Evaluation of a bar-code system for nutrient analysis in dietary surveys

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Abstract

Objective: A novel system for nutrient analysis has been developed and tested over 5 years. Its key features are a nutrient database of 600 commonly eaten foods (95% of foods eaten in 7-day surveys); a booklet identifying each food with a bar code, bar codes for gram weight and for portion sizes (small, medium, large) and a bar-code reader with dietary analysis software for PCs. In the present study the bar-code system has been evaluated by comparison with a commonly used manual entry nutrient analysis software for dietitians' use.
Design: Cross-sectional.
Setting: Glasgow city district.
Subjects: One hundred and sixty adults aged 18–65 years old.
Results: Comparing mean intakes for macro- and micronutrients, using the Bland and Altman method[1], the bias between the two methods was small, ranging from 0.93 to 1.03. The bar-code system took significantly less professional time in data entry and nutrient analysis than the widely used manual system (29 min per 7-day diary vs. 47 min per 7-day diary, $P < 0.001$).
Conclusions: It is suggested that the bar-code system offers greater speed with a saving of professional time needed for nutrient analysis of dietary surveys. This system is commended for maintaining accuracy while promoting economy.

Keywords
Dietary intakes
Nutrient analysis

Estimating nutrient intake of humans is of fundamental importance to nutritionists in order to investigate relationships between nutrients and health measures, to prescribe appropriate dietary regimes and to monitor the effect of dietary interventions. It is a time-consuming activity, prone to errors and biases.

Both retrospective and prospective methods are available but the prospective method has major advantages over retrospective analysis in that there is little reliance on memory, day-to-day variation can be measured and it is generally considered more accurate[2]. On the other hand a high degree of commitment is required, and good data may not be available for less motivated subjects. The choice of dietary assessment method will be influenced by the nutrients of interest, accuracy required, time frame of interest, response rates and costs. Generally the more precise the method the greater the cost, the greater the degree of subject cooperation that is required and the lower the response rate. In free-living subjects no assessment method is ideal and tends to involve compromises which depend on subject compliance and availability of funding for investigators.

Dietary assessment procedures are labour intensive and therefore expensive. Once dietary data have been collected, analysis can only proceed after food codes and weights have been identified and entered into an appropriate nutritional analysis program.

Originally developed for use in managing out-patients with diabetes[3] the Foodmeter (UK) 2 nutrient analysis system has been designed to ease analysis procedures. Bar codes were first used in 1973 by the grocery industry. The last 5 years have witnessed significant improvements to the print quality of bar codes which ensures that frustrating repeated scanning is in the past. Bar codes work first time, virtually all the time.

Medimatica are the collaborating Italian information technology company who developed the original Italian Foodmeter system, and with Anderson and Lean created the Foodmeter (UK) program. They also prepared the new Foodmeter (UK) 2 program with a larger updated database, new bar codes and bar-code booklet.

The Foodmeter (UK) 2 nutrient analysis system employs a database of 600 foods (accounting for 95% of the most commonly consumed foods in the UK) each

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identified by a bar code. The food groupings in the bar-code booklet are organized in 'consumption order' (with some food being listed twice, e.g. ice cream as a snack and a pudding) as follows: drinks ($n=40$), breads ($n=29$), spreads ($n=10$), butter and margarine ($n=8$), breakfast items ($n=18$), snacks, cakes and confectionery ($n=83$), soups ($n=12$), meat and poultry ($n=80$), fish ($n=32$), eggs ($n=10$), cheese ($n=27$), vegetables ($n=111$), potatoes, pasta and rice ($n=30$), desserts and puddings ($n=52$), fruit ($n=41$), miscellaneous ($n=37$) and spare labels ($n=6$). Compositional data were taken from the fifth edition of *The Composition of Foods*[4] with permission granted from the Royal Society of Chemistry.

The system booklet states bar codes for meal identifiers, gives a choice of gram or ounce weights, exact weight in 1 g increments (for individual food items) or automatic average portion sizes (small, medium or large) to be entered using the bar-code system. Average portion sizes were obtained from published information collected during recent UK weighed dietary surveys conducted by the Ministry of Agriculture, Fisheries and Food[5,6] supplemented by data from surveys in Aberdeen and Glasgow by Anderson and Lean.

