International Journal of Obesity (2000) 24, 882–887
 0307-0565/00 $15.00
www.nature.com/ijo

Underreporting of energy intake in four populations of African origin

LI Mennen[1*], M Jackson[2], J Cade[3], JC Mbanya[4], L Lafay[1], S Sharma[3], S Walker[2], S Chungong[4], R Wilks[2], B Balkau[1], T Forrester[2] and JK Cruickshank[3]

[1]*INSERM, Unit 258, Université Paris-Sud, Villejuif, France;* [2]*Tropical Metabolism Research Unit, University of the West Indies, Kingston, Jamaica;* [3]*Clinical Epidemiology Unit, Manchester University Medical School, Manchester, UK; and* [4]*Department of Internal Medicine, University of Yaounde I, Cameroon*

OBJECTIVE: To investigate the frequency of dietary underreporting in four African populations in different geographic and cultural settings.
SUBJECTS: Seven-hundred and forty three men and women from rural Cameroon, 1042 men and women from urban Cameroon, 857 men and women from Jamaica and 243 male and female African Caribbeans from the UK. Subjects who reported dieting or weight control were excluded.
MEASUREMENTS: Habitual dietary intake was estimated with a quantitative food frequency questionnaire, developed specifically for each country. Underreporting was defined using three cut-off levels for energy intake/estimated basic metabolic rate (EI/BMR_{est}), based on age, sex and weight, in each site.
RESULTS: The EI/BMR_{est} was highest in rural Cameroonian men at 3.07 (95% confidence interval: 2.97, 3.17) and women at 2.84 (2.74, 2.94), intermediate in urban Cameroon and Jamaica and lowest in the UK men and women at 1.44 (1.26, 1.62) and 1.41 (1.21, 1.61). This trend existed even after adjustment for age, BMI and education (P for trend < 0.0001). The trend in the frequency of underreporting using the lowest cut-off level for EI/BMR_{est} of 1.15 was 6% and 6% in rural Cameroon for women and men, respectively, 4% and 5% in urban Cameroon, 24% and 19% in Jamaica and 28% and 39% in the UK. With higher cut off levels this trend was similar.
CONCLUSION: The results suggest that the frequency of dietary underreporting differs between societies and that Westernization may be one of the factors underlying this phenomenon.
International Journal of Obesity (2000) 24, 882–887

Keywords: dietary underreporting; energy intake; culture; nutrition

Introduction

Assessment of habitual diet in studies which evaluate the relation between nutritional factors and health is difficult. All available methods are subject to bias and no 'gold standard' exists. In large epidemiological studies, self-reported methods are frequently used, although the limitations of these methods are well known.[1] Energy intake, for example, is frequently underestimated and this does not depend on the type of self-reported method used.[2] This so-called underreporting of energy intake influences the observed associations of nutritional factors, especially in studies on obesity, and exclusion of underreporters from the analyses may change the results.[3,4]

In order to clarify the background to underreporting, research has been carried out to identify the characteristics of subjects who underestimate their energy intake.[5–9] The results of these studies have shown that underreporting is more frequent in obese subjects and in subjects who are preoccupied with their weight.[5–9] Furthermore, underreporting seems to be associated with socio-professional class.[5]

Several factors have been suggested to underlie the problem of underreporting of energy intake. Among them are inaccuracy in reporting food portions, memory disturbance, and psychosocial, behavioral and cultural factors.[10] Cultural factors may be particularly important for underreporting in a healthy population. We hypothesized that if this were true, the frequency of underreporting would differ between societies with a different cultural background. We have tested this hypothesis in an international study, which aimed to evaluate the relations between the habitual diet and chronic diseases in four populations of African origin from Cameroon, Jamaica and the UK.

Methods

Cameroon

Cameroonian men and women of African origin, aged 24–74 y were studied in an urban area, Cité Verte Housing District, Yaoundé and in a rural area in

*Correspondence: LI Mennen, INSERM, Unit 258, 16 Avenue Paul Vaillant Couturier, 94807 Villejuif Cedex, France.
E-mail: mennen@vjf.inserm.fr
Received 19 July 1999; revised 9 December 1999; accepted 26 January 2000

Evodoula, Cameroon.[11] The study was approved by the Ministry of Health's National Ethical Committee.

