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**Development of a short questionnaire to assess diet quality
among older community-dwelling adults**

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ABSTRACT

OBJECTIVES: To evaluate the use of a short questionnaire to assess diet quality in older adults.

DESIGN: Cross-sectional study.

SETTING: Hertfordshire, UK

PARTICIPANTS: 3217 community-dwelling older adults (59-73 years)

MEASUREMENTS: Diet was assessed using an administered food frequency questionnaire (FFQ); two measures of diet quality were defined by calculating participants' 'prudent diet' scores, firstly from a principal component analysis of the data from the full FFQ (129 items) and, secondly, from a short version of the FFQ (including 24 indicator foods). Scores calculated from the full and short FFQ were compared with nutrient intake and blood concentrations of vitamin C and lipids.

RESULTS: Prudent diet scores calculated from the full FFQ and short FFQ were highly correlated (0.912 in men, 0.904 in women). The pattern of associations between nutrient intake (full FFQ) and diet scores calculated using the short and full FFQs were very similar, both for men and women. Prudent diet scores calculated from the full and short FFQs also showed comparable patterns of association with blood measurements: in men and women, both scores were positively associated with plasma vitamin C concentration and serum HDL; in women, an inverse association with serum triglycerides was also observed.

CONCLUSIONS: A short food-based questionnaire provides useful information about the diet quality of older adults. This simple tool does not require nutrient analysis, and has the potential to be of value to non-specialist researchers.

KEY WORDS: diet quality, dietary assessment, short questionnaire, older adults

INTRODUCTION

Declining food consumption and monotonous habitual diets make it difficult for some older people to meet nutrient needs [1,2]. However, relatively little is known about dietary choices in older age, and in particular, how age-related changes in physical and mental function impact on patterns of food consumption. As the 'healthiness' or quality of diet of older community-dwelling adults has been shown to be a strong predictor both of future health [3,4] and mortality [5,6], understanding more about the determinants of food choices is likely to be key to developing strategies to promote optimal health in later life.

Progress in this area is contingent on an ability to assess the diets of older community-dwelling adults, including individuals who may be hard to engage in research. The challenges of dietary assessment are significant, as current methods may be burdensome for older participants, and are also resource-intensive. With a growing focus on the importance of quality of diet in older age, Friesling and colleagues have recently conducted a systematic review of *a priori*-defined indexes of diet quality used in studies of older adults [7]. In the majority of studies included in the review, the index scoring was based on estimates of food and nutrient intake, which require detailed dietary assessment and analysis. However, there is evidence to show that simpler, short food-based questionnaires describe diet quality well [8,9]. These have the advantages that they are less burdensome, do not require nutrient analysis, and offer the possibility that they can be used by non-specialists. This approach has been used successfully in one study of older people in the US; the dietary screening tool developed for the Geisinger Rural Aging Study has been shown to identify dietary patterns and detect nutritional risk in older adults [10,11]. To date, few studies have evaluated diet quality in older adults in the UK [5], and to our knowledge, there are no simple screening tools available to do this.

In this paper we describe the development of a short food-based questionnaire to assess diet quality in an older population of community-dwelling adults in the UK. We compare it with a full dietary assessment, and consider its characterisation of diet quality, in relation to nutrient intakes and blood lipid and vitamin C concentrations.

METHODS

The Hertfordshire Cohort Study (HCS)

From 1911-48, detailed records were kept on all infants born in Hertfordshire, UK [12]. In 1998, men and women born 1931-39 were traced using the NHS central registry; 1684 (54%) men and 1541 (52%) women agreed to be interviewed at home, when information was obtained on the participant's social and medical history, and diet was assessed. 1579 of these men (94%) and 1418 of the women (92%) subsequently attended a clinic for further investigations. Fasting blood samples were taken from participants who were not known to be diabetic (1459 men and 1329 women) for measurement of cholesterol and triglyceride concentrations; vitamin C concentration was assayed in a subgroup of participants (497 men and 545 women). Total cholesterol, high-density lipoprotein (HDL) cholesterol and triglyceride concentrations were measured using standard enzymatic methods; low-density lipoprotein cholesterol (LDL) concentrations were calculated using the Friedwald-Fredrickson formula [13]. The measurement of Vitamin C concentration in plasma was based on the method of Margolis and Davis, using 6% metaphosphoric acid to stabilise the sample [14]. Height was measured at clinic to the nearest 0.1cm using a Harpenden pocket stadiometer (Chasmors Ltd, London, UK) and weight to the nearest 0.1kg on a SECA floor scale (Chasmors Ltd, London, UK). The study had ethical approval from the Bedfordshire & Hertfordshire Local Research Ethics Committee and the West Hertfordshire Local Research Ethics Committee. All participants gave written informed consent.