Food intake can be recorded either by a subject or investigator. Analysis includes breakdown per week, day or meal, and also as a mean for each meal or snack (e.g. mean breakfast intake) for the number of days studied. Analysis is provided immediately after the data is downloaded from the bar-code reader to the computer.

The commonly used COMP-EAT 4 database (Nutrition Systems Ltd) contains in the region of 3000 foods and was used as the reference method in this study. The system has the conventional approach of manual data entry with selection made from a large list of foods which may be menu driven. Portion size is then added, either from weighed data or from standard portion weights.

The overall aim of the current study was to validate the Foodmeter (UK) 2 system against a widely used manual entry nutrient analysis system as a reference point. The specific objectives of the study were to carry out a dietary survey of Glaswegian adults in order to obtain prospective, weighed dietary records and fasting plasma blood samples in order to: (i) assess whether Foodmeter (UK) 2 dietary analysis can be used interchangeably with COMP-EAT dietary analysis in surveys; (ii) examine associations between estimated intakes of vitamin C, vitamin E and carotenoids obtained from Foodmeter (UK) 2 dietary analyses by comparing these with plasma concentrations of these vitamins; and (iii) to explore the ease of use of the Foodmeter system compared to the reference nutrient analysis system.

Methods

A dietary survey of adults was conducted within the Glasgow city district to collect appropriate data for the validation of the Foodmeter (UK) 2 system. Ethical permission for this study was obtained from the Greater Glasgow Community and Primary Care Local Research Ethics Committee. Power calculations based on the standard deviations for energy, fat, carbohydrate and iron from a previous weighed dietary survey in Scottish adults indicated that a sample size of 160 adults would be sufficient to exclude differences greater than 10% of standard deviation for each measure in paired data with 90% confidence.

Sample

Fieldwork for this study was undertaken between October 1994 and October 1995. A random sample of the names of 1138 adults aged 16–65 years resident in Glasgow city were provided from the Community Health Index of the Greater Glasgow Health Board (GGHB).

Prior to contacting the subjects, a letter was sent to the individual's general practitioner explaining the study and exclusion criteria (namely diabetes, pregnancy, residence in institutions, mental illness). Practitioners were given a period of 3 weeks to respond before any possible participants were contacted. One-third (33%) of these were ineligible for the study.

Individuals were then contacted by letter to briefly explain the study and invited to participate by returning a reply paid letter. About half (47%) could not be contacted. Of the 407 adults who were eligible and contacted about the study, 55.3% refused to participate. The Community Health Index was found to be out of date and this accounted largely for the non-contacts. This had a limited impact as the achieved sample was quite close to the socioeconomic breakdown of the actual GGHB population of that age group. People from the most deprived areas were underrepresented in the sample and there was a 16% overrepresentation of females in the sample (Table 1).

Procedure and measurements

Individuals who agreed to take part in the study were then contacted again and an appointment made to visit them in their home where possible. On the first visit (which lasted approximately 30–45 min) the study was discussed in more detail and basic information on sociodemographic characteristics were collected. Sociodemographic data was collected as category data as far as possible to avoid 'sensitive' issues. Thus income and age were obtained as category rather than continuous variables. Other details included marital status, household composition, employment status, occupation, smoking status and medications.

Table 1 Representativeness of the sample of Glaswegian adults: desired and achieved sample composition by deprivation category and gender

	Desired* (%)	Achieved	
		%	*n*
Deprivation category			
1	9.4	10.6	17
2	7.8	10.6	17
3	7.5	8.7	14
4	13.8	21.3	34
5	9.2	11.3	18
6	22.8	21.3	34
7	29.4	16.3	26
Total	100.0	100.0	160
Gender			
Male	49.0	33.1	53
Female	51.0	66.9	107
Total	100.0	100.0	160

*GGHB population of 18–65 years old in 1995.

Confidentiality of data was stressed. Respondents were invited, but not obliged, to provide a fasting blood sample.

