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Meal-based intake assessment tool: relative validity when determining dietary intake of Fe and Zn and selected absorption modifiers in UK men

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A computer-based dietary assessment tool, the meal-based intake assessment tool (MBIAT), is described. In the current study, dietary intakes of Fe and Zn fractions (total Fe, non-haem Fe, haem Fe, meat Fe, total Zn) and dietary components that influence Fe and Zn absorption (vitamin C, phytate, Ca, grams of meat/fish/poultry, black tea equivalents, phytate:Zn molar ratio) were assessed. The relative validity of the MBIAT was determined in forty-eight UK men aged 40 years and over by comparing its results with those from weighed diet records collected over 12 d. There was good agreement between the MBIAT and the weighed diet records for median intakes of total, non-haem, haem and meat Fe, Zn, vitamin C, phytate, grams of meat/fish/poultry and phytate:Zn molar ratio. Correlations between the two methods ranged from 0·32 (for Ca) to 0·80 (for haem Fe), with 0·76 for total Fe and 0·75 for Zn. The percentage of participants classified by the MBIAT into the same/opposite weighed diet record quartiles ranged from 56/0 for Fe and 60/0 for Zn to 33/10 for Ca. The questionnaire also showed an acceptable level of agreement between repeat administrations (e.g. a correlation for total Fe of 0·74). In conclusion, the MBIAT is appropriate for assessing group dietary intakes of total Fe and Zn and their absorption modifiers in UK men aged 40 years and over.

Iron: Zinc: Dietary intake: Dietary assessment

The three ‘classic’ methods for assessing dietary intake over a period of time – diet record, diet history and food-frequency questionnaire – all pose problems when used as research tools in a population setting. The diet record has a high respondent burden and requires considerable resources to administer and analyse. The diet history, in its traditional form, requires a skilled interviewer and gives qualitative rather than quantitative dietary information. The food-frequency questionnaire requires considerable cognitive skills on the part of the respondent, who must recall multiple situations in which a particular food is eaten and convert these to the frequencies with which individual foods are consumed. The food-frequency questionnaire must also use a limited food list to make it possible for the participant to respond to frequency questions on each food in the questionnaire.

The computerised meal-based intake assessment tool (MBIAT) described in the present paper was designed to generate quantitative dietary data while incurring a considerably lower respondent burden than a diet record, as well as to collect information on habitual dietary intake by meal rather than by food, so that participants were able to report their food intake as they recalled it, the burden of calculation being borne by the researcher. The tool allows participants access to a food list that is as limited or as extensive as the researcher chooses.

The version of the MBIAT tested in this paper used a food list designed to investigate the dietary intake of Fe and Zn and their absorption modifiers in UK men aged 40 years and over. These nutrients were chosen because Fe and Zn have a moderately high intra-individual variation in intake so require multiple days of diet recording to generate data on usual intake (e.g. 12 d for Fe; Bingham, 1987). It has been claimed that high Fe status may increase the risk of chronic diseases such as CHD (Salonen *et al.* 1992), and although this hypothesis is controversial (Heath & Fairweather-Tait, 2003), it is important to assess Fe intake in any study evaluating Fe status. One such study is the Iron in Men Project, in which the relationship between dietary Fe and genotype, and Fe absorption and status, is being investigated in 140 UK men aged 40 years and over. Older men are likely to have a higher Fe status because of their higher energy (and hence Fe) intakes, and lower Fe losses, but they are also a population who may be less likely to shop for or prepare their own food, and they may therefore have particular difficulty with both weighed record and memory-based dietary assessment methods.

The present paper describes the development and validation of a research tool to assess the intake of total Fe, non-haem Fe, haem Fe, meat Fe, vitamin C, phytate, Ca, grams of meat/fish/poultry, black tea equivalents, total Zn and phytate:Zn molar ratio in men aged 40 years and over.

Materials and methods

Participants

Forty-nine healthy male volunteers aged 40 years and over were recruited through local advertisements to take part in the study. Potential volunteers were initially screened by telephone to exclude those with chronic or acute illness that might affect Fe intake or status (because the volunteers were also taking part

Abbreviations: MBIAT, meal-based intake assessment tool; WDR, weighed diet record.

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in a study to investigate the genetic, dietary and lifestyle predictors of Fe status), or those taking regular medication that could affect Fe absorption (because some volunteers would participate in a parallel study investigating Fe absorption in relation to genotype and Fe status).

Study design

Habitual dietary intake of total Fe, non-haem Fe, haem Fe, meat Fe, vitamin C, phytate, Ca, grams of meat/fish/poultry, black tea equivalents, total Zn and phytate:Zn molar ratio were estimated using the MBIAT and weighed diet record (WDR). Participants were randomised to one of two groups in order to evaluate potential training effects in their responses to the different dietary assessment methods. Group A completed the assessment tools in the following order: MBIAT, WDR (immediately after MBIAT), repeat MBIAT (1 month after completion of WDR). Group B completed the assessment tools in the following order: WDR, MBIAT (1 month after completion of WDR), repeat MBIAT (1 month after completion of first MBIAT). Both groups completed the MBIAT a third time, 6 months after the first MBIAT administration, in order to assess the stability of Fe intake across seasons in this population.

Meal-based intake assessment tool

The MBIAT was based on an existing computerised Fe intake assessment tool (Heath *et al.* 2000) that had previously been validated for use in New Zealand women aged 18–40 years. The MBIAT was modified to include foods consumed in the UK and to be administered by personal computer rather than Macintosh computer, and was interviewer-administered. The computer format allowed: (1) data on food frequency and amount to be collected by participant-defined meals, rather than by individual food; (2) an extensive food list to be made available to participants to describe their dietary intake; (3) context-sensitive portion size estimation questions to be embedded in the questionnaire; (4) participants to oversee the entry of their reported meals, minimising researcher coding and entry errors.

Participants began the MBIAT by recalling the number of times per week they ate breakfast, lunch and dinner meals, and morning, afternoon and evening snacks (overall meal frequency).

Participants were then asked to describe the meals and snacks they had eaten during the past month (individual meals), using a list of 630 foods sorted into sixteen food groups. They were asked to describe the serving size for each food as multiples and proportions of common standard measures (e.g. cups of coffee, slices of bread). Three-dimensional food models were provided for meats, cheese, pizza, slices of cake and potato chips, and dried beans and plates were used to assist in volume estimation. As they completed each individual meal, participants were asked to report an exact frequency of consumption for that particular meal per week (individual meal frequency).

When participants had recalled as much of their ‘usual’ intake as they could remember, they were shown a checklist of sixty-two foods that could make an important contribution to the intake of Fe, Zn or their absorption modifiers. Where any of these food items had been ‘missed’, they were added into the individual’s MBIAT as new meals or additions to meals already entered.

Finally, participants were shown their original overall meal frequency responses and asked to confirm or correct them.

An earlier study of a similar Fe intake assessment tool suggested that participants are able to estimate the relative frequency of consumption of meals better than the absolute frequency of their consumption, and concluded that an adjustment factor should be used to account for this effect (Heath *et al.* 2000). Therefore, an adjustment factor was calculated for each meal and snack category:

$$\text{adjustment factor} = \text{overall meal frequency}/(\Sigma\,\text{individual meal frequencies}),$$

so that the ‘adjusted’ nutrient intakes were calculated:

$$\text{‘adjusted’ nutrient intake breakfast A} = \text{individual meal frequency breakfast A} \times \text{breakfast adjustment factor} \times \text{nutrient intake breakfast A}.$$

‘Unadjusted’ nutrient intakes were calculated using the individual meal frequencies alone.