Dietary assessment

Diet was assessed using a food frequency questionnaire (FFQ) that was modified from the EPIC questionnaire [15]. The FFQ includes 129 foods and food groups, and was used to assess an average frequency of consumption of the listed foods (never, <1/month, 1-3/month, 1/week, 2-4/week, 5-6/week, 1/day, 2-3/day, 4-5/day, ≥ 6 /day) over the 3-month period preceding the interview. Each FFQ was administered by a trained research nurse. Prompt cards were used to show the foods included in each food group, to ensure standardised responses to the FFQ. Frequencies of other foods that were not listed on the FFQ were also recorded if consumed once per week or more. Standard portion sizes were allocated to each food apart from milk and sugar for which daily quantities consumed were recorded. Nutrient intakes were calculated by multiplying the frequency of consumption of a portion of each food by its nutrient content according to the UK national food composition database or manufacturers' composition data [13].

Development of the short dietary questionnaire

We have previously described the dietary patterns of the HCS participants, defined using principal component analysis (PCA) of the FFQ data [16]. The first component in the PCA (that explains the greatest variance in the dietary data) described a dietary pattern that was characterised by high consumption of fruit and vegetables, oily fish and wholemeal cereals but low consumption of white bread, added sugar, full-fat dairy products, chips and processed meat. This pattern was labelled 'prudent' as it conforms to healthy eating recommendations. A prudent pattern score was calculated for every participant as follows: (i) fat spreads and milks were categorised as full-fat or reduced fat versions (reduced fat spreads <69g fat/100g, milks <3.5g fat/100g), (ii) weekly frequencies of consumption were calculated as: never=0, <1/month=0.2, 1-3/month=0.5,

1/week=1, 2-4/week=3, 5-6/week=5.5, 1/day=7, 2-3/day=17.5, 4-5/day=31.5, $\geq 6/\text{day}=42$, (iii) food variables were standardised by subtracting the means and dividing by the SDs for the HCS population, (iv) the coefficient for each food (Table 2) was multiplied by the standardised food variable, (v) these values were summed - resulting in one score for each subject. The score indicates the participant's compliance with the prudent pattern, and was interpreted as a marker of their diet quality.

By definition, the foods that characterise the prudent pattern have the largest coefficients; variation in consumption of these indicator foods is therefore the primary determinant of variation in prudent pattern scores across the population. In a study of young women, we have previously shown that a short FFQ, that included 20 indicator foods, yielded useful information about quality of diet; when comparing prudent pattern scores calculated from the short or full FFQ, they were highly correlated and both showed comparable associations with a blood biomarker (red cell folate) [8]. For the present study, we used the same approach, using HCS data [16], to develop a 'short FFQ' to estimate prudent diet scores, to characterise the diet quality of older adults.

To calculate the prudent diet score using a smaller number of foods, the individual coefficients from the PCA of the full FFQ [16], were used. To determine the number of foods to include in the short FFQ, we repeated the calculation of prudent diet scores, increasing the number of foods from 1 to 30; to evaluate the optimal number of foods to include, we examined the effect of increasing number of food items on the correlation between the prudent diet scores calculated from the smaller number of foods with the scores from the full FFQ.

Data analysis

The normality of variables was assessed. Body mass index (BMI) and nutrient variables were not normally distributed and were transformed by taking their natural logarithms. Prudent diet scores were used as continuous variables to examine how nutrient intakes and blood concentrations of vitamin C and lipids related to compliance with this dietary pattern; correlations and univariate linear regressions were used to explore the correlates of dietary pattern scores. In order to compare relationships between pattern scores and nutrient intake that were independent of total energy intake, nutrient intakes were adjusted for energy intake according to Willett's residual method [17]. Data were analysed using Stata version 14 [18].