Following these procedures, the research dietitian instructed and demonstrated to subjects how to record food and drink intake. All subjects were provided with a food recording diary in A5 format with card covers, information on the Department of Human Nutrition, University of Glasgow, including a telephone number and contact name (the research dietitian). Four pages per day were provided for recording details of food descriptions (e.g. cooking methods, cut of meat), food weights (derived from Salter food scales) as served, and weight of leftovers. Two extra pages per day were also available for recipe details (description of foods, weights and serving portions) and descriptions of food eaten outside the home (menu item and catering outlet). Written instruction on weighing and recording was also provided. Cross-check questions on type of milk, bread and spread, use of sugar and milk in hot beverages, alcohol consumption, use of table salt, dietary supplements and other medications were also included.

SALTER Selectronic 2200 food scales with a tare facility were given to each subject and the importance of accurate weighing was emphasized. Advice was also given on using household measures to describe portion sizes and a single (double-sided) A4 sheet depicting three portion sizes of 15 commonly eaten foods (to aid assessment of portion weight estimation developed by Edington *et al.*[7]) was provided. Respondents were also invited to retain the packaging from manufactured food to assist the identification of specific food products.

Subjects were asked to weigh and record all foods and drinks consumed over the following 7 consecutive days. It was stressed that participants should eat their usual diet (no matter how 'bad' or 'good' they perceived that to be). All subjects were given a demonstration of how to use the food scales and record food weights. Following this demonstration, height, weight and a triceps skinfold thickness were also measured.

The second visit took place within 3 days of the food diary completion so that the blood sample could be taken as close to the food intake reporting period as possible. Diaries were checked by the research dietitian for legibility, weight appropriateness and exact details of food and drinks recorded. Recipe details were also checked where provided. Respondents were also probed for omissions, particularly drinks and confectionery. Unusual food weights were queried, often by re-weighing crockery or food portions such as milk in tea or spread on bread.

Diary data were manually entered on the COMP-EAT nutritional analysis program, using average portion weight data[5] when foods or drinks had not been weighed. All diaries were analysed in batches, firstly by COMP-EAT and then using Foodmeter (UK) 2 and vice versa for subsequent batches.

A small proportion of the sample (5.4%) returned unusable diaries and 39.3% provided usable diaries (n = 160). Of these, 120 (75%) also provided fasting blood samples. Reasons for refusals included perceived difficulties with weighing and recording food, time limitations, chronic illness, slimming and blood sampling procedures.

During the diary collection visit, a 30 ml fasting blood sample was obtained. Samples were analysed for plasma ascorbate, α-carotene, β-carotene, lutein, lycopene, retinol and α-tocopherols using a high-performance liquid chromatography method developed by the Departments of Human Nutrition and Pathological Biochemistry, Glasgow Royal Infirmary[8].

Results

The sociodemographic profiles of subjects who completed diaries are presented in Table 2. The sample was predominantly female, with slightly more than half (52.8%) the male sample aged between 18 and 50 years and most (71%) of the female sample in this younger age category. Subjects were mostly from social classes I–III (non-manual), although, of the four income categories considered, the majority came from households with an income between £10 000 and £19 999 per annum with no children aged under 18 living in the household. About one-quarter (24.5%) of male and just over a third (36.4%) of female respondents were smokers. The mean BMI was in the overweight category for both men ($25.8 \pm 3.5\,kg\,m^{-2}$) and women ($26.0 \pm 4.9\,kg\,m^{-2}$).

Table 3 shows comparisons of nutrient intakes estimated by each system. From analysis using the

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Table 2 Sociodemographic details of the sample

	Male		Female	
	n	%	*n*	%
Gender	53	33.1	107	66.9
Age (years)				
18–50	28	52.8	76	71.0
50–65	25	47.2	31	29.0
Social class*				
I, II, III (non-manual)	26	53.1	72	76.6
III, IV, V (manual)	23	46.9	22	23.4
Household income				
< £9999	9	18.0	21	20.0
£10 000–£19 999	17	34.0	39	37.1
£20 000–£29 999	13	26.0	21	20.0
> £30 000	11	22.0	24	22.9
Children in household				
0	34	64.2	60	56.1
1	8	15.1	20	18.7
2	9	17.0	21	19.6
3	2	3.8	6	5.6
Smokers	13	24.5	39	36.4
Non-smokers	40	75.5	68	63.6
Body mass index (kg m^{-2})				
< 20	1	2.1	4	4.1
20–24.99	17	36.2	50	51.0
25–29.99	20	42.6	34	34.7
⩾ 30	9	19.1	10	10.2

*Based on classification of occupations[13].

