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Sex differences in macronutrient intake and adherence to dietary recommendations: findings from the UK Biobank

Elizabeth Bennett[1,2], Sanne A.E. Peters [1], Mark Woodward[1, 3, 4]

Affiliations:

[1] The George Institute for Global Health, University of Oxford, UK

[2] School of Medicine, Faculty of Medicine, Nursing and Health Sciences, Flinders University, Australia

[3] The George Institute for Global Health, University of New South Wales, Sydney, Australia

[4] Department of Epidemiology, John Hopkins University, Baltimore, Maryland, USA

Correspondence to: Dr Sanne Peters, The George Institute for Global Health University of Oxford, Le Gros Clark Building, South Parks Road, Oxford OX1 3QX, sanne.peters@georgeinstitute.ox.ac.uk

Abstract

Objectives: To characterise gender differences in macronutrient intakes and adherence to dietary recommendations in the United Kingdom (UK) Biobank population.

Design: Cross-sectional population-based study

Setting: United Kingdom Biobank Resource

Participants: 210,106 (52.5% women) individuals with data on dietary behaviour.

Main outcome measures: Men-minus-women mean differences in nutrient intake in grams and as a percentage of energy and men-to-women odds ratios in non-adherence, adjusting for age, socioeconomic status and ethnicity.

Results: There were gender differences in energy intake and distribution. Men had greater intakes of energy, and were less likely to have energy intakes above the estimated average requirement (EAR) compared to women. Small, but significant, gender differences were found in the intakes of all macronutrients. Men had greater absolute intakes of all macronutrients while females had greater intakes of all macronutrients as a percentage of energy. Women were more likely to have intakes that exceeded recommendations for total fat, saturated fat and total sugar. Men were less likely to achieve the minimum recommended intakes for protein, polyunsaturated fat and total carbohydrate. The overwhelming majority of men and women were non-adherent to fibre recommendations. All observed gender differences in dietary intakes were moderated by age and some were moderated by socioeconomic status.

Conclusions: Although the macronutrient composition of the diets of men and women are similar, there are significant gender differences in adherence to dietary recommendations, particularly for sugar. However, given the increased focus on food groups and dietary patterns for nutritional policy, these differences alone may not be useful for policy and health promotion. Future studies that are able to explore the gender differences in intakes of different food groups that are risk factors for diet-related diseases are warranted in order to improve the current understanding of the differential impact of diet on health in women and men.

Strengths and Limitations

The large size of the UK Biobank, with information on dietary behaviour from over 200,000 individuals, permits a comprehensive evaluation of sex differences in dietary behaviours. This is the largest study of dietary data ever undertaken in the UK. Dietary data collection was done through multiple 24-hour recalls, which has been shown to effectively represent normal dietary intakes with less bias than other methods used for large epidemiological studies. Over half of participants completed more than one dietary recall, which meant that estimated energy and nutrient intakes were able to be averaged across repeated assessments. Intakes were compared to current dietary recommendations in the UK, which allowed novel insights into proportional non-adherence in both sexes. However, self-reported dietary data can be subject to recall bias, social desirability bias and bias caused by lack of compliance with a particular risk of underreporting. Given that over 90% of the participants in the UK Biobank are Caucasian, the analyses presented here cannot be generalised to other ethnic groups. The cross-sectional nature of our analyses precluded the examination of associations between dietary behaviours and NCD outcomes in women and men that can only be examined using cohort data. We aim to explore this further in the UK Biobank sample once sufficient follow up data have been collected.

Introduction

Poor quality diet is a leading cause of morbidity and mortality worldwide and the leading risk factor for non-communicable diseases (NCDs) (1-3). Worldwide, the burden of NCD is expected to further increase with population ageing and increasing rates of obesity, together with other diet-related risk factors. Even modest dietary changes are associated with meaningful reductions in cardiovascular disease morbidity and mortality, type 2 diabetes, specific cancer sites and their major risk factors, including hypercholesterolaemia, hypertension, and obesity (4-9).

In the UK and elsewhere, adults continue to consume too much saturated fat, sugar, red and processed meat and sugar-sweetened beverages, while intakes of fruit, vegetables, oily fish and fibre are insufficient (10). Recent analyses indicate that there is little or no evidence of change in the problematic nutrition patterns in UK adults, suggesting that current strategies to improve diet are insufficient at a population level (10-12).

It is widely recognised that sex differences in dietary intakes and dietary behaviour exist, however these are not well characterised (13-18). Previous analyses of dietary intakes in the UK have relied on estimates from the National Diet and Nutrition Survey, a small study limited by well-documented under-reporting, or from estimates of expenditure intakes, which may not accurately reflect actual consumption (10, 19). These national estimates did not examine sex differences as a primary outcome, nor their variation across age and sociodemographic subpopulations.