RESULTS

Complete dietary data were available for 3217 men and women in the HCS. Their characteristics are shown in **Table 1**. To determine how many foods to include in the short FFQ, prudent diet scores were calculated using the principal component coefficients and reported consumption of an increasing number of foods (between 1 and 30 foods with the greatest coefficients [16]), and compared with the prudent diet scores calculated from the full FFQ. We have previously reported that in separate principal component analyses of the HCS men's and women's dietary data, the dietary patterns were almost identical [16]; the dietary data were therefore combined for the evaluation of the number of foods needed in a short FFQ. **Figure 1** shows the correlation coefficients for each of these comparisons. Using a greater number of indicator foods in the calculation of the prudent diet score increased the correlations. For example, the correlation between the score calculated using the three foods with the largest coefficients (white bread, raw peppers, green salad [16]) and the score calculated from the full FFQ was 0.722, compared with a correlation of 0.948 when using 30 foods. The increases in correlation up to 10 foods were

marked, but the increments thereafter with increasing number of foods became smaller. A pragmatic decision was made to include 22 foods in the short FFQ, to be able to provide good information about diet quality, but also including some other foods to mask the obvious contrast between ‘healthy’ and ‘unhealthy’ foods (eg eggs, boiled potatoes). Because the type of milks and spreading fats consumed were categorised as full-fat or reduced-fat, addition of the reduced-fat options increased the number of foods to 24 in the short FFQ (Supplementary file). The indicator foods for the prudent pattern identified in this cohort, together with the coefficients from the PCA, are shown in **Table 2**. The correlation between the short FFQ prudent diet score, based on 24 foods, and the prudent diet score calculated from the full FFQ was 0.912 in men and 0.904 in women.

We have previously shown in this cohort that, with the exception of retinol, prudent diet scores (full FFQ) are positively associated with micronutrient and protein intakes, but negatively associated with fat and saturated fat intakes [16]. **Figure 2** shows the pattern of correlations for prudent diet scores calculated from the full and short FFQs with intakes of individual nutrients. The pattern of associations between nutrient intake and prudent diet scores calculated using the short and full FFQs were very similar, and comparable for men and women.

Table 3 shows associations between prudent diet scores (independent variable) and blood vitamin C and lipid concentrations (dependent variables). Prudent diet scores calculated from the full FFQ were positively associated with plasma vitamin C concentration and serum HDL; among women there was also an inverse association with serum triglycerides. There were no associations with serum total cholesterol or LDL concentrations in either sex. These patterns of association were also evident when using prudent diet scores calculated from the short FFQ (Table 3).

DISCUSSION

We have shown that diet quality of older adults, defined by their 'prudent diet' scores, can be assessed using a short FFQ. Although the short questionnaire only included 24 indicator foods, the associations between prudent diet scores calculated from it, and nutrient intake, blood vitamin C and lipid concentrations, were similar to those seen with scores calculated from the full FFQ. These findings suggest that a short FFQ is a useful tool to assess diet quality among older community-dwelling men and women. The advantages of a short questionnaire are clear in terms of participant burden, and it may be of particular value for the collection of dietary information from older adults who are harder to reach in the population, and who may be more vulnerable. A particular advantage is that because it does not require nutrient analysis, it also offers potential as a useful tool for non-specialist researchers.

The quality of diet of older adults has received increasing attention in recent years, because of the clear links between diets of poor quality and poorer health [3-6]. Although relatively few studies have evaluated diet quality in the UK, there is evidence that poor diets are common. For example, in a cross-country comparison of data from older adults, aged 50 and above, living in four European countries that included the UK, Irz and colleagues showed that overall diet quality in each of the older EU populations was low [19]. These analyses used UK household food consumption data, but the message is consistent with findings from two other UK studies of older adults, in which detailed individual dietary assessments were carried out [5, 20]. The cross-country comparison highlighted the heterogeneity within each population, indicating wide variation in diet quality [19]. The influences on dietary choices and the causes of poorer diets in older age are not fully understood. As future development of effective nutrition policy to support

older adults will require a clearer understanding of the drivers of diet quality, the development of simple assessment tools that enable routine collection of relevant dietary data could make an important contribution to this.