Bland and Altman[1] method, the bias between the two methods, for each absolute nutrient intake estimate, was small ranging from 0.93 to 1.03 (Table 3c). For illustrative purposes the Bland and Altman plot for the estimated daily total fat intake (g) is shown in Fig. 1. The level of agreement between the two methods was not significantly associated with gender or BMI except for three weak (possibly spurious) associations between gender and vitamin B_2, BMI and calcium, and BMI and folate. Differences were only found to be significant when comparing the two extreme groups.

Tables 4 and 5 provide a summary of the correlations between fasting plasma concentrations and COMP-EAT and Foodmeter (UK) 2 dietary analysis of nutrient intake. Data on the individual carotenes in many foods are not available, so for the present study total carotenoid equivalents was used as a proxy measure. There were significant linear relationships between total carotenoid equivalents intake by COMP-EAT and plasma lutein ($r = 0.50$, $P < 0.001$), α-carotene ($r = 0.40$, $P < 0.001$) and β-carotene ($r = 0.32$, $P < 0.01$).

The time taken to enter and edit the information for each food diary was recorded for both COMP-EAT and Foodmeter (UK) 2 nutritional analysis programs. It was found that the mean time taken to analyse the diaries by COMP-EAT was 47 (± 13.0) min compared to 29 (± 8.1) min for Foodmeter (UK) 2. Times ranged from 20–85 min for COMP-EAT to 15–55 min using Foodmeter (UK) 2. Paired *t*-tests for the mean time values showed that the difference in time taken to analyse the same diary by the different methods was highly significant ($P < 0.001$).

Discussion

Assessment of bar-code system for analysis of prospective records

Differences in nutrient intake between Foodmeter (UK) 2 and COMP-EAT can also occur when occasional weights are missing from the diaries. This occurs in most food records. The weight is then entered at the discretion of the dietitian. Using COMP-EAT, only one average portion size is available on the database if the measured weight was missing, whereas the Foodmeter (UK) 2 system provides portion sizes for small, medium

Table 3a Comparison of estimated nutrient intakes by the bar-code system (Foodmeter UK 2) and manual system (COMP-EAT)

	Bar-code system		Manual system		Paired differences			Spearman correlation coefficient between two methods
	Mean	SEM	Mean	SEM	Mean	SEM	t value	
Total energy (MJ)	8.2	0.2	8.2	0.2	0.01	0.04	0.25	0.97***
Total protein (g)	79.0	2.6	73.0	1.9	6.1	2.2	2.72**	0.75***
Total fat (g)	82.4	2.1	80.9	2.2	1.6	0.7	2.11*	0.92***
Saturated fat (g)	30.4	0.9	30.5	1.0	–0.1	0.4	–0.35	0.89***
Total carbohydrate (g)	233.5	5.5	227.0	5.4	6.6	1.2	5.29***	0.97***
Starch (g)	132.9	2.9	126.9	2.9	6.0	0.9	6.93***	0.95***
Sugars (g)	98.6	3.4	94.5	3.5	4.1	0.9	4.42**	0.97***
Non-starch polysaccharides (NSP) (g)	11.7	0.4	11.3	0.4	0.4	0.1	3.59***	0.96***
Energy from protein (%)	16.3	0.5	15.0	0.2	1.4	0.5	2.77**	0.18*
Energy from fat (%)	37.0	0.4	37.0	0.4	0.02	0.2	0.09	0.89***
Energy from saturated fat (%)	13.6	0.2	13.9	0.3	–0.3	0.1	–2.03*	0.83***
Energy from carbohydrate (%)	44.1	0.5	43.7	0.5	0.4	0.2	2.30*	0.93***
Retinol (μg)	666.9	86.9	672.8	92.8	–5.9	19.7	–0.30	0.98***
Vitamin C (mg)	63.7	4.4	64.4	4.5	–0.7	1.7	–0.41	0.92***
Calcium (mg)	837.5	27.3	829.4	29.6	8.1	8.1	1.00	0.96***
Iron (mg)	11.3	0.3	11.4	0.3	–0.1	0.09	–1.33	0.97***
Folate (mg)	204.5	7.2	207.6	7.5	–3.1	2.5	–1.24	0.94***