Three of the seven villages of the rural area of Evoduoula, Minwoho, Nkolassa and Nloudou, situated about 60 km from Yaoundé, were randomly selected as the rural sites. All eligible subjects were invited to participate. The occupation of the people of Evodoula is mainly farming and hunting; 436 women and 307 men were included in the rural sample of the study. The urban subjects recruited from a housing estate were mostly middle grade civil servants and middle income earners for those in the private sector. All subjects were invited to participate, of whom 584 women and 458 men consented and were included in the urban sample. Response rates were over 95% in both the rural and the urban sample.

Jamaica

The region immediately surrounding Spanish Town, 15 miles from Kingston, the Capital of Jamaica, was found to be representative of the island's population, urban as well as rural dwellers. The probability-proportional-to-size method was used for sampling. Enumeration district lists provided name and address but not age, and house-to-house invitations were made to one adult per household. In total 512 women and 345 men were included, with a response rate of 60%. All subjects were between 24 and 74 y of age.

UK

Random samples stratified by age decade and sex were taken from population registers in Manchester, UK held in health centers serving the inner city wards where most African-Caribbeans live. Initially any individual was eligible but later, as ethnicity is not identified and to increase numbers sampled, lists were scanned for names more likely to be African-Caribbean; all these people were invited and a random subsample of 1:3 others. Ethical permission was granted by the Central Manchester Health District Ethical Committee. In total 147 women and 96 men were included in the UK sample, representing over 80% of those invited for the food frequency questionnaire. The age range for women was 26–69 y and for men 25–72 y of age.

In Jamaica and the UK, African-Caribbean ethnicity was determined by at least three of four grandparents being of African descent and Caribbean origin. People of direct African origin, thus not coming from the Caribbean, or mixed descent were not included. Exclusion criteria for the present study were pregnancy and reported efforts to control weight by dietary or other means. Subjects reporting to be losing weight were excluded.

Dietary assessment

In each country a food frequency questionnaire was carefully developed to assess habitual nutrient intake during the previous 12 months and included those foods contributing at least 90% of total energy, fat, carbohydrate and protein intake.[12] They were designed to be interviewer administered and interviewers used local cooking utensils, specially prepared wooden food models and cutlery to help subjects to describe their own portion size (in the UK familiar household units were used). For Cameroon the questionnaire included 76 food items and variations in consumption of foods between the wet and dry seasons was ascertained. The Jamaican questionnaire included 69 foods and drinks. The UK questionnaire included 108 food items from the Carribean as well as Europe. To calculate the nutrient composition of the habitual diet several food tables[13–15] and the nutritional analysis package, Microdiet,[16] were used. Since these tables did not cover all the typical dishes eaten in Cameroon and the UK dishes were prepared by local people, all contents and the final cooked dish were weighed by trained field workers to be able to calculate the nutrient composition of the dishes. The UK questionnaire was calibrated against 24 h recalls and 4 day weighed intake in a subsample of the total population. Spearman rank correlation coefficients ranged from 0.38 for protein to 0.62 for carbohydrate intake when compared with the 4 day weighed intake and from 0.38 for fat intake to 0.50 for energy intake when compared with the 24 h recall. When the food frequency questionnaire was compared with the 4 day weighed record, 39% of subjects fell in identical quartiles and 44% were in adjacent quartiles, and none were grossly misclassified, showing reasonable comparison of these different methods. In Jamaica the reproducibility was tested in a subsample of 118 subjects and Pearson's correlation coefficients between protein, fat and carbohydrate intake from the first and the second measurement were 0.62, 0.67 and 0.69 respectively (unpublished data, PhD thesis, M Jackson, 1998).