An extensive food list was developed to ensure that the researchers’ preconceptions did not influence the foods that participants were able to report having consumed. The food list comprised the fifth edition of the *UK Food Composition Tables* (Holland *et al.* 1991*b*) and supplements to the fourth and fifth editions (Holland *et al.* 1988, 1989, 1991*a*, 1992*a*,*b*, 1993; Chan *et al.* 1994, 1995, 1996) with the following deletions: (1) culturally specific foods unlikely to be consumed by men aged 40 years and over living in Norfolk; (2) specific varieties when a generic food was available; (3) foods with a negligible content of the food components of interest (e.g. fats).

The average daily intake of each dietary component was analysed using a Microsoft Excel-based computer program (MBIAT version 4.2 available from Mark Roe, Institute of Food Research, Norwich Research Park, Colney Lane, Norwich NR4 7UA, UK; marka.roe@bbsrc.ac.uk) that calculated the sum of the products of the nutrient content of the foods in each meal and the individual meal frequencies, for example:

Fe intake per d = [(Σ Fe content of foods in breakfast 1) × (individual meal frequency for breakfast 1)/7)] + [(Σ Fe content of foods in breakfast 2) × (individual meal frequency for breakfast 2)/7)] + ...

The nutrient content of the foods in each meal was calculated as:

nutrient content of food = (food consumed (g)/100) × nutrient content/100 g food.

The food composition data for total Fe, Zn, vitamin C and Ca were compiled using the *UK Food Composition Tables* and supplements (Holland *et al.* 1988, 1989, 1991*a*,*b*, 1992*a*,*b*, 1993; Chan *et al.* 1994, 1995, 1996). Meat/fish/poultry values were calculated as animal tissue in 100 g edible portion of food. Haem Fe was calculated as the product of meat Fe and the proportion of haem Fe in the specific meat using values from the literature (Rangan *et al.*, 1997; Hallberg & Hulthén, 2000). Non-haem Fe was the difference between haem Fe and total Fe. Meat Fe was calculated as the product of the total Fe content per 100 g specific meat(s) in the food and the meat/fish/poultry value of the food expressed as a proportion. Therefore, meat Fe was equal to total Fe both for foods with a meat/fish/poultry value of 100 g/100 g and for foods with all their Fe coming from meat. Phytate values were based on published data (Harland & Oberleas, 1987; Holland *et al.*, 1988, 1991*a*, 1992*a*,*b*; Bunch & Murphy, 1996).

Phytate values of foods of similar composition were used when phytate values could not be found in the literature. Black tea equivalents were calculated as follows: a value of 100 was assigned to 100 g black tea infusion. Other beverages with an appreciable content of tannins were assigned a proportion of this figure according to their inhibitory effect on Fe absorption compared with black tea (Morck *et al.*, 1983; Cook *et al.*, 1995; Hurrell *et al.*, 1999). The phytate:Zn molar ratio was calculated by: (1) dividing the mg phytic acid by 660 (the molecular weight of the phytate ion) and the mg Zn by 65·4 (the atomic weight of Zn); (2) dividing the mmol of phytic acid by the mmol Zn (Oberleas & Harland, 1981). For composite dishes, phytate and meat/fish/poultry content was estimated using recipes published with the *UK Food Composition Tables* and supplements (Holland *et al.*, 1988, 1989, 1991*a*,*b*, 1992*a*,*b*, 1993; Chan *et al.*, 1994, 1995, 1996), online recipe books (primarily www.recipesource.com) or manufacturer's information (primarily via www.tesco.com).

Weighed diet record – reference method

The WDR was chosen as the reference method because it has a high level of accuracy when validated using 24 h urinary N as a biological marker for protein (Bingham *et al.*, 1995) and because, unlike the MBIAT, it does not depend on memory, is open-ended and involves the direct measurement of portion size. WDR were collected for 12 d, enabling an estimation of a person's total Fe intake to within 10 % of their mean habitual intake (Bingham, 1987). Participants were asked to complete their weighed record on 12 specified days, divided into four blocks of 3 consecutive days (to minimise recording fatigue) and including 4 weekend days (to allow for the weekend effect), over a period of 5 weeks. Participants were provided with electronic scales (Salter; Tonbridge, Kent; maximum weight 2 kg, accurate to $\pm 0{\cdot}1\%$) and instructions on how to use the scales and when and how to complete their WDR. Following completion of the WDR, researchers checked the record with the participant for completeness.

The WDR were coded, entered on the Diet Cruncher nutritional analysis program (Way Down South Software, Dunedin, New Zealand; www.waydownsouthsoftware.com), checked by a nutritionist and then analysed using the same Diet Cruncher program. Where amounts were estimated, they were calculated using values derived from Ministry of Agriculture Fisheries and Food data (1993). The food list and food composition data for the program were based on the *UK Food Composition Tables* and supplements (Holland *et al.*, 1988, 1989, 1991*a*,*b*, 1992*a*,*b*, 1993; Chan *et al.*, 1994, 1995, 1996) with data on grams of meat/fish/poultry, haem Fe, non-haem Fe, meat Fe, phytate and black tea equivalents added as for the MBIAT database.

Statistical analyses

SPSS for Macintosh Version 10.0.7a was used to carry out all the statistical analyses. Because the majority of nutrients were not normally distributed, medians and 25th and 75th percentiles are reported, and non-parametric tests were carried out, for instance Spearman's rank correlation coefficients to measure associations, and Wilcoxon matched-pairs signed-rank tests to determine statistical confidence in the differences. Two-sided significance levels are quoted.

Agreement between the WDR and the MBIAT at an individual level was assessed using mean difference and standard deviation of the difference (Bland & Altman, 1986).

Individual results for nutrient intake estimated by the WDR and the MBIAT were classified into quartiles to assess the MBIAT's ability to assign individuals to the same quartile of intake as the WDR. The following percentages were calculated: percentage correctly classified into the same quartiles, percentage correctly classified to within one adjacent quartile, percentage correctly classified into the extreme quartiles (Q1 or Q4), and percentage grossly misclassified (classified into opposite quartiles). 'Actual values for surrogate categories' (Willett, 1990) were calculated as follows: participants were assigned to quartiles according to nutrient intake estimated by the MBIAT, and then the mean nutrient intake in each quartile was calculated using intake determined by the WDR method. This gives an indication of the 'true' (i.e. WDR) intakes that are indicated by the MBIAT intake quartiles. One-way ANOVA with Tukey's honestly significant difference was used to determine whether differences between the quartiles were statistically significant.

The reproducibility of the MBIAT was assessed using the Wilcoxon matched-pairs signed-rank test to determine whether there was a significant difference between the nutrient intakes reported in the first and second, or first and third, MBIAT administrations.

To assess possible training effects, the association between the first or third MBIAT and the WDR were compared between group A and group B by transforming both correlation coefficients using the Fisher *r*-to-Z transformation, computing the Z test for the equality of the two correlations and then evaluating the Z value against a standard normal distribution for statistical significance (www.utexas.edu/its/rc/answers/general/gen26.html).

Ethical considerations

Participants were sent an information sheet explaining the study to read before their first appointment. The study was then explained in detail to each participant during a visit to the Human Nutrition Unit at the Institute of Food Research (Norwich, UK), when participants were given an opportunity to have their questions answered, and written informed consent was obtained. The study was approved by the Norwich District Ethics Committee.