Optimising dietary habits to improve population health requires systematically identified and evaluated data (20). Thus, a better understanding of dietary patterns of nutrient consumption by men and women is crucial to establish priorities for dietary guidelines and to inform, design and implement strategies for reducing diet-related disease. Identification of sex disparities in dietary intakes and adherence to dietary guidelines can help to subsequently facilitate improvement in population nutrition strategies.

In this study, we therefore aimed to characterise sex differences in macronutrient intakes and adherence to dietary recommendations in the UK Biobank Resource, which includes the largest dietary survey in the UK to date (21).

Methods

Study population

Cross-sectional data were used from the UK Biobank, a large-scale, prospective cohort study among 502 712 men and women aged 40-69 at baseline (21). Between 2006 and 2010, participants attended one of the 22 centres across the UK for detailed baseline assessment that involved collection of questionnaire data, physical measurements, and biological samples. All participants provided electronic informed consent.

Dietary data collection

The baseline assessment included a relatively short set of questions about the frequency of commonly consumed foods. To allow assessment of total energy intake and some other specific nutrients, this approach was supplemented by repeated 24-hour dietary recall questionnaires (22). These questionnaires were first introduced as part of the assessment visit towards the end of the recruitment phase, and were also completed remotely via the internet for those participants who have provided UK Biobank with e-mail addresses. The questionnaires contained questions on the intake of approximately 200 commonly consumed food and drinks on the day prior to the assessment. A total of 208, 641 participants completed the 24-hour recall of diet and were included in the current analyses.

Nutritional data

The nutrient intakes for each participant were calculated using the UK food composition database (23). Each food and beverage listed in the questionnaire was assigned a portion size based on the unit listed in the questionnaire (24). The percentage of energy intake of macronutrients was determined by, first, multiplying the consumption by the metabolizable energy conversion factors and, second, dividing the resulting kilojoule contribution by the total energy intake.

Adherence to dietary guidelines

Adherence to dietary guidelines was assessed by comparing the intakes of macronutrients to recommendations from the most recent UK government guidelines (17, 25, 26). For energy, the maximum recommended values are 10,460 kJ for men and 8,368 kJ for women (Table 1). Finally, the recommended intake for protein is 0.75g per kg of body weight for both sexes. Energy intakes more than four standard deviations from the mean were considered implausible and were excluded when physical activity data are unavailable (27, 28).

Statistical methods

Baseline characteristics are presented as means (standard deviations) for continuous variables and as percentages for categorical variables. General linear models were used to obtain the men-minus-women differences and 95% confidence intervals (CI) in mean energy and macronutrient intake. Logistic regression analyses were used to compute the men-to-women odds ratios (ORs) for adherence to recommended dietary intakes. All analyses were adjusted for age, socioeconomic status (SES) and ethnicity. Five SES groups were defined using the quintiles of the Townsend deprivation index in England from the 2001 Census (29). Subgroup analyses were performed by age group and socioeconomic status. All analyses were conducted using Stata version 14.0.(30)

Results

Of the 210,106 participants who completed the 24-hour dietary recall, the mean age at recruitment was 56 years and 55% was women. On average, men were more likely to be a current or previous smoker, to be overweight or obese, and to have a history of diabetes, cardiovascular disease and hypertension (Table 2).

Energy and macronutrient intakes

Men had a significantly ($p<0.05$) higher energy and macronutrient intake than women, with a mean difference in total energy intake of 1358 kJ per day. However, 42% of women consumed more energy than recommended, compared with 32% of men.

Intake of macronutrients as a percentage of energy intake was greater for women than for men for all macronutrients, with the largest difference being for total sugar intake (22.5% of total energy intake in men compared to 24.2% in women). Sex differences in energy and macronutrient intake decreased with age (Figure 1 and eTable 1). Total energy intake was 1555kJ greater in men than women in participants aged 40-44 years compared to 1157kJ in participants aged 64-69 years old. The differences in total fat, saturated fat and polyunsaturated intakes decreased by 3.8g, 1.6g and 0.5g respectively, between the youngest and oldest participants (p-value for interaction between sex and age < 0.01 for all macronutrients). The differences in carbohydrate, sugar, fibre, and protein intakes decreased by 15.1g, 11g, 0.3g, and 4.1g, respectively, between the youngest and oldest participants (p-values for interaction < 0.01). Sex differences in dietary intakes did not differ materially by socioeconomic status, with the exceptions of sugar and protein intake (eTable 2). The sex difference in sugar intake was 8.5g in the least deprived group and 13.3g in the most deprived group. The sex difference in protein intake was 8.2 g in the least deprived group and 10.3g in the most deprived group.

Adherence to dietary guidelines

Non-adherence to macronutrient intake recommendations was high in both men and women for most macronutrients. More than half of all participants did not adhere to recommendations for the intake of total sugar, fibre, saturated fat, carbohydrate, and polyunsaturated fat (Figure 2). Women were significantly more likely than men to exceed recommended intakes of total sugar (male to female OR for non-adherence: 0.42 [95%CI: 0.41; 0.43]), total fat (0.72 [0.70; 0.77]), and saturated fat (0.95 [0.93; 0.97]). Men were more likely than women to have intakes of polyunsaturated fat (1.36 [1.29; 1.43]), carbohydrates (1.22, [1.20; 1.25]) and protein (1.48 [1.45; 1.52]), that were under the recommended amounts. Women were significantly more

likely than men to have fibre intake below the recommended guidelines (0.74 [0.70; 0.77]), although even then more than 96% of men failed to eat a sufficient amount of fibre.