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

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Table 3b Bland–Altman analysis: a comparison of the COMP-EAT and Foodmeter (UK) 2 systems

	Data transformed by natural log									
					Upper limit			Lower limit		
Daily intakes	Mean (d)*	SD (s)	95% CI		d + 2s	95% CI		d − 2s	95% CI	
Energy (kcal)	−0.02	0.06	−0.04	−0.001	0.10	+0.08	0.12	−0.14	−0.16	−0.12
Fat (g)	−0.026	0.12	−0.05	−0.006	0.21	+0.17	0.25	−0.27	−0.31	−0.23
Saturates (g)	−0.004	0.16	−0.03	−0.02	0.32	+0.28	0.36	−0.32	−0.36	−0.28
Polyunsaturates (g)	−0.074	0.26	−0.1	−0.03	0.45	+0.37	0.58	−0.59	−0.67	−0.51
Monounsaturates (g)	−0.055	0.16	−0.08	−0.03	0.27	+0.23	0.31	−0.38	−0.42	−0.34
Protein (g)	−0.042	0.40	−0.1	+0.02	0.76	+0.66	0.86	−0.84	−0.94	−0.74
Carbohydrate (g)	−0.03	0.07	−0.04	−0.02	0.11	+0.09	0.13	−0.17	−0.19	−0.15
Starch (g)	−0.05	0.08	−0.06	−0.04	0.11	+0.09	0.13	−0.21	−0.23	−0.19
Sugars (g)	−0.055	0.12	−0.08	−0.04	0.19	+0.15	0.23	−0.30	−0.34	−0.26
NSP (g)	−0.04	0.12	−0.06	−0.02	0.20	+0.16	0.24	−0.28	−0.32	−0.24
Sodium (mg)	−0.004	0.14	−0.03	+0.02	0.28	+0.24	0.32	−0.28	−0.32	−0.24
Potassium (mg)	−0.02	0.09	−0.03	+0.004	0.17	+0.15	0.19	−0.19	−0.21	−0.17
Calcium (mg)	−0.02	0.11	−0.04	+0.002	0.20	+0.16	0.24	−0.24	−0.28	−0.20
Iron (mg)	+0.003	0.1	−0.01	+0.02	0.20	−0.04	0.44	−0.20	−0.44	+0.04
Selenium (μg)	−0.01	0.2	−0.05	−0.05	0.39	+0.33	0.45	−0.41	−0.47	−0.35
Retinol (μg)	+0.001	0.3	−0.05	+0.05	0.60	+0.52	0.68	−0.60	−0.68	−0.52
Carotene (μg)	−0.04	0.4	−0.11	+0.03	0.76	+0.66	0.86	−0.84	−0.94	−0.74
Folate (μg)	+0.01	0.1	−0.01	+0.03	0.21	+0.19	0.23	−0.19	−0.21	−0.77
Vitamin D (mg)	−0.07	0.6	−0.16	+0.02	1.13	+0.97	1.29	−1.27	−1.43	−1.11
Vitamin B_1 (mg)	−0.07	0.1	−0.09	−0.05	0.13	+0.11	0.15	−0.27	−0.29	−0.25
Vitamin B_2 (mg)	+0.001	0.1	−0.02	+0.02	0.20	+0.18	0.22	−0.20	−0.22	−0.18
Vitamin B_6 (mg)	−0.07	0.1	−0.09	−0.05	0.13	+0.11	0.15	−0.27	−0.29	−0.25
Vitamin B_{12} (mg)	+0.02	0.2	−0.02	+0.06	0.42	+0.36	0.48	−0.38	−0.44	−0.32
Vitamin C (mg)	−0.01	0.2	−0.05	+0.03	0.39	+0.33	0.45	−0.41	−0.47	−0.35

*COMP-EAT minus Foodmeter (UK) 2.