Results

Data are presented for forty-eight of the forty-nine participants recruited into the study (98 %). One person did not complete the WDR and was excluded. The participants were aged 46 to 75 years (mean 61 (SD 8) years).

Median Fe and Zn intakes from the WDR and from the adjusted MBIAT were not significantly different (Table 1). There were also no significant differences between the median intakes of non-haem Fe, haem Fe, meat Fe, vitamin C, phytate, grams of meat/fish/poultry or phytate:Zn molar ratio between the two methods (Table 1). However, differences between the median intakes of Ca and black tea equivalents between the two methods were significant (Table 1).

The mean difference between the Fe intakes reported in the WDR and the adjusted MBIAT was 0·5 (SD 3·6) mg (Table 1). Therefore, an individual's MBIAT Fe intake was likely to fall between 6·7 mg below (mean difference −2 SD) and 7·7 mg above (mean difference +2 SD) their WDR intake. The mean

Table 1. Dietary intakes of Fe and Zn, and absorption enhancers and inhibitors, estimated by weighed diet record (WDR) and Meal-Based Intake Assessment Tool (MBIAT)

	MBIAT										WRD					Difference‡	
	Unadjusted					Adjusted†											
	Median	25th percentile	75th percentile	Mean	SD	Median	25th percentile	75th percentile	Mean	SD	Median	25th percentile	75th percentile	Mean	SD	Mean	SD
Total Fe (mg)	16·5	13·6	19·2	17·0	5·7	15·4	12·7	19·1	16·0	4·7	16·5	14·3	18·3	16·5	3·5	0·5	3·6
Non-haem Fe (mg)	15·5	12·2	17·8	15·9	5·7	14·6	11·1	17·9	15·0	4·8	15·6	13·2	17·3	15·4	3·3	0·4	3·5
Haem Fe (mg)	1·1	0·7	1·4	1·1	0·6	1·0	0·7	1·3	1·0	0·5	1·1	0·7	1·4	9·1	0·7	0·1	0·4
Meat Fe (mg)	2·0	1·2	2·8	2·1	1·2	2·0	1·3	2·4	2·0	1·1	1·9	1·2	2·6	2·1	1·5	0·1	0·8
Vitamin C (mg)	94	71	144	119	84	93	68	123	110	73	100	66	152	112	56	2·0	53·0
Phytate (mg)	1412	994	1921	1513	825	1328	918	1876	1436	755	1374	855	1707	1366	559	70·0	460·0
Ca (mg)	1013	858	1365	1084	348	957*	838	1234	1016	286	1044	936	1262	1116	240	100·0	335·0
Meat/fish/ poultry (g)	126	102	189	145	62	128	99	171	138	54	134	108	177	141	56	3·0	42·0
Black tea equivalents (g)	823	548	1355	918	540	776*	570	1211	847	463	964	642	1292	990	486	143·0	433·0
Zinc (mg)	11·07	9·83	15·73	12·37	4·75	10·80	9·31	13·15	11·42	2·89	11·5	10·00	12·65	11·72	2·43	-0·3	2·1
Phytate:Zn molar ratio	11·50	8·10	15·50	12·11	5·28	11·64	8·24	15·07	12·18	5·13	11·03	8·62	14·64	11·69	4·74	0·5	34

* Mean values were Significant different between the adjusted MBIAT and the WDR (Wilcoxon: $P \leq 0{\cdot}05$).

† Individual meal frequencies adjusted using participant-reported overall meal frequency so that the sum of adjusted individual meal frequencies was equal to the participant-reported overall meal frequency.

‡ Mean difference between the adjusted MBIAT and the WDR.

difference between the Zn intakes reported in the WDR and the adjusted MBIAT was −0·3 mg (SD 2·1; Table 1). Therefore, an individual's MBIAT Zn intake was likely to fall between 4·5 mg below (mean difference −2 SD) and 3·9 mg above (mean difference +2 SD) their WDR intake.

Adjusted MBIAT dietary component intakes had considerably higher correlations with the WDR intakes than the unadjusted intakes (Table 2).

Table 3 summarises the extent of correct classification of the MBIAT dietary component intakes into WDR quartiles. The MBIAT classified 56 % of people into the correct quartile for total Fe intake and 60 % into the correct quartile for Zn intake, with no individuals being grossly misclassified. Similar results were achieved for non-haem Fe, meat Fe, phytate, grams of meat/fish/poultry and phytate:Zn molar ratio (with no participants grossly misclassified). The MBIAT grossly misclassified the haem Fe intake of just one participant (i.e. 2%). Whereas the MBIAT correctly classified a lower percentage of vitamin C and black tea equivalents intakes (44 and 48, respectively), no vitamin C intakes, and only 4% (*n* 2) of black tea equivalent intakes, were grossly misclassified. However, this version of the MBIAT did not classify Ca intakes well, with only 33% of participants correctly classified and 10% grossly misclassified.

Actual values for surrogate categories show the expected stepwise increase for total Fe, non-haem Fe, haem Fe, meat Fe, vitamin C, phytate, grams of meat/fish/poultry, black tea equivalents, Zn and phytate:Zn molar ratio, but not for Ca. The MBIAT clearly differentiated between the first and fourth quartiles for all the dietary components assessed except Ca (Table 4).

All participants completed the MBIAT on a second occasion to assess the questionnaire's reproducibility. There was no significant difference between the median dietary component intake assessed at the two administrations, except for phytate (although the correlation between the two administrations for phytate was 0·86) (Table 5). The correlation coefficient between the two administrations ranged from 0·64 for Zn to 0·87 for the phytate:Zn ratio, with a correlation of 0·74 for total Fe (Table 5).

All participants completed the MBIAT a third time, 6 months (mean 24 weeks) after the first MBIAT was administered, to investigate seasonal effects. There was no significant difference between the median dietary component intake assessed at the first and third administrations, except for the phytate:Zn molar ratio (Table 6). The correlation coefficient between the first and third administrations ranged from 0·62 for vitamin C to 0·79 for grams of meat/fish/poultry, with a correlation of 0·75 for total Fe and 0·73 for Zn (Table 6).

Table 2. Spearman's correlation coefficients between the meal-based intake assessment tool (MBIAT) and the weighed diet record (WDR)

	Correlation between WDR and:	
	Adjusted* MBIAT	Unadjusted MBIAT
Total Fe	0·76	0·66
Non-haem Fe	0·76	0·70
Haem Fe	0·80	0·63
Meat Fe	0·79	0·61
Vitamin C	0·63	0·66
Phytate	0·78	0·79
Ca	0·32	0·32
Meat/fish/poultry	0·73	0·66
Black tea equivalents	0·67	0·70
Zn	0·75	0·66
Phytate:Zn molar ratio	0·80	0·75

* Individual meal frequencies adjusted using participant-reported overall meal frequency so that the sum of adjusted individual meal frequencies was equal to the participant-reported overall meal frequency.

When the correlations between the first MBIAT and the WDR for group A (*n* 23, order of administration MBIAT–WDR–MBIAT) were compared with those for group B (*n* 25, order of administration WDR–MBIAT–MBIAT), there was a significant difference between the groups for phytate, black tea equivalents and phytate:Zn molar ratio. When the correlations between the third MBIAT and the WDR for group A were compared with those for group B, only the correlations for phytate remained significantly different.

