight were associated with a higher risk of over-reporting[7]. Underweight has also been associated with over-reporting in other studies[3,8]. Although these variables may not always be associated with EI misreporting, and the association should be dependent on the population characteristics, dietary assessment methods and the procedure for identifying misreporters, accumulating literature clearly indicates that misreporting occurs non-randomly in adult populations. Specific to NHANES, we found that survey cycle was associated with both under-reporting and over-reporting of EI at least in some analyses based on two 24-h dietary recalls, which has also been indicated in a previous univariate analysis[14]. This differential reporting may severely distort the validity of trend analyses using dietary intake data. Thus, previously reported trend analyses should be cautiously interpreted in this regard, and future analyses should properly take into account misreporting of EI. Nonetheless, it should also be pointed out that survey cycle was not associated with either under-reporting or over-reporting when only the first 24-h dietary recall was analysed.

Several limitations of the present study are acknowledged. At present, the only way to obtain unbiased information on energy requirements in free-living settings is to use doubly labelled water as a biomarker[1]. This technique is expensive and impractical for application to large-scale epidemiological studies, and thus alternative procedures are used[3,5,9,25]. In the present study, EER was calculated with the use of equations from the US Dietary Reference Intakes, which have been developed based on a large number of measurements of total energy expenditure by the doubly labelled water method and are highly accurate (R^2 0·82 for men and 0·79 for women)[27]. In the absence of actual, measured total energy expenditure, these equations should serve as the best proxy. Owing to constraints within the data set, we did not have a validated and individualised measure of physical activity. Instead, we assumed 'low active' level of physical activity for all subjects during the calculation of EER (as well as using the PAL for sedentary lifestyle for all subjects when using the Goldberg principles). This seems adequate for most US adults, based on the accelerometer-based data in NHANES 2003–2006[30,31]. Nevertheless, in some very active individuals, EER would be underestimated, having the effect of over-estimating EI:EER, thus tending to retain those individuals as acceptable reporters or over-reporters. Further, we do not know the sensitivity and specificity of the procedures for identifying under-reporters and over-reporters of EI used; in addition, there is currently not enough information on relative merits of the different methods (i.e. EI:BMR and EI:EER) for detecting misreporters. Thus, we are unable to determine whether the associations found between misreporting of EI and several characteristics are true, or were artifacts caused by the procedure used to identify misreporters, as well as errors associated with food composition databases used. Finally, the cross-sectional nature of the study does not permit the assessment of causality, owing to the uncertain temporality of the association.

In conclusion, in this comprehensive analysis based on data from NHANES 2003–2012, we found that misreporting of EI assessed by two 24-h dietary recalls was too prevalent to ignore in US adults aged ≥20 years: 26·5 % based on EI:BMR and 28·2 % based on EI:EER. Unfortunately, such EI misreporting was differential among populations. Under-reporting was associated with female sex, older age, non-Hispanic blacks (compared with non-Hispanic whites), lower education, lower family poverty income ratio and overweight and obesity, whereas over-reporting was associated with male sex, younger age, lower family poverty income ratio, current smoking and underweight. The results were similar when only the first 24-h dietary recall was assessed based on data from NHANES 1999–2012. Thus, it is essential to consider this differential misreporting of EI when using dietary data from NHANES.

Acknowledgements

This work was supported in part by the Grants-in-Aid for Young Scientists (B) from the Ministry of Education, Culture, Sports, Science and Technology of Japan (K. M., grant number 15K16213). The Ministry of Education, Culture, Sports, Science and Technology of Japan had no role in the design, analysis or writing of this article.

K. M. contributed to the concept and design of the study, statistical analysis, data interpretation and manuscript writing. M. B. E. L. critically reviewed the manuscript. All the authors read and approved the final version of the manuscript.

There are no conflicts of interest.

Supplementary material

For supplementary materials referred to in this article, please visit http://dx.doi.org/10.1017/S0007114515002706

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