Underreporting

Weight and height were measured with subjects in light clothing and the body mass index was calculated by dividing weight (kg) by the square of height (m^2). The basal metabolic rate (BMR_{est}) was estimated according to Schofield's equations[17] using age, sex and weight. The determination of the cut-off values for EI/BMR_{est} is based on the fact that, during weight maintenance, EI should equal total energy expenditure (TEE). The lower cut-off value for EI/BMR to define underreporting is then calculated as 2 s.d. below the mean TEE/BMR.[5,18] With this calculation the intra-individual variation of EI, the inter-individual variation of TEE/BMR, an estimate of physical activity level, the error associated with the estimation of BMR and the number of days on which the assessment of the habitual diet is based are taken into account. For the latter we have taken 365 days, since the food frequency questionnaire covered the food intake during the last year. As the aim was to determine cut-off values for individuals, the number of subjects used in the equation for the cut-off was 1. The mean TEE/BMR is assumed to be 1.55 for sedentary people,[19] 1.78 for people involved in mild physical activity[20] and 2.00 for people involved in regular strenuous physical activity.[19] In the present study, the physical activity level, although not measured directly, clearly differed among the four populations, from visibly active rural Cameroonians to progressively less active urban dwellers and those elsewhere. Therefore, three cut-off values were calculated using these three different estimates for TEE/BMR, which resulted in cut-off values of 1.15, 1.32 and 1.48 for sedentary, mildly active and very active subjects, respectively. The prevalence of underreporting was thus calculated three times in each group, in other words, each cut-off was used in each group. An example of the calculation of the cut-offs is given in the appendix.

Data-analyses

The mean of the EI/BMR_{est} was calculated by site. Generalized linear models were used to calculate means adjusted for age, BMI and achieved education (assessed by questionnaire and divided in three levels). Three classes of BMI were defined (BMI $< 25\,kg/m^2$, BMI $25-30\,kg/m^2$, BMI $\geq 30\,kg/m^2$) and the mean EI/BMR_{est} was calculated by class of BMI and by site. The percentage of subjects who were defined as underreporters (according to three cut-off levels of EI/BMR_{est}) were calculated.

Results

Mean age was similar in rural Cameroon, Jamaica and the UK, but lower in urban Cameroon, for women as well as for men (Table 1). Total energy intake was highest in rural Cameroon and lowest in the UK, with an opposite trend for BMI. The distribution of the level of education differed between the four sites, with the lowest level in rural and highest in urban Cameroon.

There was a clear decreasing trend in the EI/BMR_{est} from rural Cameroon to the UK, in men as well as in women (Table 2). Adjustment of mean EI/BMR_{est} for age, BMI and education attenuated the differences between sites somewhat, but the trend remained the same (Table 2).

In each site the EI/BMR_{est} was associated with BMI (Table 3); the EI/BMR_{est} was lowest in obese subjects (BMI $\geq 30\,kg/m^2$), highest in non-obese subjects (BMI < 25) and intermediate in overweight subjects (BMI ≥ 25 and $< 30\,kg/m^2$). The decreasing

Table 1 General characteristics of the study population by site (mean (s.d.) or frequencies)

	Rural Cameroon	*Urban Cameroon*	*Jamaica*	*UK*
Women				
n	436	584	512	147
Age (y)	46 (13)	38 (9)	46 (13)	48 (13)*
Body mass index (kg/m^2)	22.3 (3.3)	27.0 (5.0)	27.6 (6.4)	28.8 (5.7)*
Energy intake (kcal)	3900 (1526)	3364 (1238)	2389 (1045)	1997 (676)*
Basal metabolic rate (MJ/24 h)	5.44 (0.44)	5.99 (0.59)	6.19 (0.83)	6.03 (0.65)*
Education:				
primary school or less	89	18	69	5
secondary school	9	42	23	72
college or more	3	40	8	23*
Men				
n	307	458	345	96*
Age (y)	48 (14)	38 (9)	46 (14)	55 (13)*
Body mass index (kg/m^2)	21.9 (2.7)	25.0 (3.7)	23.5 (4.3)	27.1 (3.3)*
Energy intake (kcal)	4315 (1822)	3919 (1400)	3006 (1245)	2307 (925)*
Basal metabolic rate (MJ/24 h)	6.54 (0.79)	7.27 (0.63)	7.16 (0.96)	7.07 (0.87)*
Education:				
primary school or less	71	5	65	8*
secondary school	24	27	28	70
college or more	5	68	7	22

*$P < 0.05$ for difference between groups.