Discussion

The MBIAT can estimate group median intakes well for total, non-haem, haem and meat Fe, and vitamin C, phytate, grams of meat/fish/poultry, Zn and phytate:Zn molar ratio. At a group level, it correctly classifies intake of Fe and Zn, and most of their dietary absorption modifiers, to within one adjacent quartile

Table 3. Cross-classification of adjusted meal-based intake assessment tool (MBIAT) and weighed diet record (WDR) quartiles (proportion (95% CI for the proportion))

	Correctly classified (%)		Classified to within one adjacent quartile (%)		Correctly classified to extreme quartiles (%)		Grossly misclassified (%)
Chance	25	25th percentile, 75th percentile	63	25th percentile, 75th percentile	13	25th percentile, 75th percentile	13
Total Fe (mg)	56	42, 70	94	87, 100	38	24, 52	0
Non-haem Fe (mg)	54	40, 68	92	84, 100	38	24, 52	0
Haem Fe (mg)	56	42, 70	92	84, 100	33	20, 46	2 (0, 6)
Meat Fe (mg)	60	46, 74	90	82, 98	35	22, 48	0
Vitamin C (mg)	44	30, 58	85	75, 95	31	18, 44	0
Phytate (mg)	52	38, 66	90	82, 98	31	18, 44	0
Ca (mg)	33	20, 46*	77	65, 89	17	6, 28*	10 (2, 18)*
Meat/fish/poultry (g)	52	38, 66	90	82, 98	33	20, 46	0
Black tea equivalents (g)	48	34, 62	85	75, 95	27	14, 40	4 (0, 10)
Zn (mg)	60	46, 74	90	82, 98	35	22, 48	0
Phytate:Zn molar ratio	52	38, 66	94	87, 100	33	20, 46	0

* Not significantly different from chance.

Table 4. Nutrient intake assessed by weighed diet record (WDR) for participants classified by adjusted meal-based intake assessment tool (MBIAT) and WDR

	Quartiles defined by:	Mean WDR intake Q1	Q2	Q3	Q4	Significant* differences
Total Fe (mg)	MBIAT	12·7	16·1	17·2	20·0	Q1 *v.* Q2, Q3, Q4
	WDR	12·4	15·3	17·5	20·8	
Non-haem Fe (mg)	MBIAT	11·9	15·0	16·0	18·6	Q1 *v.* Q2, Q3, Q4
	WDR	11·3	14·3	16·4	19·5	
Haem Fe (mg)	MBIAT	0·53	0·97	1·2	1·8	Q1 *v.* Q3, Q4
	WDR	0·42	0·90	1·2	2·0	
Meat Fe (mg)	MBIAT	0·87	1·7	2·2	3·6	Q1 *v.* Q3, Q4
	WDR	0·74	1·6	2·2	3·9	
Vitamin C (mg)	MBIAT	64	107	112	163	Q1 *v.* Q4
	WDR	50	90	117	189	
Phytate (mg)	MBIAT	789	1292	1575	1807	Q1 *v.* Q2, Q3, Q4
	WDR	706	1143	1542	2073	
Ca (mg)	MBIAT	1098	963	1155	1248	
	WDR	832	982	1160	1489	
Meat/fish/poultry (g)	MBIAT	80	138	152	193	Q1 *v.* Q2, Q3, Q4
	WDR	74	123	153	213	
Black tea equivalents (g)	MBIAT	585	966	1148	1259	Q1 *v.* Q3, Q4
	WDR	431	790	1135	1602	
Zn (mg)	MBIAT	9·4	11·4	12·0	14·1	Q1 *v.* Q3, Q4
	WDR	9·1	10·8	11·.9	14·9	
Phytate:Zn molar ratio	MBIAT	6·8	10·9	12·8	16·3	Q1 *v.* Q2, Q3, Q4
	WDR	6·3	9·6	13·0	17·8	

* Mean values were significantly different between the stated quartiles (ANOVA; *$P \leq 0·05$).

Table 5. Comparison of intakes of Fe and Zn, and absorption enhancers and inhibitors, for repeat (first and second) administrations of the adjusted meal-based intake assessment tool (MBIAT)

(Median (25th, 75th percentile))

	First MBIAT Median, 25th percentile & 75th percentile	Second MBIAT Median, 25th percentile & 75th percentile	Difference Mean	Difference SD	Correlation
Total Fe (mg)	15·4 12·7, 19·1	14·.9 13·1, 17·6	0·29	2·9	0·74
Non-haem Fe (mg)	14·5 11·1, 17·9	14·1 12·2, 16·6	0·33	2·.8	0·77
Haem Fe (mg)	1·0 0·7, 1·3	1·0 0·6, 1·3	−0·038	0·51	0·70
Meat Fe (mg)	2·0 1·3, 2·4	1·8 1·2, 2·5	−0·031	1·1	0·72
Vitamin C (mg)	93 68, 123	91 63, 124	5	56	0·65
Phytate (mg)	1328 918, 1876	1153 840, 1694*	129	402	0·86
Ca (mg)	957 838, 1234	978 782, 1256	−22	248	0·66
Meat/fish/poultry (g)	128 99, 171	139 92, 171	−5	42	0·81
Black tea equivalents (g)	776 570, 1211	709 467, 1093	61	295	0·86
Zn (mg)	10·8 9·3, 13·1	11·0 9·4, 12·7	0·20	2·1	0·64
Phytate:Zn molar ratio	11·6 8·2, 15·1	11·1 8·1, 14·8	0·55	2·5	0·87

* Mean values were significantly different between the first and second administration (Wilcoxon; *$P \leq 0·05$).

for more than 90% of participants. Although its performance is poorer for Ca, it is able to classify individuals' Ca intake correctly to within one quartile 77% of the time. Our correlations of 0·6–0·9 for dietary component intakes between two administrations of the questionnaire suggest that the MBIAT is as reproducible as multiple sets of diet records (Hartman *et al.*, 1990). However, the large standard deviation of the mean difference between intakes assessed by the two methods suggest that the questionnaire is of limited use for estimating intake in individuals. The improvement in MBIAT performance when data are adjusted using participant-reported overall meal frequency confirms the finding that participants in diet studies are able to estimate the relative frequency of consumption of foods better than they can estimate absolute frequency of consumption (Heath *et al.*, 2000; Matthys *et al.*, 2004).