Table 3c Bland–Altman analysis: antilogs

	Data transformed by natural log									
					Upper limit			Lower limit		
Daily intakes	Mean (d)*	SD (s)	95% CI		d + 2s	95% CI		d − 2s	95% CI	
Energy (kcal)	0.98	1.06	0.96	1.00	1.11	1.08	1.13	0.87	0.85	0.89
Fat (g)	0.97	1.13	0.95	0.99	1.23	1.19	1.28	0.76	0.73	0.79
Saturates (g)	0.96	1.17	0.97	0.98	1.38	1.32	1.43	0.73	0.70	0.76
Polyunsaturates (g)	0.93	1.30	0.90	0.97	1.57	1.45	1.79	0.55	0.51	0.60
Monounsaturates (g)	0.95	1.17	0.92	0.97	1.31	1.26	1.36	0.68	0.66	0.71
Protein (g)	0.96	1.49	0.90	1.02	2.14	1.93	2.36	0.43	0.43	0.48
Carbohydrate (g)	0.97	1.07	0.96	0.98	1.12	1.09	1.14	0.84	0.83	0.86
Starch (g)	0.95	1.08	0.94	0.96	1.12	1.09	1.14	0.84	0.79	0.83
Sugars (g)	0.95	1.13	0.92	0.96	1.21	1.16	1.26	0.74	0.71	0.77
NSP (g)	0.96	1.13	0.92	0.98	1.22	1.17	1.27	0.76	0.73	0.79
Sodium (mg)	1.00	1.15	0.97	1.02	1.32	1.27	1.38	0.76	0.73	0.79
Potassium (mg)	0.98	1.09	0.97	1.00	1.19	1.16	1.21	0.83	0.81	0.84
Calcium (mg)	0.98	1.12	0.96	1.00	1.22	1.17	1.27	0.79	0.76	0.82
Iron (mg)	1.03	1.11	0.99	1.02	1.22	0.96	1.55	0.82	0.64	1.04
Selenium (μg)	0.99	1.22	0.95	0.95	1.48	1.39	1.57	0.66	0.63	0.70
Retinol (μg)	1.00	1.35	0.95	1.05	1.82	1.68	1.97	0.56	0.51	0.59
Carotene (μg)	0.96	1.49	0.90	1.03	2.14	1.93	2.36	0.43	0.39	0.48
Folate (μg)	1.01	1.11	0.99	1.03	1.23	1.21	1.26	0.82	0.81	0.90
Vitamin D (mg)	0.93	1.82	0.85	1.02	3.10	2.64	3.63	0.28	0.24	0.33
Vitamin B_1 (mg)	0.93	1.11	0.91	0.95	1.14	1.12	1.16	0.76	0.75	0.78
Vitamin B_2 (mg)	1.00	1.11	0.98	1.02	1.22	1.20	1.25	0.82	0.80	0.84
Vitamin B_6 (mg)	0.93	0.11	0.91	0.95	1.14	1.12	1.16	0.76	0.75	0.78
Vitamin B_{12} (mg)	1.02	1.22	0.98	1.06	1.52	1.43	1.62	0.68	0.64	0.73
Vitamin C (mg)	0.99	1.22	0.95	1.03	1.48	1.39	1.57	0.66	0.63	0.70

*COMP-EAT minus Foodmeter (UK) 2.