There may be particular challenges in assessing the diets of older adults. Experience from the Boyd Orr cohort, of collecting dietary data from adults aged 60 years and over, suggests that questionnaires need to be sufficiently detailed to capture dietary information across the population, whilst not being so onerous that they deter completion [21]. There is growing interest in the use of short screening tools to assess diet, especially those that can be used in clinical practice [22]. In a recent systematic review of 35 short dietary assessment tools for the management of obesity, cardiovascular disease and type 2 diabetes, England et al concluded that, in general, the tools demonstrated adequate validity [22], indicating the value of short assessment methods to enable collection of useful dietary information. Most studies were of younger adults, and many studies focused on specific foods or fat intake, rather than diet quality [22]. Diet quality has been described in different ways, and a number of *a priori* scoring methods have been used, including the Healthy Eating Index, Recommended Diet Score and Mediterranean Food Score [23]. As many overlap in terms of their common core tenets, they often show comparable associations with later health [6]. However, a limitation is that the derivation of many of the existing dietary scores requires an assessment of nutrient as well as food intake. This has resource implications, and may limit data collection to specialist researchers. But to provide an overall ‘picture’ of diet quality may not require assessment of nutrient intake, and the potential for food based indices that retain the complexity of dietary information but are simple enough to enable use in monitoring and surveillance needs to be explored [21, 24, 25].

To our knowledge, the use of a food-based short assessment tool to evaluate dietary patterns of older adults was first reported in the Geisinger Rural Aging Study in the US [10,11]. The Dietary Screening Tool (DST) included 25 questions, and used a scoring algorithm to define diet quality [26]. The DST captures information on the ‘healthiness’ of the diet in the US, and is therefore comparable with the prudent diet evaluated in the present study, although there are some differences in the foods included between the questionnaires developed in the two settings. We did not develop thresholds of nutritional risk from our data, but the overall findings of the studies are similar. Both the DST and the short FFQ-assessed prudent diet scores (based on 24 foods) showed associations with nutrient intake that were alike (positive associations with protein, fibre, most micronutrients, negative associations with fat and saturated fat intakes) as well as with blood lipid concentrations (positive association with HDL cholesterol concentrations, negative associations with serum triglyceride in women) [10]. The two studies point to the value of short food-based questionnaires to provide useful information about the diet quality of older adults – a message that is consistent with findings of studies of younger age groups [8,9,27]. Importantly, poor diet quality, identified by the DST has subsequently been shown to predict greater mortality in follow-up of the cohort [26].

A strength of the present study is that we collected dietary data from a large population of older men and women living in the community. Although membership of this cohort was defined by area of birth, and there has been loss to follow-up, the participants’ characteristics are comparable with those of the wider community [12] and the findings should be of relevance to older adults in other parts of the UK. The prudent dietary pattern, that is the most important dietary pattern in the HCS cohort [16] describes compliance with healthy eating recommendations, and comparable patterns have been described in other studies of adults in the UK [28,29,30]. A limitation of our study is that the short FFQ only defines compliance with the prudent dietary pattern; it does not

provide useful information on other aspects of diet or measures of nutrient intake. However, the correlations between prudent diet scores assessed using the short FFQ and nutrient intake estimated from a complete dietary assessment (full FFQ) show that, a short food-based questionnaire can provide useful information about variation in nutrient intake (Figure 2). Although there are concerns about self-reported dietary data [31], and in particular, FFQs may be prone to measurement error [32], they have been shown to define dietary patterns in a comparable way to other dietary assessment methods [33,34], and prudent diet scores in this study showed expected associations with a range of blood biomarkers. A weakness of the study is that the presented data are cross-sectional. A further limitation of our short FFQ is that it is designed to assess variation in diet in a UK context; because of cultural variations in diet between countries, its applicability in other settings would need to be evaluated.

CONCLUSION

This study provides strong evidence of the utility of a short food-based questionnaire to describe the diet quality of older adults. The tool is simple to administer, does not require nutrient analysis, and therefore has the potential to be of value to non-specialist researchers. The development of simple assessment tools that enable routine collection of relevant dietary data could make an important contribution to understanding the role of diet quality as an influence on the health of older adults.

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Table 1 Characteristics of participants in the Hertfordshire Cohort Study

	Men			Women		
	N	Mean	SD	N	Mean	SD
Age (yrs)	1677	65.6	2.9	1540	66.6	2.7
BMI (kg/m²)¹	1570	26.9	1.1	1416	27.2	1.2
		%			%	
Social class (N=1627 men, 1539 women)						
I-III ¹	664	40.8		639	41.5	
III ¹ -V	963	59.2		900	58.5	
Current smokers (N=1677 men, 1538 women)	262	15.6		166	10.8	
Marital status (N=1676 men, 1540 women)						
Single/ divorced/ separated/ widowed	246	14.7		429	27.9	
Married/cohabiting	1430	85.3		1111	72.1	
Age left education (N=1676 men, 1540 women)						
≤ 14 years	325	19.4		276	17.9	
≥ 15 years	1351	80.6		1264	82.1	