The performance of the MBIAT in estimating dietary Fe and Zn intake in this population exceeded the recommendations recently proposed by Masson *et al.* (2003): 'Spearman correlation coefficients above 0·5, more than 50% of subjects correctly classified and less than 10% of subjects grossly misclassified into thirds, and weighted kappa values above 0·4 are recommended for nutrients of interest in epidemiological studies'. Spearman correlation coefficients between the MBIAT and WDR were 0·76 and 0·75 for Fe and Zn respectively, the Fe intakes of 56% of participants and the Zn intakes of 60% of participants were classified to the correct quartile, no participants were grossly misclassified for either

Table 6. Comparison of intakes of Fe and Zn, and absorption enhancers and inhibitors, for repeat (first and third) administrations of the adjusted meal-based intake assessment tool (MBIAT)

(Median, 25th, 75th percentile)

	First MBIAT Median, 25th percentile & 75th percentile	Third MBIAT Median, 25th percentile & 75th percentile	Difference		Correlation
			Mean	SD	
Total Fe (mg)	15·4 12·7, 19·1	14·5 12·9, 18·5	−0·17	3·4	0·75
Non-haem Fe mg	14·5 11·1, 17·9	13·4 11·8, 17·3	−0·16	3·4	0·76
Haem Fe mg	1·0 0·7, 1·3	1·0 0·6, 1·3	−0·012	0·39	0·71
Meat Fe mg	2·0 1·3, 2·4	1·9 1·2, 2·5	−0·019	0·81	0·70
Vitamin C mg	93 68, 123	91 67, 132	2	62	0·62
Phytate mg	1328 918, 1876	1366 755, 1617	167	567	0·67
Ca mg	957 838, 1234	1017 819, 1184	−27	226	0·69
Meat/fish/poultry g	128 99, 171	128 98, 163	2	43	0·79
Black tea equivalents g	776 570, 1211	749 459, 1130	1	324	0·75
Zn mg	10·8 9·3, 13·1	10·7 9·8, 13·4	−0·06	2·1	0·73
Phytate:Zn molar ratio	11·6 8·2, 15·1	11·4 8·6, 13·8*	1·09	3·6	0·75

* Mean values were significantly different between the first and third administration Wilcoxon; * $P \leq 0·05$.

Fe or Zn, and κ values were 0·41 for Fe and 0·47 for Zn. Willett (2001) has proposed a ‘ceiling’ of validity at correlations of 0·7. The MBIAT exceeded this ceiling for its principal nutrients of interest, total Fe (0·76) and Zn (0·75). It is likely that this was achieved because, unlike a traditional food frequency questionnaire, the MBIAT allows participants to choose from an extensive food list (630 foods available) and determine their own portion size, so it is better able to capture the ‘inherent complexity of diet that cannot be fully captured by a structured questionnaire’ (Willett, 2001).

Interestingly, this application of the MBIAT also performed better than either of the earlier New Zealand (Heath *et al.*, 2000) or Belgian (Matthys *et al.*, 2004) versions, which reported correlation coefficients between the tested and reference methods of 0·52 (Heath *et al.*, 2000) and 0·45 (Matthys *et al.*, 2004), respectively, for Fe (MBIAT =0·76). The percentage of participants classified by the MBIAT into the same/opposite WDR quantile for Fe was also better for this administration of the MBIAT (56/0) when compared with either the New Zealand (43/4) or Belgian (38/6) version. There are a number of possible reasons for these differences. For any memory-based dietary method, the ability of the participant to give valid responses will be influenced by three key factors: (1) the extent to which the participant understands, and attends to, the task required; (2) the extent to which the participant’s ability to remember past food habits is supported by the form of the questionnaire; (3) the extent to which the research method is able to capture the intake of foods that contribute to the intake of the nutrient of interest.

We can compare the three versions of the questionnaire under these headings. (1) In contrast to the MBIAT, both earlier versions of the questionnaire were self-administered (although there were researchers available to provide support while the questionnaire was being completed). Participants in the earlier studies appeared to have a full understanding of how to complete the questionnaire, but it is likely that, in the current study, the interviewer played an important role as a motivator for participants to provide a greater level of detail in their answers. (2) All three versions used the same meal-based format to elicit dietary information, so it is unlikely that differences in the participants’ recall of past eating events explains the differences in questionnaire performance (particularly since it is often considered that men have a poorer memory for food intake than women; Krall *et al.*, 1988). (3) The MBIAT made full use of the computer interface to access an extensive food list of 630 foods, in contrast to the earlier New Zealand (206 foods) and Belgian (209 foods) versions, so that the interviewers seldom found that they were unable to enter a food that had been reported by a participant (apart from fats and sugars). The better performance of the MBIAT may therefore be explained by the extensive food list used, and by the increased understanding or motivation provided by a one-to-one interview.

However, the MBIAT appeared to estimate Ca intake poorly when compared with the WDR. An investigation of the five participants grossly misclassified by the MBIAT suggests two explanations for this poor agreement: (1) true dietary change; (2) difficulty estimating cheese intake. For two of the five grossly misclassified participants, the lack of agreement between the MBIAT and the WDR probably reflects true changes in intake, since these participants reported consuming milk with beverages in their WDR, but not in the MBIAT. This is unlikely to be due to memory lapse because a prompt asking whether anything was consumed with beverages was used when the MBIAT was administered. Moreover, these participants reported no intake of at least one other dairy product in the MBIAT that had appeared in substantial amounts in the WDR. Both participants were obese (BMI $>30\,kg/m^2$), and these changes are consistent with the Atkins diet, which was a popular weight-loss diet at the time. For two of the other grossly misclassified participants, almost 200 mg of the MBIAT Ca overestimate (44 and 36% of the overestimate) could be accounted for by a substantially higher reported cheese intake. It is likely that inaccurate recall of cheese intake accounts for much of the discrepancy between Ca intakes in the MBIAT and in the WDR because cheese is such a rich source of Ca (cheddar cheese contains 740 mg Ca per 100 g). Whereas a Ca-specific questionnaire is able to ask multiple questions about cheese intake in different settings (e.g. sliced, grated, spread, in recipes), the MBIAT required participants to report the amounts of cheese eaten in multiples or proportions of a single food model (a slice of cheese). Also, the New Zealand (Heath *et al.*, 2000) and Belgian (Matthys *et al.*, 2004) versions of the MBIAT reported much closer agreement with WDR data for Ca intake in women (correlations of r 0·47 and r 0·52, respectively, *v.* r 0·32 for the current study), and this may reflect a comparative lack of awareness of the presence of cheese in baked goods and recipes among this population of middle-aged and elderly men.

To test whether the order of MBIAT and WDR completion affected the relationship between the MBIAT and the reference method, twenty-three participants were randomly assigned to complete their first MBIAT before the WDR (group A) and twenty-five participants were randomly assigned to complete the MBIAT 1 month after finishing the WDR (group B). Group B demonstrated significantly higher correlations between the first MBIAT and the WDR than group A for phytate, phytate:Zn molar ratio and black tea equivalents. There are three possible explanations for this: (1) there was a training effect whereby completing the WDR 1 month before completing the MBIAT improved the ability to estimate phytate and black tea equivalent intake; (2) the participants randomised to group B were better at estimating the intake of these food components than those in group A; (3) there was a greater range in intakes in group B, resulting in higher correlation coefficients. There is evidence that at least some of the difference between the correlation coefficients for groups A and B results from factors other than a training effect. First, both groups completed a third MBIAT 5–6 months after the WDR. Group B participants maintained a significantly higher correlation for phytate between the MBIAT and the WDR even though any training effect would be expected to be similar for group A participants since they had also completed their WDR before this third administration. Second, group B participants had a substantially wider range of intakes, as assessed by the WDR, than group A: 64% wider for phytate and 47% wider for black tea equivalents.

To test whether there was any difference in the intake of Fe, Zn or their absorption modifiers across seasons in this population, the MBIAT was administered a third time, 6 months after the first MBIAT. The only significant difference between the first and third MBIAT was for phytate:Zn molar ratio. This suggests that the intake of food components of interest was stable across seasons, since an earlier version of the MBIAT was able to demonstrate significant changes in diet in adult New Zealand women undergoing a dietary intervention that resulted in changes in Fe status (Heath *et al.*, 2001).