Table 2 Energy intake/estimated basal metabolic rate (mean (95% confidence interval)) by site and sex

	Rural Cameroon	*Urban Cameroon*	*Jamaica*	*UK*
Women				
Crude	3.07 (2.97, 3.17)	2.43 (2.55, 2.51)	1.82 (1.72, 1.92)	1.44 (1.26, 1.62)*
Adjusted[a]	2.93 (2.83, 3.03)	2.47 (2.39, 2.55)	1.71 (1.63, 1.79)	1.60 (1.42, 1.78)*
Men				
Crude	2.84 (2.74, 2.94)	2.34 (2.26, 2.42)	1.68 (1.60, 1.76)	1.41 (1.21, 1.61)*
Adjusted[a]	2.70 (2.58, 2.82)	2.44 (2.34, 2.54)	1.76 (1.66, 1.86)	1.58 (1.38, 1.78)*

*$P < 0.0001$ for trend from rural Cameroon to the UK.
[a]Adjusted for age, BMI and education.

Table 3 Energy intake/estimated basal metabolic rate (mean (95% confidence interval)) by site, sex and class of body mass index (BMI, kg/m²)

	Rural Cameroon	*Urban Cameroon*	*Jamaica*	*UK*
Women				
BMI < 25	3.11 (2.91, 3.31) $n=350$	2.59 (2.45, 2.73) $n=225$	1.88 (1.76, 2.00) $n=175$	1.67 (1.47, 1.87) $n=34$
BMI 25–30	2.98 (2.65, 3.31) $n=53$	2.42 (2.30, 2.54) $n=207$	1.65 (1.53, 1.77) $n=153$	1.38 (1.26, 1.50) $n=40$
BMI ≥ 30	2.17 (1.52, 2.78) $n=13$	2.19 (2.07, 2.31) $n=136$	1.42 (1.32, 1.52) $n=128$	1.31 (1.15, 1.47) $n=39$
Men				
BMI < 25	2.86 (2.72, 3.00) $n=267$	2.53 (2.41, 2.65) $n=245$	1.95 (1.85, 2.05) $n=239$	1.69 (1.41, 1.97) $n=19$
BMI 25–30	2.65 (2.25, 3.05) $n=28$	2.10 (1.98, 2.22) $n=157$	1.55 (1.39, 1.71) $n=77$	1.42 (1.28, 1.54) $n=49$
BMI ≥ 30	2.71 (1.04, 4.38) $n=4$	2.05 (1.85, 2.25) $n=43$	1.30 (1.06, 1.54) $n=19$	1.05 (0.80, 1.30) $n=16$

trend from the lowest BMI class to the highest BMI class was statistically significant ($P < 0.005$) in each site and in both sexes, except for men in rural Cameroon. The decreasing trend in EI/BMR_{est} from rural Cameroon to the UK was seen in each BMI class in women as well as in men. There was no interaction effect on EI/BMR_{est} between BMI class and site. When adjustments were made for age and education, the same trends across BMI classes and across sites were seen.

The percentage of subjects who were underreporters increased across sites from rural Cameroon to the UK (Table 4). With each cut-off level the highest percentage was seen in the UK and the lowest in rural Cameroon. The number of underreporters in rural as well as in urban Cameroon was never higher than 15%, while even with the lowest cut-off level (for subjects not engaged in regular physical activity) already one-third of the population in the UK was defined as underreporters. In all sites, the percentage of underreporters almost doubled going from the lowest to the highest cut-off level.