Non-adherence to dietary guidelines varied by age in both men and women, with evidence that the magnitude of the sex difference in non-adherence increased with age for total carbohydrate and total sugar (Figure 3 and eTables 3 and 4). For fibre, the sex difference in non-adherence was lower among older than among younger participants. The sex difference in non-adherence varied by socioeconomic status for all macronutrients, except polyunsaturated fat and total carbohydrate (eTable 4 and 5).

Discussion

This large study of over 200,000 men and women from the UK Biobank showed that there are some notable sex differences in macronutrient intakes and adherence to dietary recommendations. While adherence to recommended dietary guidelines was suboptimal in both sexes, women were significantly more likely than men to exceed recommended intakes of total sugar, total fat, and saturated fat, whereas men were more likely to have intakes under the recommended amounts of polyunsaturated fat, carbohydrate, and protein. Sex differences in energy and macronutrient intakes varied by age and socioeconomic status, suggesting the need for tailored interventions to optimise dietary behaviour in men and women across the life-course.

The sex differences in energy intake reported here are consistent with the well-established sex differences in energy intake due to differences in physiological composition (26). The National Diet and Nutrition Survey (NDNS), an annual nationally representative survey of 500 adults, found that men have greater absolute intakes of all macronutrients, as was found in this study. The most recent NDNS data found that men consume a greater percentage of total energy from sugar than women, while women consume more fat, saturated fat, carbohydrate and protein as percentage of total energy than men. Apart from sugar intakes, this is consistent with the results of this study where women had greater intakes of all macronutrients. Several analyses of NDNS data have found significant underreporting in this study with a higher rate of underreporting of energy intake in women (19, 31). Hence, our observation that more women than men exceeded their estimated average energy requirement may be an underestimate of the true sex difference in excess energy intake.

Overall, women were more likely to exceed macronutrient recommendations that were *maximum* amounts (i.e. total fat, saturated fat and sugar) while men were less likely to achieve macronutrient recommendations that were *minimum* amounts (i.e. carbohydrate, protein, polyunsaturated fat). This is contrary to the general assumption that women would be more likely to adhere to dietary recommendations and have a higher quality diet (32-34). Most notably, over 20% more women than men exceeded the recommended daily intake of total sugar. There are currently no studies in the UK that examine adherence to dietary guidelines, so it is difficult to place these results in context of the current literature. However, these findings suggest different areas of focus may be useful in targeting adherence to dietary guidelines in men and women, particularly for sugar. Several studies have shown that women have a higher intake of sugar compared to men (35-37). A potential explanation for this difference may be that women in the UK consume more fruit than men (10). Fruit is a source of natural sugar and therefore would result in increased total sugar without increasing free or added sugar intake. However, there is also evidence that women consume more foods high in added sugars than men, such as cookies, chocolate, and ice-cream (38-40). A recent UK governmental report found there is robust evidence that adherence to sugar recommendations would result in substantial cost and health benefits (41). Therefore, future studies should examine sex differences in dietary sources of sugar to identify key foods for policy targeting.

Although this research provides valuable insights into sex differences in dietary behaviour in the UK, there is a move nutritional research and policy towards focusing on the food groups and diet patterns opposed to individual macronutrients (42). Sex differences in food groups, dietary patterns and overall dietary quality were not examined in this study, as this information was not available at the time of analysis. Furthermore, this research does not consider micronutrients, within-individual correlations of different diet components, or that there might be synergistic or antagonistic effects of nutrients that are consumed together. Future studies should investigate these components as this information may provide a more

detailed and holistic analysis of sex differences in diet and would be in line with an increased focus on dietary patterns in nutritional interventions (42). In particular, further exploration of the dietary sources (i.e. fruit and vegetables or processed foods) of sugar will be vital in understanding the association between sex differences in sugar intake.

In conclusion, adherence to UK dietary recommendations for macronutrient intake is suboptimal, particularly for fibre, and varies considerably by sex, particularly for sugar. Given the increased focus on food groups and dietary patterns for nutritional policy, these differences alone may not be suitable for policy and health promotion. Future studies that are able to explore the sex differences in intakes of different food groups that are risk factors for NCDs are warranted in order to improve the current understanding of the differential impact of diet on health in women and men.

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Disclosures
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Funding
None

Conflicts of interests
None

Ethics and permission
UK Biobank has obtained Research Tissue Bank approval from its governing Research Ethics Committee, as recommended by the National Research Ethics Service. No separate ethics approval was required. Permission to use the UK Biobank Resource was approved by the Access Sub-Committee of the UK Biobank Board.