In conclusion, the MBIAT has a lower respondent burden than the WDR, and because the data are entered directly during the interview, it generates fewer researcher errors and saves substantial coding and entry time. Our analysis of group medians and the correlations between the questionnaire and the WDR suggests that the MBIAT is appropriate for assessing group nutrient intakes and ranking individuals' intakes of the tested nutrients. The MBIAT is an appropriate research method for assessing group dietary intakes of total Fe and Zn and their absorption modifiers in UK men aged 40 years and over. Different food lists could be used to enable the MBIAT to estimate the intake of other nutrients in other population groups.

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References

Bingham S (1987) The dietary assessment of individuals: methods, accuracy, new techniques and recommendations. *Nutr Abstr Rev Ser Hum Exp* **57**, 705–742.

Bingham S, Cassidy A, Cole T, *et al.* (1995) Validation of weighed records and other methods of dietary assessment using the 24h urine nitrogen technique and other biological markers. *Br J Nutr* **73**, 531–550.

Bland J & Altman D (1986) Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* **1**, 307–310.

Bunch S & Murphy S (1996) *World Food Dietary Assessment System*. Version 2.0. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/infoods/software_worldfood_en.stm (accessed 4 November 2003).

Chan W, Brown J & Buss D (1994) *Miscellaneous Foods: Fourth Supplement to the 5th Edition of McCance and Widdowson's The Composition of Foods*. Cambridge: Royal Society of Chemistry.

Chan W, Brown J, Church S & Buss D (1996) *Meat Products and Dishes: Sixth Supplement to the 5th Edition of McCance and Widdowson's The Composition of Foods*. Cambridge: Royal Society of Chemistry.

Chan W, Brown J, Lee S & Buss D (1995) *Meat, Poultry and Game: Fifth Supplement to the 5th Edition of McCance and Widdowson's The Composition of Foods*. Cambridge: Royal Society of Chemistry.

Cook J, Reddy M & Hurrell R (1995) The effect of red and white wines on nonheme-Fe absorption in humans. *Am J Clin Nutr* **61**, 800–804.

Hallberg L & Hulthén L (2000) Prediction of dietary Fe absorption: an algorithm for calculating absorption and bioavailability of dietary Fe. *Am J Clin Nutr* **71**, 1147–1160.

Harland B & Oberleas D (1987) Phytate in foods. *World Rev Nutr Diet* **52**, 235–259.

Hartman A, Brown C, Palmgren J, Pietinen P, Verkasalo M, Myer D & Virtamo J (1990) Variability in nutrient and food intakes among older middle-aged men: implications for design of epidemiologic and validation studies using food recording. *Am J Epidemiol* **132**, 999–1012.

Heath A, Skeaff C & Gibson R (2000) The relative validity of a computerized food frequency questionnaire for estimating intake of dietary Fe and its absorption modifiers. *Eur J Clin Nutr* **54**, 592–599.

Heath A-L & Fairweather-Tait S (2003) Health implications of Fe overload: the role of diet and genotype. *Nutr Rev* **61**, 45–62.

Heath A-L, Skeaff C, O'Brien S, Williams S & Gibson R (2001) Can dietary treatment of non-anemic Fe deficiency improve Fe status? *J Am Coll Nutr* **20**, 477–484.

Holland B, Brown J & Buss D (1993) *Fish and Fish Products: Third Supplement to McCance and Widdowson's The Composition of Foods (*5th edition*)*. Cambridge, UK: The Royal Society of Chemistry.

Holland B, Unwin I & Buss D (1988) *Cereals and Cereal Products: Third Supplement to McCance and Widdowson's The Composition of Foods (*4th edition*)*. Nottingham: Royal Society of Chemistry.

Holland B, Unwin I & Buss D (1989) *Milk Products and Eggs: Fourth Supplement to McCance and Widdowson's The Composition of Foods (*4th edition*)*. Cambridge: Royal Society of Chemistry.

Holland B, Unwin I & Buss D (1991*a*) *Vegetables, Herbs and Spices: Fifth Supplement to McCance and Widdowson's The Composition of Foods (*4th edition*)*. Cambridge: Royal Society of Chemistry.

Holland B, Unwin I & Buss D (1992*a*) *Fruits and Nuts: First Supplement to*

*McCance and Widdowson's The Composition of Foods (*5th edition*).* Cambridge: Royal Society of Chemistry.

Holland B, Welch A & Buss D (1992*b*) *Vegetable Dishes: Second Supplement to McCance and Widdowson's The Composition of Foods (*5th edition*).* Cambridge: Royal Society of Chemistry.

Holland B, Welch A, Unwin I, Buss D, Paul A & Southgate D (1991*b*) *McCance and Widdowson's The Composition of Foods,* Fifth revised and ext edition. Cambridge: Royal Society of Chemistry.

Hurrell R, Reddy M & Cook J (1999) Inhibition of non-haem Fe absorption in man by phenolic-containing beverages. *Br J Nutr* **81**, 289–295.

Krall E, Dwyer J & Coleman K (1988) Factors influencing accuracy of dietary recall. *Nutr Res* **8**, 829–841.

Masson L, McNeill G, Tomany J, Simpson J, Peace H, Wei L, Grubb D & Bolton-Smith C (2003) Statistical approaches for assessing the relative validity of a food-frequency questionnaire: use of correlation coefficients and the kappa statistic. *Public Health Nutr* **6**, 313–321.

Matthys C, Pynaert I, Roe M, Fairweather-Tait S, Heath A-L & De Henauw S (2004) Validity and reproducibility of a computerised tool for assessing the Fe, Ca and vitamin C intake of Belgian women. *Eur J Clin Nutr* **58**, 1297–1305.

Ministry of Agriculture Fisheries and Food (1993) *Food Portion Sizes*, 2nd ed. London: HMSO.

Morck T, Lynch S & Cook J (1983) Inhibition of food Fe absorption by coffee. *Am J Clin Nutr* **37**, 416–420.

Oberleas D & Harland B (1981) Phytate content of foods: effect on dietary Zn bioavailability. *J Am Diet Assoc* **79**, 433–436.

Rangan A, Ho R, Blight G & Binns C (1997) Haem Fe content of Australian meats and fish. *Food Aust* **49**, 508–511.

Salonen J, Nyyssönen K, Korpela H, Tuomilehto J, Seppänen R & Salonen R (1992) High stored Fe levels are associated with excess risk of myocardial infarction in Eastern Finnish men. *Circulation* **86**, 803–811.

Willett W (1990) *Nutritional Epidemiology*. New York: Oxford University Press.

Willett W (2001) Invited commentary: a further look at dietary questionnaire validation. *Am J Epidemiol* **154**, 1100–1102.

Appendix: The meal-based intake assessment tool food list (630 food items in sixteen food groups)

All foods are as eaten unless stated otherwise; e.g. legumes are cooked and drained.