¹ Geometric mean (SD)

Table 2: Indicator foods for the ‘prudent’ dietary pattern, identified in the Principal Component Analysis of the full FFQ: data from 3217 older men and women in the Hertfordshire Cohort Study

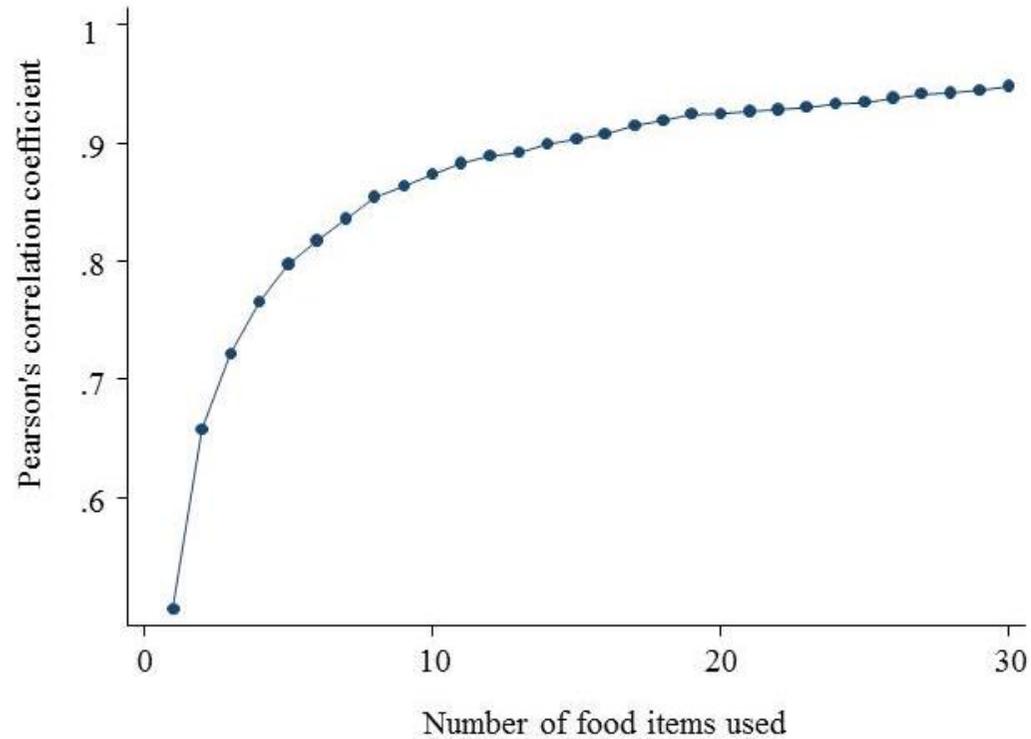
Food	Principal component coefficient
<i>Positive coefficients</i>	
1. Peppers (raw and cooked)	0.193
2. Green salad (eg lettuce, cucumber)	0.182
3. Garlic (raw and cooked)	0.175
4. Tropical fruits (eg melon, pineapple, kiwi)	0.154
5. White fish (cooked, not in batter)	0.153
6. Marrow and courgettes	0.151
7. Oily fish (eg mackerel, salmon)	0.149
8. Pasta (eg spaghetti, macaroni)	0.145
9. Yogurt (low-fat)	0.134
10. Brown or wholemeal bread	0.124
11. Apples	0.114
12. Bananas	0.103
13. Reduced fat milk	0.054
14. Reduced fat spread	0.018
<i>Negative coefficients</i>	
15. Eggs (boiled, scrambled)	-0.047
16. Boiled and jacket potatoes	-0.086
17. Bacon and gammon	-0.089
18. Biscuits	-0.101
19. Full fat milk	-0.119
20. Meat pies	-0.126
21. Full-fat spreading fat	-0.149
22. Chips	-0.152
23. Added sugar	-0.159
24. White bread	-0.201

Table 3. Association between prudent diet scores (independent variable) calculated from full and short FFQs with blood vitamin C and lipid concentrations (dependent variables) in older men and women in the Hertfordshire Cohort Study