Discussion

The results of this study have shown that the EI/BMR_{est} among people of African origin is much lower in the UK and Jamaica than in rural and urban Cameroon, in men as well as in women. The frequency of underreporting increased significantly across sites, from rural Cameroon to the UK.

Table 4 Percentage of subjects (%(n)) who were underreporters according to different cut-off values for energy intake/estimated basic metabolic rate, by site and by sex

	Rural Cameroon	*Urban Cameroon*	*Jamaica*	*UK*
Women				
Cut-off 1.15	6 (27)	4 (21)	24 (110)	28 (32)
Cut-off 1.32	8 (32)	7 (41)	34 (157)	46 (53)
Cut-off 1.48	9 (38)	13 (73)	47 (215)	60 (69)
Men				
Cut-off 1.15	6 (17)	5 (22)	19 (62)	39 (33)
Cut-off 1.32	9 (27)	9 (41)	30 (100)	53 (45)
Cut-off 1.48	11 (34)	14 (62)	37 (125)	66 (56)

The subjects from rural Cameroon were much leaner than those from Jamaica and UK, and this difference in BMI could have confounded the relation between site and underreporting. However, the trend across sites persisted in each BMI class. Similarly the level of education could have confounded our data. After adjustment for education, however, the results remained similar. Thus neither BMI nor the level of education could explain our observations. Memory is another factor which has been suggested to explain underreporting.[10] We may assume that people in rural Cameroon know best what they eat, since the food diversity may be lower and most of them are farmers, growing their own food, and thus have less chance of underreporting their energy intake by lack of memory. However, this argument is not valid for subjects in urban Cameroon (where the same food frequency questionnaire was used as in the rural area), while the EI/BMR_{est} was clearly higher than in the UK. Other factors that influence underreporting are dietary restraint and dieting. In our study all subjects who reported to be under weight control were excluded. Lifetime dietary restrainers, however, could still be included in our population samples. Although we did not measure dietary restraint in the present study, the number of dietary restrainers may well be higher in the UK than in Cameroon. In our opinion the basis of dietary restraint may be cultural too, which makes dietary restraint an intermediate factor between culture and underreporting and would thus not confound the relation.

The cut-off level for defining underreporting depends on the physical activity level of the population. When taking a TEE/BMR of 1.55, which is average, we arrived at a cut-off level of 1.15, while taking TEE/BMR of 2.00, which is considered high, the cut-off level was 1.48. Since subjects in Cameroon were involved in regular strenuous exercise the latter cut-off may be more suitable, especially for subjects from rural Cameroon. In the UK, however, where the physical activity level is expected to be low, a cut-off of 1.15 would be more suitable. Since it may be questioned whether it is justified to use different cut-off levels when comparing populations, we preferred to show the frequency of underreporting for each site, for each cut-off level, separately. It can be seen that, even when comparing the frequency in Cameroon at the highest cut-off level and that in the UK and Jamaica at the lowest cut-off level, the frequency was still much higher in the UK and Jamaica than in Cameroon.

The comparison of the frequency of underreporting of our study with that observed in other studies is difficult. First of all, different cut-off levels for EI/BMR_{est} have been chosen to define underreporting and different methods to assess the habitual diet have been used. Secondly, to the best of our knowledge no studies on underreporting in a non-Western society have been published, which makes comparison of our data in Jamaica and in Cameroon with other studies difficult. Lafay *et al*[5] found a frequency of underreporting of 16% in young to middle-aged French men and women, using a low cut-off level of 1.05. Their unadjusted mean level of EI/BMR_{est} in men and women was very similar to the ones we observed in Manchester. Recently Johansson *et al*[8] observed in a Norwegian dietary survey a frequency of 20% in men and of 25% in women, with a cut-off for EI/BMR ratio of 1.35. Pryer *et al*[9] found much higher frequencies, of almost 50% in men and 30% in women. The frequencies we observed in Cameroon were all lower than those shown in the above-mentioned studies. The observations from Jamaica were close to those from Johansson *et al*[8] when taking a similar cut-off at 1.34, although the frequency in men was higher in our study. The results from the UK resembled those from a study in British subjects.[9]