Beans, peas and lentils (nineteen food items)

- Baked beans
- Baked beans, with burgers
- Baked beans, with sausages
- Bean sprouts, mung, raw
- Broad beans
- Chick peas
- Green beans/French beans, boiled
- Hummus
- Lentils, green and brown
- Lentils, red
- Mange-tout peas, stir-fried
- Mushy peas
- Peas, boiled
- Red kidney beans, canned
- Red kidney beans, dried, boiled
- Runner beans
- Soya beans
- Split peas
- Tofu, fried

Breads and cereals (thirty-two food items)

- Barley, pearl
- Breadcrumbs
- Brown bread
- Brown rolls
- Chapati
- Croissants
- Currant bread
- Granary bread
- Hamburger buns
- Hovis
- Malt bread
- Naan bread
- Oatbran
- Papadums
- Pasta, white
- Pasta, wholemeal
- Pastry, flaky
- Pastry, shortcrust
- Pastry, wholemeal
- Pitta bread
- Popcorn
- Rice, brown
- Rice, white
- Rye bread
- Tortilla, wheat
- Wheatbran
- Wheatgerm
- Wheatgerm bread
- White bread
- White rolls
- Wholemeal bread
- Wholemeal rolls

Breakfast cereals (twenty-six food items)

- All-Bran
- Bran Flakes
- Coco Pops
- Corn Flakes
- Crunchy Nut Corn Flakes
- Frosties
- Fruit n Fibre
- Muesli, Swiss style
- Nutri-Grain
- Oat and Wheat Bran
- Oat Bran Flakes
- Porridge, made with milk
- Porridge, made with water
- Puffed Wheat
- Raisin Splitz
- Ready Brek
- Rice Krispies
- Shredded Wheat

- Shreddies
- Smacks
- Special K
- Start
- Sugar Puffs
- Sultana Bran
- Weetabix
- Weetaflake

Cakes and biscuits (fifty-three food items)

- Baklava
- Battenburg cake
- Brandy snaps
- Cake, plain
- Chelsea buns
- Cherry cake
- Chocolate biscuits, full coated
- Chocolate cake
- Chocolate éclairs
- Choux buns
- Coconut cake
- Cream crackers
- Cream horns
- Crispbread, rye
- Crispie cakes
- Crumpets, toasted
- Custard tarts
- Danish pastries
- Digestive biscuits, chocolate
- Digestive biscuits, plain
- Doughnuts, jam or custard
- Eccles cake
- Fancy iced cakes, individual
- Flapjacks
- Fruit cake
- Fruit mince pies
- Gingerbread
- Gingernut biscuits
- Homemade biscuits
- Hot cross buns
- Jaffa cakes
- Jam tarts
- Madeira cake
- Muffins, bran
- Oatcakes
- Plain sweet biscuits
- Rock cakes
- Sandwich biscuits
- Scones, cheese
- Scones, fruit
- Scones, plain
- Scones, wholemeal
- Scotch pancakes
- Shortbread
- Sponge cake
- Swiss roll
- Swiss rolls, chocolate, individual
- Teacakes, toasted
- Vanilla slices
- Wafer biscuits, filled
- Waffles
- Water biscuits
- Wholemeal crackers

Drinks (forty-eight food items)

- Apple juice
- Barley water
- Bitter
- Blackcurrant juice drink, with water
- Bournvita powder
- Brown ale
- Build-up powder
- Champagne
- Cider, dry
- Cider, low alcohol
- Cocoa powder
- Coffee, infusion
- Coffee, instant
- Complan powder, savoury
- Complan powder, sweet
- Cream liqueurs
- Drinking chocolate powder
- Fruit drink/squash, with water
- Fruit juice drink, ready to drink
- Grape juice
- Grapefruit juice
- Guinness
- Horlicks powder
- Lager
- Liqueurs, high strength
- Liqueurs, low–medium strength
- Lucozade
- Mild
- Mulled wine
- Orange juice
- Orange juice, freshly squeezed
- Ovaltine powder
- Pale ale
- Port
- Prune juice
- Red wine
- Rosé wine
- Rosehip syrup, with water
- Sherry
- Soya milk
- Spirits
- Strong ale
- Tap water
- Tea, black
- Tea, herbal
- Tomato juice
- Vermouth
- White wine

Fish and shellfish (fifty-one food items)

- Anchovies
- Cockles
- Cod, battered
- Crab

- Crab, canned
- Crabsticks
- Fish cakes
- Fish fingers
- Fish paste
- Fish pie
- Fish, other
- Fishermans pie
- Haddock, in crumbs
- Halibut, grilled
- Herring, canned
- Herring, grilled
- Herring, pickled
- Kedgeree
- Kipper, grilled
- Lemon sole, grilled
- Lobster
- Mackerel, canned
- Mackerel, grilled
- Mackerel, smoked
- Mullet, grey, grilled
- Mussels
- Mussels, canned and bottled
- Oysters
- Pilchards, canned
- Plaice, battered
- Plaice, in crumbs
- Prawns
- Rock salmon/dogfish, battered
- Salmon, canned
- Salmon, grilled
- Salmon, smoked
- Sardines, canned
- Sardines, grilled
- Scampi, in crumbs
- Shrimps
- Shrimps, canned
- Skate, grilled
- Sprats, fried
- Squid, battered
- Taramasalata
- Trout, brown, steamed
- Tuna pâté
- Tuna, canned
- Whelks
- Whitebait, fried
- Winkles

Fruit (forty-five food items)

- Apples, raw
- Apples, stewed
- Apricots, canned
- Apricots, dried
- Apricots, raw
- Avocado
- Banana chips
- Bananas
- Blackberries, raw
- Blackcurrants, stewed
- Cherries, canned
- Cherries, raw
- Clementines
- Currants
- Dates
- Dried mixed fruit
- Figs, dried
- Fruit cocktail, canned
- Gooseberries, dessert, raw
- Grapefruit, canned
- Grapefruit, raw
- Guava, canned
- Kiwi fruit
- Lychees, canned
- Mandarin oranges, canned
- Mangoes, raw
- Melon, average
- Nectarines
- Olives
- Oranges
- Peaches, canned
- Peaches, raw
- Pears, canned
- Pears, raw
- Pineapple, canned
- Plums, raw
- Prunes
- Prunes, canned
- Raisins
- Raspberries, raw
- Rhubarb, canned
- Rhubarb, stewed
- Strawberries, raw
- Sultanas
- Tangerines

Meat (thirty-three food items)

- Bacon rashers
- Beef, mince
- Beef, mince patties
- Beef, roasted
- Beef, silverside
- Beef steak
- Beef, strips, stir-fried
- Hare
- Heart, lamb
- Kidney, lamb
- Kidney, ox
- Kidney, pig
- Lamb, chump chops
- Lamb, cutlets
- Lamb, leg, roasted
- Lamb, mince, stewed
- Lamb, not leg, roasted
- Lamb, strips, stir-fried
- Liver, calf
- Liver, lamb
- Liver, pig
- Oxtail
- Pork, chump chops
- Pork, diced, casseroled

- Pork, mince, stewed
- Pork, roasted
- Pork, steaks
- Rabbit
- Sweetbread, lamb
- Tongue, ox
- Tongue, sheep, stewed
- Veal, mince
- Venison

Meat products (thirty-five food items)

- Beef pie
- Beef sausages
- Beefburgers
- Bierwurst
- Black pudding
- Bratwurst
- Burger, Big Mac
- Burger, Cheeseburger
- Burger, Hamburger
- Burger, Quarterpounder
- Burger, Whopper
- Chicken fingers, baked
- Chicken kiev, baked
- Chicken nuggets, takeaway
- Chicken pie
- Corned beef, canned
- Cornish pastie
- Frankfurter
- Ham
- Lamb samosa
- Luncheon meat, canned
- Meat spread
- Pâté, liver
- Pepperami
- Polony
- Pork pie
- Pork sausages
- Salami
- Sausage rolls
- Saveloy, unbattered, takeaway
- Scotch pie
- Steak and kidney pudding
- Tongue, canned
- Turkey roll
- White pudding