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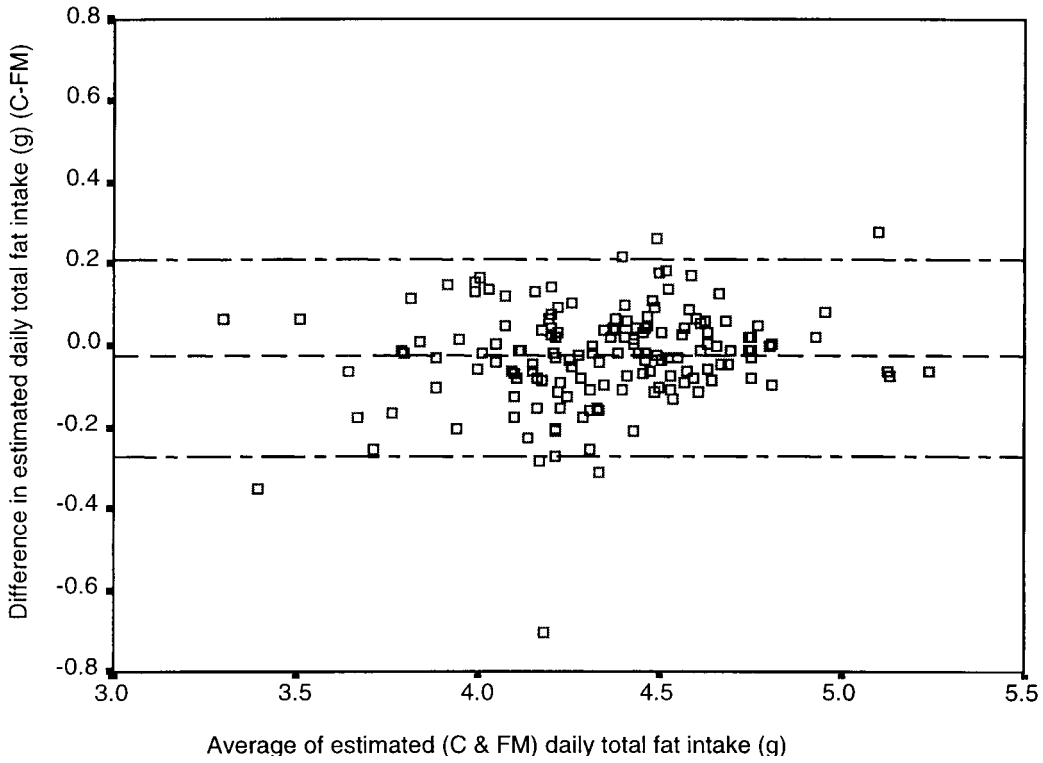

Fig. 1 Bland–Altman plot of estimated daily total fat intake (g). C, COMP-EAT; FM, Foodmeter (UK) 2

and large. Depending on which portion size is selected, the final nutrient analysis figures will be affected and may explain differences between COMP-EAT and Foodmeter (UK) 2 results. If subjects are asked to specify 'small', 'medium' or 'large' portions, Foodmeter (UK) 2 offers the opportunity to enter these items by bar code and appropriate values are entered from the figures from the database, whereas COMP-EAT requires manual editing.

COMP-EAT has a very extensive database which in itself creates problems of identifying the most appropriate food code. In some instances the information given in a diary is not sufficient to show clearly which of the many food codes should be selected. However, the extensive database was found to be advantageous in that it contains many composite dishes, such as various salads and sauces. Foodmeter (UK) 2 has a much smaller database and it was therefore more common to have to enter a 'next best code' than for COMP-EAT. The option of composite foods was not available on Foodmeter (UK) 2 so these dishes had to be entered with various single food items. In the present study approximately 2% of all foods could not be coded by COMP-EAT and 5% by Foodmeter (UK) 2. However, the Foodmeter (UK) 2 does allow the user to add extra foods in blank bar codes for use in specific (e.g. regional) dietary surveys.

Table 4 Correlations between fasting plasma concentrations and equivalent nutrient intake per 1000 kcal using COMP-EAT and Foodmeter UK 2 analyses

	COMP-EAT		Foodmeter (UK) 2	
	r	*P*	*r*	*P*
Retinol	0.24	0.023	0.27	0.01
Alpha-tocopherol	0.03	0.974	0.13	0.209
Ascorbic acid	0.241	0.023	0.244	0.021
Alpha-carotene	0.25	0.025	N/a	N/a
Beta-carotene	0.20	0.057	N/a	N/a

N/a, not available.

Estimated antioxidant vitamin intakes and antioxidant blood levels

These results confirm other studies[9] that show there are few relationships between COMP-EAT dietary intakes and fasting plasma concentrations of tocopherol and α-carotene. On the other hand the relationship between plasma lutein and dietary carotene equivalents are potentially valuable. This is confirmed by analysis using Foodmeter (UK) 2.