Contributions of authors
EB performed statistical analyses and wrote the first draft of the article. MW and SP conceived the research and produced the final version of the article.

Data sharing statement
The UK Biobank holds the data used in this article.

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Figure legend

Figure 1: Energy (kJ) and macronutrient (g) intakes per year of age by sex
The points represent the age-specific mean daily dietary intake (blue for men, red for women) at different ages. The dashed lines represent the recommended daily intake (blue for men, red for women, orange for men and women). The solid lines represent the linear model relating dietary intake to age (blue for men, red for women).

Figure 2: Adjusted odds ratios (men versus women) for non-adherence to macronutrient intake recommendations
Analyses are adjusted for age, socioeconomic status and ethnicity. Points represent odds ratios and horizontal lines indicate the corresponding 95% confidence intervals.

Figure 3: Non-adherence to dietary recommendations per year of age by sex
The points represent the age-specific non-adherence (blue for men, red for women) at different ages. The solid lines represent the linear model relating non-adherence to age (blue for men, red for women).

Table 1: Recommended dietary intake of energy and macronutrients for adults in the UK

	Recommended daily intake
Energy	
Men	<10, 460 kJ
Women	< 8363 kJ
Fat	
Total Fat	<35% EI
Saturated Fat	<11% EI
Polyunsaturated Fat	6-11% EI
Carbohydrates	
Carbohydrate	>50% EI
Total Sugars	
Men	<120g
Women	<90g
Fibre	≥30g
Protein	0.75g per kg body weight

EI: Energy intake

Table 2: Baseline characteristics of study participants

	Men	Women	Men to women difference [a] (95% CI)
n	93562	115079	
Demographic variables			
Age, years (SD)	56.6 (8.0)	55.6 (7.8)	0.9 (1.0, 0.9)
Ethnicity, white	89, 618 (95.8)	109,982 (95.6)	0.9 (0.9, 1.0)
Socioeconomic status			
Least deprived	34,142 (36.5)	40, 367 (35.1)	1.4 (1.0, 1.8)
Most deprived	7,637 (8.2)	9, 046 (7.9)	0.3 (-0.07, -0.02)
Smoking status, non-smoker	48, 041 (51.4)	69, 713 (60.6)	-9.2 (-9.7, -8.8)
BMI, kg/m^2 (SD)	27.5 (4.1)	26.5 (5.0)	1.0 (1.04, 0.86)
Overweight or obese	67,100 (71.7)	63, 809 (55.5)	16.2 (15.9, 16.7)
History of DM	5,513 (5.9)	3,415 (3.0)	2.9 (2.8, 3.1)
History of CVD	4,130 (4.4)	1,470(1.3)	2.7 (2.5, 2.7)
History of Hypertension	26, 678 (28.5)	24, 006 (20.9)	7.6 (7.2, 8.0)
Dietary macronutrient intake			
Energy (kJ)	9525.1 (8.7)	8168.0 (6.5)	1357.1 (1336.1, 1378.0)
% above EAR	31.9 (0.2)	42.4 (0.1)	10.5 (10.0, 10.6)
Fats (g)			
Total Fat	83.3 (0.1)	72.6 (0.08)	10.9 (10.6, 11.1)
% EI	32.0 (0.02)	32.5 (0.02)	-0.5 (0.6, 0.4)
Saturated Fat	32.2 (0.04)	27.8 (0.03)	4.4 (4.3, 4.5)
% EI	12.3 (0.01)	12.4 (0.01)	-0.1 (-1.1, -0.6)
Polyunsaturated fat	15.2 (0.02)	13.5 (0.02)	1.7 (1.6, 1.8)
% EI	5.8 (0.01)	6.0 (0.01)	-0.2 (0.22, 0.18)
Carbohydrates (g)			
Total sugar	125.4 (0.2)	115.5 (0.1)	9.9 (9.4, 10.2)
% EI	22.5 (0.02)	24.2 (0.02)	-1.7 (-1.8, -1.6)
Total carbohydrate	271.1 (0.3)	237.9 (0.2)	33.2 (32.5, 33.9)
% EI	48.6 (0.03)	49.6 (0.02)	-1.0 (-1.1, -0.9)
Fibre	16.6 (0.02)	16.1 (0.02)	0.5 (0.4, 0.6)
Total protein (g)	86.9 (0.09)	78.0 (0.7)	8.9 (8.7, 9.1)
% EI	15.7 (0.01)	16.5 (0.01)	-0.8 (-0.81, 0.75)

Abbreviations: g: grams; SD: standard deviation; 95% CI: 95% confidence interval, BMI; body mass index; DM; diabetes mellitus; CVD; cardiovascular disease kJ; kilojoules; EAR; estimated average requirement; EI: Energy intake

Continuous variables are expressed as means and standard deviation while categorical variables are expressed as a n and percentages

a- Sex difference calculated as Men-Women, adjusted for age, socioeconomic status and ethnicity