Milk and milk products (twenty-seven food items)

- Arctic roll
- Brie
- Camembert
- Cheddar
- Cheese, white
- Chocolate-covered ice-cream bar
- Condensed milk,sweetened
- Cornetto
- Cottage cheese
- Cream cheese
- Cream, double
- Cream, single
- Cream, whipped
- Dried milk
- Elmlea
- Evaporated milk
- Fromage frais
- Ice cream
- Milk
- Milk shake powder
- Milk shake, purchased
- Parmesan
- Processed cheese
- Ricotta cheese
- Stilton
- Yoghurt, plain
- Yogurt, fruit

Miscellaneous (fifty-nine food items)

- Almonds
- Bombay mix
- Bovril
- Brazil nuts
- Cashew nuts
- Chestnuts
- Chocolate nut spread
- Chutney, mango
- Chutney, tomato
- Coconut cream
- Coconut, desiccated
- Dressing, blue cheese
- Elevenses
- Hazelnuts
- Jam, fruit
- Jam, reduced sugar
- Lemon curd
- Macadamia nuts
- Marmalade
- Marmite
- Marzipan
- Mayonnaise
- Mixed nuts
- Nutrigrain
- Peanut butter
- Peanuts, dry roasted
- Peanuts, plain
- Peanuts, roasted
- Pecan nuts
- Pickle, sweet
- Pine nuts
- Pistachio nuts
- Pumpkin seeds
- Quorn, myco-protein
- Sandwich spread
- Sauce, black bean
- Sauce, cheese
- Sauce, cook-in-sauces
- Sauce, curry
- Sauce, Hollandaise
- Sesame seeds
- Soup, bouillabaisse

- Soup, chicken soup, cream of
- Soup, French onion
- Soup, lentil
- Soup, minestrone
- Soup, mulligatawny
- Soup, mushroom soup, cream of
- Soup, oxtail
- Soup, pea and ham
- Soup, potato and leek
- Soup, scotch broth
- Soup, vegetable
- Sunflower seeds
- Syrup, maple
- Tahini paste
- Treacle
- Walnuts
- White sauce

Poultry (seventeen food items)

- Chicken, breast
- Chicken, drumsticks
- Chicken, leg quarter
- Chicken, meat
- Chicken, thighs
- Chicken, wing quarter
- Duck
- Goose
- Grouse
- Partridge
- Pheasant
- Pigeon
- Turkey, breast
- Turkey, drumsticks
- Turkey, meat
- Turkey, mince
- Turkey, thighs, diced

Puddings (twenty-three food items)

- Bakewell tart
- Blackcurrant pie
- Blackcurrant pie, wholemeal
- Bread and butter pudding
- Cheesecake
- Chocolate mousse
- Christmas pudding
- Crumble, fruit
- Crumble, fruit, wholemeal
- Custard
- Fruit pie, individual
- Fruit pie, one-crust
- Fruit pie, one-crust, wholemeal
- Fruit pie, two-crust
- Fruit pie, two-crust, wholemeal
- Instant dessert
- Lemon meringue pie
- Pancakes, sweet
- Rice pudding
- Sponge pudding
- Spotted dick
- Treacle tart
- Trifle

Savoury dishes (seventy-eight food items)

- Beanburger
- Beef chow mein
- Beef curry
- Beef steak pudding
- Beef stew
- Beef stroganoff
- Bolognese sauce
- Broccoli in cheese sauce
- Casserole, vegetable
- Cauliflower cheese
- Chilli, vegetable
- Coleslaw, with mayonnaise
- Corn fritters
- Coronation chicken
- Couscous
- Dumplings
- Egg fried rice
- Eggs, boiled
- Eggs, scrambled
- Falafel
- Game pie
- Irish stew
- Lasagne
- Lasagne, spinach
- Lasagne, vegetable
- Leeks in cheese sauce
- Lentil roast
- Macaroni cheese
- Meat loaf
- Moussaka
- Moussaka, vegetable
- Nut cutlets, grilled
- Nut roast
- Omelette, cheese
- Omelette, plain
- Pakora/bhajia, onion
- Pakora/bhajia, potato
- Pakora/bhajia, vegetable
- Pakoras
- Pancakes, savoury
- Pesto sauce
- Pizza
- Pizza, cheese and tomato
- Pizza, tomato
- Pot savouries, made up
- Potato cakes
- Quiche, cheese and egg
- Quiche, cheese and egg, wholemeal
- Quiche, mushroom
- Ratatouille
- Refried beans
- Risotto
- Salad, bean
- Salad, carrot and nut
- Salad, pasta
- Salad, potato

- Salad, vegetable
- Samosas, meat
- Samosas, vegetable
- Sauce, curry, sweet
- Sauce, tomato and mushroom
- Sauce, tomato base
- Scotch eggs
- Soufflé, cheese
- Soufflé, plain
- Spaghetti, bolognese sauce
- Spaghetti, tomato sauce
- Steak and kidney pie
- Stuffing mix, dried, made up
- Stuffing, sage and onion
- Sweet and sour pork
- Tabouleh
- Tripe and onions
- Veal, Wienerschnitzel
- Vegebanger
- Vegeburger, retail
- Vegetable stir fry
- Yorkshire pudding

Snacks (thirty-one food items)

- Bounty bar
- Breadsticks
- Cereal chewy bar
- Cereal crunchy bar
- Chocolate-covered caramels
- Chocolate, fancy and filled
- Chocolate, milk
- Chocolate, plain
- Chocolate, white
- Corn snacks
- Creme eggs
- Fudge
- Kit Kat
- Liquorice allsorts
- Liquorice shapes
- Mars Bar
- Milky Way
- Mixed cereal and potato flour snacks
- Nougat
- Peppermint creams
- Picnic bar
- Pork scratchings
- Potato crisps
- Pretzels
- Smartie-type sweets
- Snickers
- Toffees
- Tortilla chips
- Truffles, rum
- Twiglets
- Twix

Vegetables (fifty-three food items)

- Asparagus, boiled
- Asparagus, canned
- Aubergine
- Beetroot, boiled
- Beetroot, pickled
- Broccoli, boiled
- Brussels sprouts, boiled
- Cabbage, boiled
- Cabbage, raw
- Capsicum, green, cooked
- Capsicum, green, raw
- Capsicum, red, cooked
- Capsicum, red, raw
- Carrots, raw
- Cauliflower, boiled
- Chips
- Courgette, boiled
- Courgette, fried
- Curly kale, boiled
- Gherkins
- Instant potato
- Leeks, boiled
- Lettuce, raw
- Mixed vegetables, frozen, boiled
- Mushrooms, common, fried
- New potatoes, boiled
- New potatoes, canned
- New potatoes, in skins, boiled
- Old potatoes, baked, flesh and skin
- Old potatoes, baked, flesh only
- Old potatoes, boiled
- Old potatoes, mashed
- Old potatoes, roasted
- Onions, fried
- Parsnip, boiled
- Potato croquettes
- Potato waffles
- Radish, raw
- Sauerkraut
- Spinach, boiled
- Spring greens, boiled
- Squash, baked
- Swede, boiled
- Sweet potato, boiled
- Sweetcorn, baby, canned
- Sweetcorn, boiled
- Tomato purée
- Tomatoes, canned
- Tomatoes, cherry, raw
- Tomatoes, fried
- Tomatoes, grilled
- Tomatoes, raw
- Tomatoes, sun dried