Table 5 Correlations between fasting plasma concentrations and carotenoid intake per 1000 kcal using COMP-EAT and Foodmeter (UK) 2 analyses

	COMP-EAT		Foodmeter (UK) 2	
	r	*P*	*r*	*P*
Alpha-carotene	0.40	< 0.001	0.43	< 0.001
Beta-carotene	0.32	0.003	0.18	0.099
Lycopene	0.17	0.09	0.11	0.292
Lutein	0.50	< 0.001	0.39	< 0.001

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Our results demonstrate that plasma carotenoids do correlate with estimates of carotene obtained by the dietary analysis estimates, but some carotenes correlate better than others. The failure to obtain good correlations for all carotenes may arise for a number of reasons. For example, a 7-day diet record from the previous week may not accurately reflect habitual intake. There may be a time lag before plasma carotenoids reflect dietary intake and current plasma levels may be a better marker of diet prior to commencement of the diet record. Since carotenoids are fat soluble, fluctuations in body fat may also affect plasma concentrations in women where weight loss has occurred. There may also be unrecorded intakes of carotenoids used in food additives or colourings.

Passive absorption is the supposed mode of carotene absorption, with absorption percentages of 5–50% being quoted. Efficiency of carotene absorption may vary according to other nutrients that are present, e.g. oils may facilitate carotene absorption. Metabolism of absorbed carotenoids may also influence plasma carotene levels because they have varying antioxidant capabilities. We have assumed that our population is healthy, but any systemic illness via generation of free radicals or peroxidation products may act to reduce plasma carotenoids, especially lycopene, the most potent antioxidant which is preferentially utilized[10]. For provitamin A carotenoids like α-carotene and β-carotene, enzymic conversion to retinol may affect their plasma concentrations, particularly if the diet is relatively low in preformed vitamin A. Because lutein and lycopene do not undergo such metabolism, they may be better biomarkers of dietary intake. Because these carotenoids are carried mainly on lipoproteins, adjustment for plasma cholesterol may improve the results. Plasma cholesterol was not measured in this survey; although carotenoids are concentrated in lipoproteins[11], we have found in other studies that this correction makes little difference (TK Ha *et al.*, unpublished observations).

The very minor difference between correlations of plasma antioxidant with COMP-EAT and Foodmeter (UK) 2 do not suggest any important reason to prefer one dietary analysis program to the other.

Our results demonstrate that plasma carotenoids do correlate with our 7-day food records which permits the interpretation that the estimated dietary intakes are a fairly true reflection of what was habitually eaten by these subjects. These results are similar to those seen for α-carotene and β-carotene in the Nutritional Survey of British Adults[9]. Our finding of a higher correlation for plasma lutein with total dietary carotene equivalents is in keeping with the report of Scott *et al.*[12], but on exploration must be interpreted cautiously: a high carrot consumption (high β-carotene, low lutein) would seriously weaken this association. The value of lycopene cannot adequately be judged from association with total carotene equivalents, since it is rather specifically consumed in tomatoes. Measurement of specific plasma carotenoids may be used as biochemical markers of dietary intakes of groups, but there are similar limitations with many current biomarkers in their application to individuals. For example, the applicability of plasma ascorbate is limited by influences from free radical generation and its complicated metabolism, especially in disease, may limit its applicability.

Ease of use

The results suggest that there were significant savings in professional time in the use of Foodmeter (UK) 2 for both data entry and editing before nutrient analysis. On the Foodmeter (UK) 2 system each day is divided into the eating pattern of meals and snacks which allowed the entries to be checked quickly and easily. On COMP-EAT, the data is shown for the whole day with some foods presented as cumulative totals which makes the checking process considerably slower.

Since Foodmeter (UK) 2 is an easier and less time-consuming system to use compared with COMP-EAT and there is direct equivalence in the results from the two methods, Foodmeter (UK) 2 is preferred in clinical use[3]. It is very 'user-friendly', and because few data are entered manually, transciptional errors are reduced.

It is suggested that the bar-code system offers greater speed with a saving of professional time needed for nutrient analysis of dietary surveys. This system is commended for maintaining accuracy while promoting economy. Whilst there are advantages in having a more comprehensive database for some purposes, the time taken and relative complexity with the possibility of errors makes the use of a more restricted database attractive for other survey purposes.

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