In a Western society a high energy intake and especially consumption of fat rich foods is considered to be bad for your health and fattening.[21] Consumption of these foods is therefore seen as undesirable according to the norms in this society, where a lean figure is still the ideal.[22] Social desirability, the tendency of an individual to convey an image in keeping with social norms, will play an important role while filling in a questionnaire on the habitual diet.[23] In a Western society this may lead to underreporting of foods considered bad for health and thereby to an underreporting of total energy intake. We may speculate that among our subjects, who were all of African origin, the cultural influence of Western society is lowest in rural Cameroon, somewhat higher in urban Cameroon and Jamaica and highest in the UK, where African-Caribbeans live with likely the strongest 'Westernized' food pressures and media images. This trend in cultural influence coincides with the trend in the frequency of underreporting, which was highest among subjects likely to be largely under the influence of Western society. This association suggests that Westernization is one of the main basic factors underlying the phenomenon of underreporting, which can be tested in other studies.

In conclusion the results of this study support our hypothesis that culture influences the level of dietary underreporting and that Westernization contributes to a high level of underreporting.

Acknowledgements

This work was supported by a grant from the European Union, contract no. TS3*CT92-0142. We are grateful for the financial contribution from the Conseil Régional d'Ile de France and INSERM for the post-doctoral position of Dr Mennen.

References

1 Schoeller DA. Limitations in the assessment of dietary energy intake by self-report. *Metabolism* 1995; 44(Suppl 2): 18–22.
2 Black AE, Goldberg GR, Jebb SA, Livingstone MBE, Cole TJ, Prentice AM. Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *Eur J Clin Nutr* 1991; 45: 583–599.
3 Carter LM, Whiting SJ. Underreporting of energy intake, socioeconomic status, and expression of nutrient intake. *Nutr Rev* 1998; 56: 179–182.
4 Lissner L, Heitmann BL, Lindroos AK. Measuring intake in free-living human subjects: a question of bias. *Proc Nutr Soc* 1998; 57: 333–339.
5 Lafay L, Basdevant A, Charles MA, Vray M, Balkau B, Borys JM, Eschwege E, Romon M. Determinants and nature of dietary underreporting in a free-living population: the Fleurbaix Laventie Ville Santé (FLVS) Study. *Int J Obes* 1997; 21: 567–573.
6 Heitmann BL. The influence of fatness, weight change, slimming history and other lifestyle variables on diet reporting in Danish men and women aged 35–65 years. *Int J Obes* 1993; 17: 329–336.
7 Price GM, Paul AA, Cole TJ, Wadsworth MEJ. Characteristics of the low energy reporters in a longitudinal national dietary survey. *Br J Nutr* 1997; 77: 833–851.
8 Johansson L, Solvoll K, Bjorneboe GEA, Drevon CA. Under- and overreporting of energy intake related to weight status and lifestyle in a nationwide sample. *Am J Clin Nutr* 1998; 68: 266–274.
9 Pryer JA, Vrijheid M, Nichols R, Kiggins M, Elliott P. Who are the 'low energy reporters' in the Dietary and Nutritional Survey of British Adults? *Int J Epidemiol* 1997; 26: 146–153.
10 Heymsfield SB, Darby PC, Muhlheim LS, Gallaher D, Wolper C, Allison DB. The calorie: myth, measurements, and reality. *Am J Clin Nutr* 1995; 62(Suppl): 1034S–1041S.
11 Mbanya JC, Ngogang J, Salah JN, Minkoulou E, Balkau B. Prevalence of NIDDM and impaired glucose tolerance in a rural and an urban population in Cameroon. *Diabetologia* 1997; 40: 824–829.
12 Sharma S, Cade J, Jackson M, Mbanya JC, Shungong S, Forrester T, Bennett F, Wilks R, Balkau B, Cruickshank JK. Development of food frequency questionnaires in three population samples of African origin from Cameroon, Jamaica and Caribbean migrants to the UK. *Eur J Clin Nutr* 1996; 50: 479–486.
13 Holland B, Welch AA, Unwin ID, Buss DH, Southgate PAA. *McCance and Widdowson's The Composition of foods*. The Royal Society of Chemistry: London, 1991.
14 Tan SP, Wenlock RW, Buss DH. *Immigrant Foods: Second supplement to McCance and Widdowson's The composition of foods*. HMSO: London, 1985.
15 Ngo Som J, Abono A. *Les resources alimentaires du Cameroun. Répartition Ecologique, classification et valeur nutritive*. 1989