Figure 1

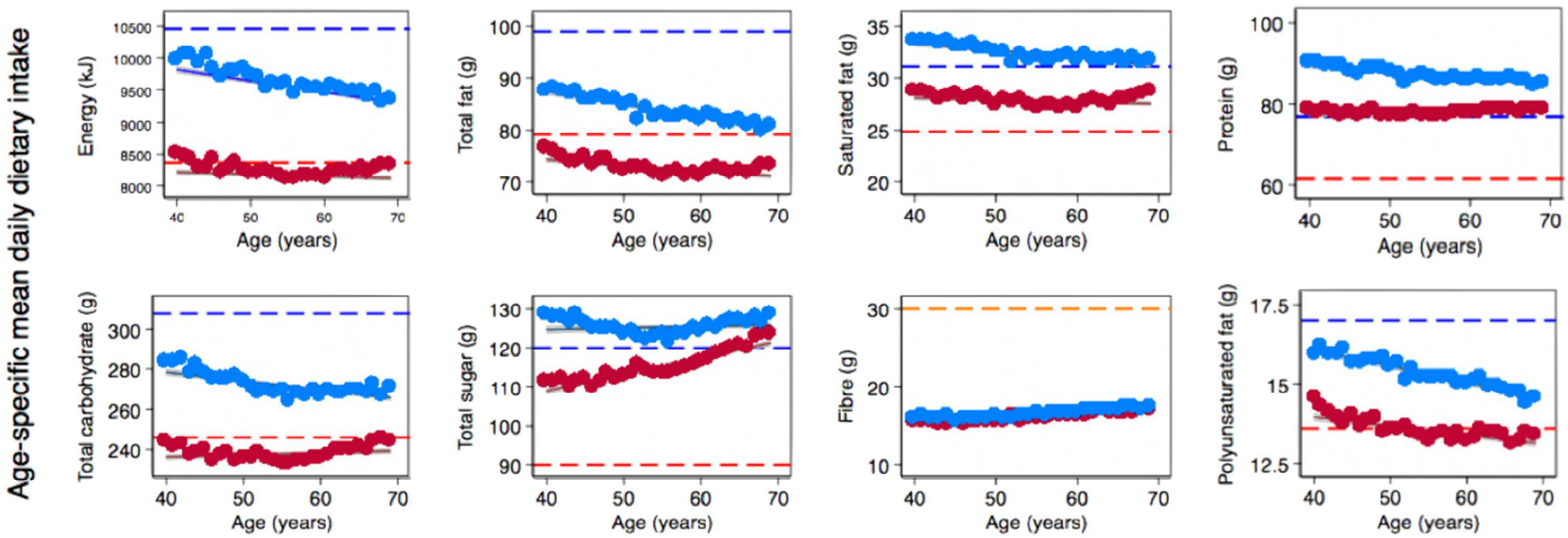
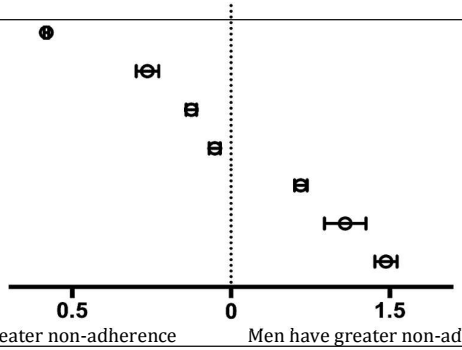