	N	Mean	SD	Full prudent diet score			Short FFQ prudent diet score		
				β	95% CI	p-value	β	95% CI	p-value
Men									
Vitamin C ($\mu\text{mol/l}$)	497	48.7	19.7	2.89	(2.19, 3.58)	<0.001	5.38	(3.97, 6.78)	<0.001
Triglycerides (z-score)*	1458	1.45	1.62	-0.017	(-0.038, 0.004)	0.104	-0.032	(-0.074, 0.010)	0.132
Cholesterol (z-score)	1458	5.93	1.03	-0.013	(-0.034, 0.008)	0.214	-0.031	(-0.073, 0.010)	0.142
HDL (z-score)*	1458	1.32	1.27	0.031	(0.010, 0.052)	0.004	0.054	(0.013, 0.096)	0.011
LDL (z-score)	1434	3.82	0.91	-0.017	(-0.038, 0.004)	0.110	-0.039	(-0.081, 0.003)	0.071
Women									
Vitamin C ($\mu\text{mol/l}$)	545	59.3	19.0	1.16	(0.50, 1.82)	0.001	3.33	(1.89, 4.77)	<0.001
Triglycerides (z-score)*	1329	1.47	1.57	-0.061	(-0.083, -0.039)	<0.001	-0.133	(-0.181, -0.086)	<0.001
Cholesterol (z-score)	1329	6.55	1.19	-0.014	(-0.036, 0.008)	0.214	-0.020	(-0.068, 0.028)	0.409
HDL (z-score)*	1329	1.66	1.27	0.055	(0.033, 0.077)	<0.001	0.113	(0.066, 0.161)	<0.001
LDL (z-score)	1313	4.08	1.06	-0.014	(-0.036, 0.009)	0.229	-0.016	(-0.065, 0.032)	0.510

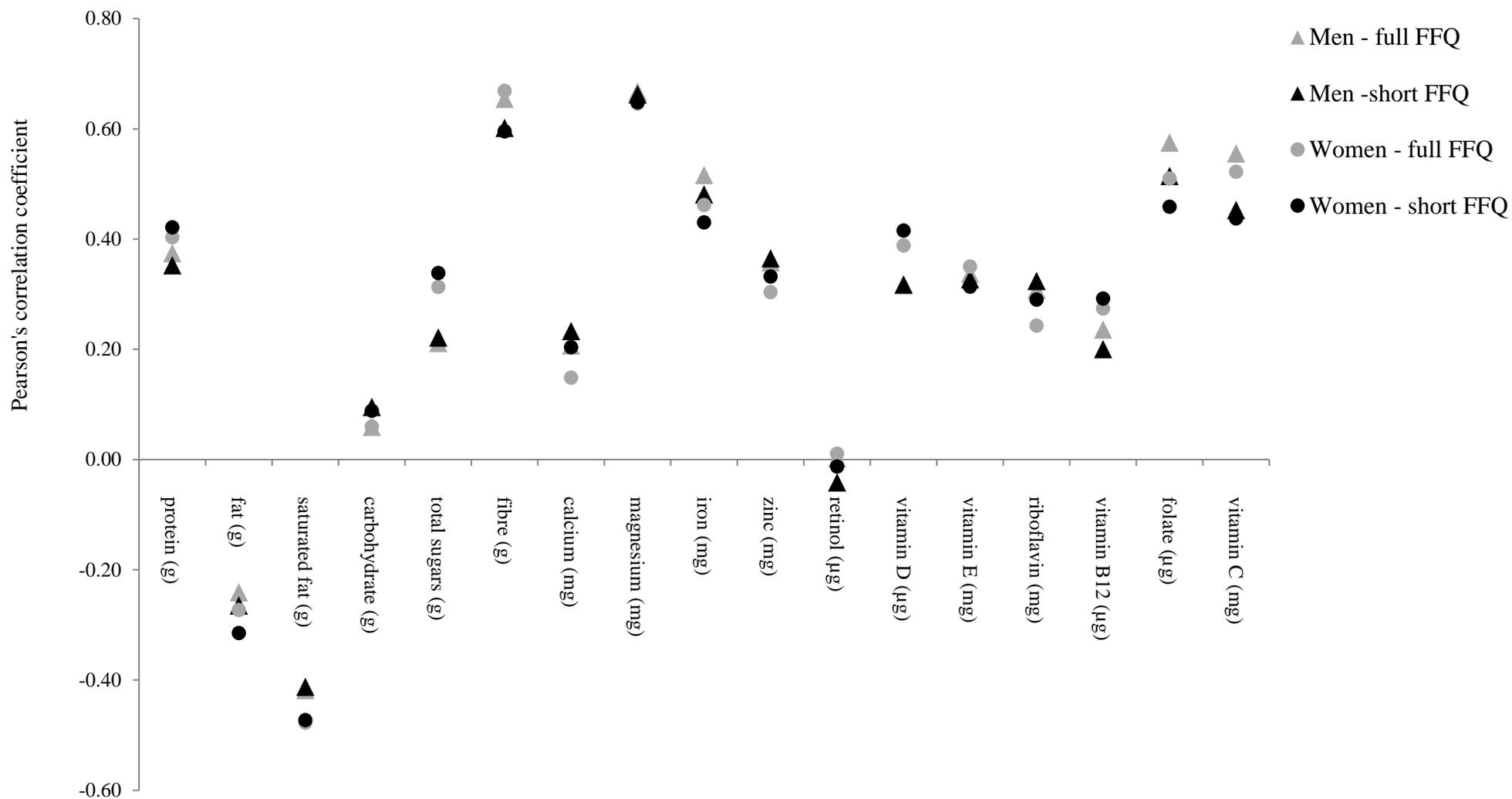
*Geometric mean (SD)