.on of under-
studies.
y support our
vel of dietary
contributes to

om the Euro-
142. We are
n the Conscil
for the post-

f dietary energy
ppl 2): 18–22.
MBE, Cole TJ,
take data using
: 2. Evaluating
Nutr 1991; 45:

energy intake,
nt intake. Nutr

uring intake in
Proc Nutr Soc

alkau B, Borys
and nature of
ion: the Fleur-
Obes 1997; 21:

: change, slim-
et reporting in
J Obes 1993:

Characteristics
ational dietary

in CA. Under-
ight status and
Nutr 1998; 68:

Elliott P. Who
nd Nutritional
26: 146–153.
ner D. Wolper
s, and reality.

E, Balkau B.
olerance in a
Diabetologia

Shungong S.
ickshank JK.
n three popu-
Jamaica and
ur 1996; 50:

athgate PAA.
of foods. The

ods: Second
mposition of

u Cameroun:
ritive. 1989.

16 Fletcher L. *Microdiet:* University of Salford: Manchester, 1994.
17 Schofield WN, Schofield C, James WPT. Basal metabolic rate. *Hum Nutr Clin Nutr* 1985; 39C(Suppl 1): 1–96.
18 Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, Prentice AM. 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* 1991; 45: 569–581.
19 FAO/WHO/UNU. *Energy and protein requirements. Report of a joint expert consultation.* WHO: Geneva, 1985.
20 Black AE. Physical activity levels from a meta-analysis double labeled water studies for validating energy inta as measured by dietary assessment. *Nutr Rev* 1996: 170–174.
21 Goldberg J. Nutrition and health communication: the messa and the media over half a century. *Nutr Rev* 1992; 50: 71–
22 Drewnowski A. Dietary fats: Perceptions and preferenc *J Am Coll Nutr* 1990; 9: 431–435.
23 Worsley A, Baghurst K, Leitch D. Social desirability respon bias and dietary inventory responses. *Hum Nutr Appl Nu* 1984; 38A: 29–35.

Appendix

Calculation of the cut-off value of the energy intake (EI)/basic metabolic rate (BMR) ratio in weight-stable subjects

The equation for calculating the cut-off value of the EI + BMR ratio is the following:

$$EI/BMR_{est} > TEE/BMR \times \exp[s.d._{min} \times ((S/100)/\sqrt{n})]$$

Where TEE (total energy expenditure)/BMR is the assumed average physical activity level (PAL) for the population under study, which is estimated to be 1.55 for low,[19] 1.78 for mild[20] and 2.00 for regular strenuous physical activity.[19] $s.d._{min}$ is −2 for 95% confidence limits, n is the number of individuals in the group (= 1 in our case as we want to evaluate the reported energy intake for an individual) and the term S includes the inter-individual varation in energy intake and the number of recorded days with a maximum of 28 days. Assuming that the coefficients of variation were 12.5% for inter-individual TEE/BMR,[19] 8% for predicted BMR,[17] and 23% for intra-individual energy in middle-aged subjects,[18] the equation for S becomes:

$$S = \sqrt{(12.5^2 + 8^2 + (23^2/28))} = 15.5\%,$$

and the equation for the cut-off using a low PAL becomes:

$$EI/BMR_{est} > 15.5 \times \exp[-2 \times ((15.5/100)/\sqrt{1})] = 1.15.$$

Using a PAL of 1.78 leads to a cut-off of 1.32 and a PAL of 2.00 to a cut-off of 1.48.