Figure 2

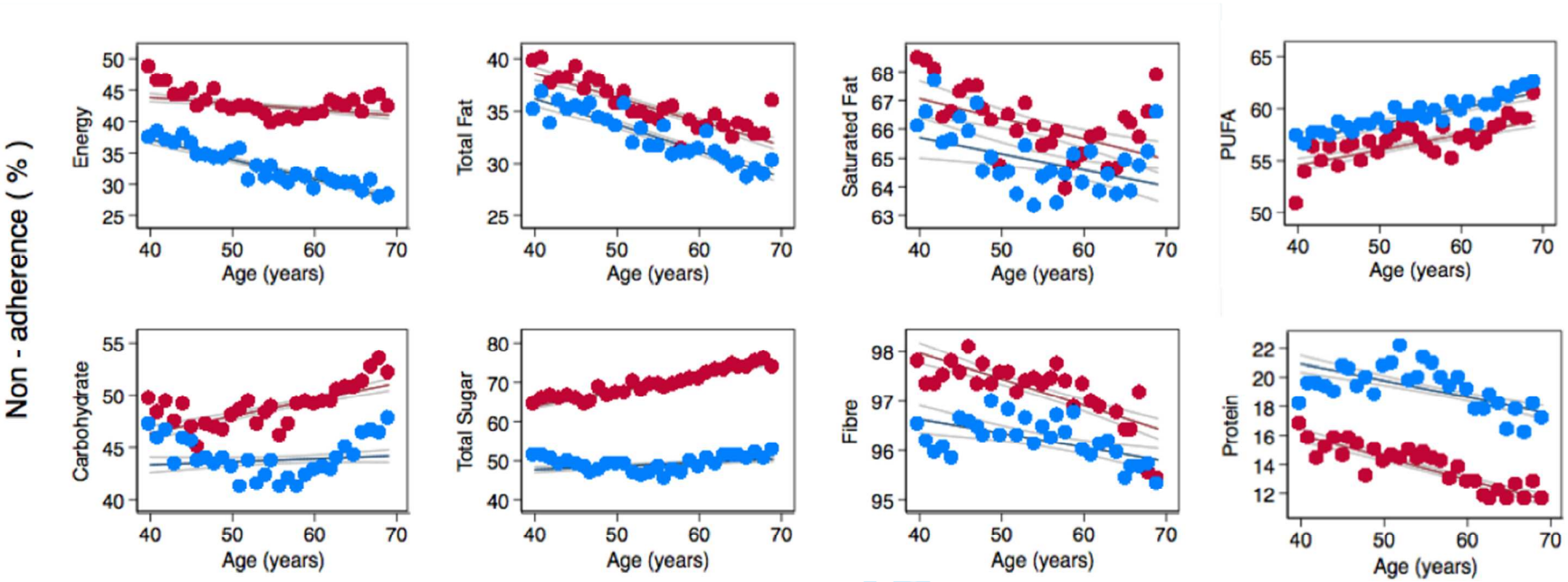
Macronutrient	Percentage non-adherence (±SE)		Adjusted OR (95% CI)
	Men	Women	
Total sugar	49.2 (0.2)	69.9 (0.1)	0.42 (0.41, 0.43)
Fibre	96.2 (0.2)	97.1 (0.1)	0.74 (0.70, 0.77)
Total fat	32.0 (0.2)	35.0 (0.1)	0.88 (0.86, 0.89)
Saturated fat	64.8 (0.2)	66.0 (0.1)	0.95 (0.93, 0.97)
Total carbohydrates	56.2 (0.2)	51.1 (0.1)	1.22 (1.20, 1.25)
Polyunsaturated fat	64.8 (0.2)	66.0 (0.1)	1.36 (1.29, 1.43)
Protein	19.0 (0.1)	13.6 (0.1)	1.48 (1.45, 1.52)



Analyses are adjusted for age and Townsend deprivation index.