Figure 1. Correlations between prudent diet scores calculated for 3217 older men and women in the Hertfordshire Cohort Study using the full FFQ and prudent diet scores calculated using between 1 and 30 food items



Prudent diet scores were calculated using coefficients from the principal component analysis of the dietary data from the full dietary assessment, increasing the number of foods in each calculation from 1 up to 30 food items; correlations are with prudent diet scores calculated from the full dietary assessment

Figure 2. Correlations between nutrient intakes calculated from the full FFQ and prudent diet scores assessed using the full or short FFQ: 3217 men and women in the HCS



APPENDIX

Now I am going to ask you how often over the past 3 months you have eaten particular foods.

	FOOD AND AMOUNTS	AVERAGE USE IN PAST 3 MONTHS														
		Never	less than once/month	1-3 per month	Once a week	2-4 per week	5-6 per week	Once a day	2-3 per day	4-5 per day	6+ per day					
1.	White bread (one slice)															
2.	Brown and wholemeal bread (one slice)															
3.	Biscuits eg digestive (one)															
4.	Apples (one fruit)															
5.	Bananas (one fruit)															
6.	Melon, pineapple, kiwi and other tropical fruits (medium serving)															
7.	Green salad eg lettuce, cucumber, celery															
8.	Garlic – raw and cooked dishes															
9.	Marrow and courgettes															
10.	Peppers – cooked & fresh															
11.	Yogurt (125g pot)															
12.	Eggs as boiled, fried, scrambled etc. (one egg)															
13.	White fish eg cod, haddock, plaice, sole (not in batter/crumbs)															
14.	Oily fish, eg. mackerel, tuna, salmon															
15.	Bacon and Gammon															
16.	Meat pies, eg. pork pie, pasties, steak & kidney, sausage rolls															
17.	Boiled, mashed and jacket potatoes (one egg size potato)															
18.	Chips															
19.	Pasta eg spaghetti, macaroni															
Which is the main spreading fat you have used for example on bread or vegetables?																
20.	Spreading fat (teaspoon) _____															
	<table border="1" style="display: inline-table; vertical-align: middle;"><tr><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td><td style="width: 20px; height: 20px;"></td></tr></table>															

ADDITIONAL DIETARY QUESTIONS

Q21 Which types of milk have you used regularly in drinks and added to breakfast cereals over the past three months?

1. Whole pasteurised
2. Semi-skimmed pasteurised (include 1% milks)
3. Skimmed pasteurised
4. Whole UHT
5. Semi-skimmed UHT
6. Skimmed UHT
7. Other
9. None (*go to Q23*)

Milk A Other (specify) _____

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Milk B Other (specify) _____

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Milk C Other (specify) _____

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Q22 On average over the past 3 months how much of each milk have you consumed per day?

Milk A •

--	--

 pints

Milk B •

--	--

 pints

Milk C •

--	--

 pints

Q23 Have you added sugar to tea and coffee or breakfast cereals in the past 3 months?

0. No

1. Yes (*go to Q24*)

Q24 Approximately how many teaspoons of sugar have you added each day?

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