OR: odds ratio; SE: standard error; 95% CI: 95% confidence interval

Figure 3



Supplementary appendix

eTable 1 Energy and macronutrient intake by age and sex

	Age group					
	40-44	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**
N						
Women	12728	16617	19s772	22665	27490	15807
Men	9723	11736	13765	17322	23752	17264
Energy Intake						
Women	8293.5 (2367.6)	8220.8 (2298.2)	8138.6 (2223.8)	8069.1 (2157.4)	8153.0 (2156.3)	8216.0 (2212.4)
Men	9848.1 (2931.7)	9697.8 (2825.8)	9544.8 (2720.5)	9471.0 (2621.5)	9446.4 (2534.3)	9372.6 (2530.9)
Mean difference	-1554.6 (-1623.8, -1485.3)	-1477.0 (-1536.7, -1417.1)	-1406.2 (-1459.2, -1353.1)	-1401.9 (-1448.8, -1355.1)	-1293.4 (-1334.0, -1252.7)	-1156.6 (-1208.0, -1105.1)
Total Fat						
Women	75.0 (28.8)	73.9 (28.0)	72.4 (27.2)	71.4 (26.3)	71.9 (26.3)	72.5 (26.4)
Men	87.4 (34.6)	85.8 (33.6)	83.7 (32.4)	82.8 (31.3)	82.2 (30.4)	81.1 (29.9)
Mean difference	-12.4 (-13.2, -11.5)	-11.8 (-12.6, -11.1)	-11.3 (-12.0, -10.7)	-11.3 (-11.9, -10.7)	-10.2 (-10.7, -9.7)	-8.6 (-9.2, -8.0)
Saturated Fat						
Women	28.4 (11.9)	28.2 (11.8)	27.6 (11.5)	27.2 (11.3)	27.6 (11.3)	28.1 (11.6)
Men	33.6 (14.7)	33.0 (14.3)	32.1 (13.7)	31.9 (13.5)	31.8 (13.2)	31.7 (13.2)
Mean difference	-5.2 (-5.5, -4.8)	-4.8 (-5.1, -4.5)	-4.5 (-4.8, -4.2)	-4.7 (-4.9, -4.4)	-4.2 (-4.4, -4.0)	-3.6 (-3.8, -3.3)
PUFA						
Women	14.1 (7.2)	13.8 (7.0)	13.5 (6.8)	13.4 (6.5)	13.4 (6.6)	13.3 (6.6)
Men	16.0 (8.2)	15.7 (8.0)	15.4 (7.8)	15.1 (7.5)	15.0 (7.4)	14.7 (7.3)
Mean difference	-1.9 (-2.1, -1.7)	-1.9 (-2.1, -1.8)	-1.9 (-2.0, -1.7)	-1.8 (-1.9, -1.7)	-1.6 (-1.8, -1.5)	-1.4 (-1.6, -1.3)
Total carbohydrate						
Women	240.6 (78.7)	237.0 (77.0)	236.1 (75.6)	234.2 (73.6)	238.4 (74.1)	243.0 (77.8)
Men	282.1 (94.5)	275.8 (92.5)	269.7 (88.5)	267.6 (86.2)	268.7 (83.5)	269.4 (85.1)
Mean difference	-41.5 (-43.8, -39.2)	-38.8 (-40.8, -36.8)	-33.6 (-35.3, -31.8)	-33.4 (-35.0, -31.9)	-30.3 (-31.7, -29.0)	-26.4 (-28.2, -24.6)
Total sugar						
Women	111.3 (46.2)	111.8 (46.2)	114.0 (45.9)	114.5 (44.6)	118.2 (45.3)	121.8 (48.4)
Men	127.8 (55.8)	125.2 (54.1)	123.1 (51.4)	123.4 (50.2)	125.7 (49.2)	127.4 (50.5)
Mean difference	-16.6 (-17.9, -15.2)	-13.4 (-14.6, -12.2)	-9.2 (-10.2, -8.1)	-8.8 (-9.8,-7.9)	-7.5 (-8.3, -6.7)	-5.6 (-6.7, -4.5)
Fibre						
Women	15.4 (6.5)	15.4 (6.2)	15.9 (6.3)	16.1 (6.2)	16.6 (6.3)	16.9 (6.5)
Men	16.1 (7.0)	16.0 (6.8)	16.2 (6.9)	16.6 (6.7)	17.0 (6.7)	17.3 (6.8)
Mean difference	-0.7 (-0.8, -0.5)	-0.5 (-0.7, -0.4)	-0.3 (-0.5, -0.2)	-0.4 (-0.5, -0.3)	-0.4 (-0.5, -0.3)	-0.4 (-0.5, -0.2)
Protein						
Women	77.9 (24.6)	77.8 (23.7)	77.5 (22.9)	77.4 (22.1)	78.5 (22.0)	78.6 (22.1)
Men	89.9 (30.4)	88.5(29.2)	87.0 (27.6)	86.2 (26.1)	86.0 (25.0)	85.7 (24.9)
Mean difference	-12.0 (-12.7, -11.2)	-10.7 (-11.3, -10.1)	-9.5 (-10.1, -9.0)	-8.8 (-9.2, -8.3)	-7.5 (-7.9, -7.1)	-7.1 (-7.6, -6.6)

Data are mean kJ for energy and grams for macronutrients (standard deviation) for continuous variables in women and men. Mean difference is the women minus men difference (95% confidence interval).

eTable 2 Energy and macronutrient intake by socioeconomic status and sex

	SES

	Most Deprived	SES 2	SES 3	SES 4	Least Deprived
N					
Women	40367	28387	21267	15873	9046
Men	34142	22922	16527	12219	7627
Energy Intake					
Women	8177.3 (2134.6)	8168.1 (2167.3)	8200.7 (2248.6)	8164.2 (2349.7)	8055.7 (2456.5)
Men	9501.6 (2551.2)	9533.9 (2608.6)	9561.9 (2668.2)	9575.8 (2816.5)	9449.0 (3019.0)
Mean difference	-1324.2 (-1357.9, -1290.6)	-1365.7 (-1407.1, -1324.4)	-1361.1 (1410.8, -1311.5)	-1411.7 (-1472.1, -1351.2)	-1393.3 (-1476.4, -1310.1)
Total Fat					
Women	72.3 (26.2)	72.5 (26.4)	73.1 (27.1)	73.1 (28.4)	72.4 (29.4)
Men	83.0 (30.5)	83.3 (31.3)	83.9 (31.8)	83.8 (33.1)	82.7 (35.1)
Mean difference	*-10.7 (-11.1, -10.2)*	*-10.8 (-11.3, -10.3)*	*-10.8 (-11.4, -10.2)*	*-10.7 (-11.5, -10.0)*	*-10.4 (-11.4, -9.4)*
Saturated Fat					
Women	27.7 (11.2)	27.8 (11.3)	27.9 (11.5)	27.9 (12.0)	27.7 (12.5)
Men	32.1 (13.2)	32.2 (13.4)	32.4 (13.8)	32.2 (14.2)	31.9 (15.2)
Mean difference	*-4.4 (-4.6, -4.2)*	*-4.4 (-4.7, -4.2)*	*-4.5 (-4.8, -4.3)*	*-4.3 (-4.6, -4.0)*	*-4.2 (-4.6, -3.8)*
Polyunsaturated Fat					
Women	13.5 (6.6)	13.5 (6.6)	13.6 (6.8)	13.5 (6.9)	13.3 (7.2)
Men	15.2 (7.4)	15.2 (7.6)	15.2 (7.5)	15.4 (8.0)	15.0 (8.1)
Mean difference	*-1.7 (-1.8, -1.6)*	-1.7 (-1.8, -1.6)	*-1.6 (-1.7, -1.5)*	*-1.9 (-2.1, -1.7)*	*-1.7 (-1.9, -1.4)*
Total carbohydrate					
Women	238.2 (72.6)	238.1 (73.9)	238.3 (77.1)	237.5 (79.8)	235.5 (84.2)
Men	270.6 (83.8)	271.6 (85.3)	271.1 (88.2)	272.0 (92.2)	270.3 (99.9)
Mean difference	*-32.5 (-33.6, -31.3)*	*-33.5 (34.9, -32.1)*	*-32.8 (-34.5, -31.1)*	*-34.5 (-36.6, -32.5)*	*-34.8 (-37.6, -32.0)*
Total sugar					
Women	116.7 (44.5)	115.8 (44.8)	115.0 (46.4)	114.2 (47.9)	113.2 (51.7)
Men	125.2 (49.0)	125.5 (49.7)	124.8 (51.4)	125.6 (54.5)	126.5 (60.2)
Mean difference	*-8.5 (-9.2, -7.9)*	*-9.7 (-10.5, -8.8)*	*-9.8 (-10.8, -8.8)*	*-11.4 (-12.6, -10.7)*	*-13.3 (-15.0, -11.6)*
Fibre					
Women	16.3 (6.1)	16.2 (6.2)	16.2 (6.5)	15.9 (6.6)	15.5 (6.9)
Men	16.8 (6.5)	16.7 (6.7)	16.5 (6.8)	16.6 (7.2)	16.0 (7.7)
Mean difference	*-0.5 (-0.6, -0.4)*	*-0.6 (-0.7, -0.5)*	*-0.3 (-0.4, -0.2)*	*-0.7 (-0.8, -0.5)*	*-0.5 (-0.7, -0.3)*
Protein					
Women	78.7 (21.7)	78.1 (22.0)	77.9 (23.1)	77.1 (24.4)	75.8 (25.4)
Men	86.9 (25.2)	87.0 (25.9)	86.8 (27.1)	87.0 (29.0)	86.1 (31.2)
Mean difference	*8.2 (-8.5, -7.8)*	*-8.8 (-9.3, -8.4)*	*-8.9 (-9.4, -8.4)*	*-9.9 (-10.5, -9.2)*	*-10.4 (-11.2, -9.5)*

Data are mean kJ for energy and grams for macronutrients (standard deviation) for continuous variables in women and men. Mean difference is the women minus men difference (95% confidence interval).

eTable 3: Non-adherence (%) to dietary recommendations by age and sex

	Age group					
	40-44	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**
N						
Women	12728	16617	19772	22665	27490	15807
Men	9723	11736	13765	17322	23752	17264
Energy Intake						
Women	45.4 (49.8)	43.4 (49.6)	41.9 (49.3)	40.3 (49.0)	42.1 (49.4)	42.8 (49.5)
Men	37.3 (45.4)	34.8 (43.4)	32.7 (41.9)	31.1 (46.3)	30.3 (45.9)	29.2 (45.5)
Mean difference	8.1 (6.8, 9.4)	8.6 (7.4, 9.7)	9.2 (8.1, 10.2)	9.2 (8.2, 10.1)	11.9 (11.0, 12.7)	13.7 (12.6, 14.7)
Total Fat						
Women	38.5 (48.7)	37.7 (48.5)	35.2 (47.8)	33.9 (47.3)	33.4 (47.2)	33.6 (47.2)
Men	35.4 (47.8)	34.8 (47.6)	33.1 (47.0)	31.5 (46.5)	31.0 (46.3)	29.4 (45.5)
Mean difference	3.1 (1.9, 4.4)	2.9 (1.8, 4.0)	2.1 (1.1, 3.1)	2.4 (1.4, 3.3)	2.4 (1.6, 3.2)	4.2 (3.2, 5.2)
Saturated Fat						
Women	67.4 (46.9)	67.0 (47.0)	66.0 (47.4)	65.1 (47.7)	65.2 (47.6)	66.4 (47.2)
Men	66.3 (47.3)	65.7 (47.5)	64.2 (47.9)	64.4 (47.9)	64.2 (47.9)	64.9 (47.7)
Mean difference	1.1 (-0.1, 2.4)	1.3 (0.1, 2.4)	1.8 (0.7, 2.7)	0.7 (-0.2, 1.6)	1.0 (0.1, 1.8)	1.5 (0.5, 2.6)
PUFA						
Women	54.7 (49.8)	55.7 (49.7)	57.2 (49.5)	56.4 (49.6)	57.2 (49.5)	59.2 (49.1)
Men	57.3 (49.5)	58.2 (49.3)	59.0 (49.2)	59.6 (49.1)	59.8 (49.0)	61.7 (48.6)
Mean difference	-2.6 (-3.9, -1.2)	-2.5 (-2.6, -1.2)	-1.8 (-2.9, -0.7)	-3.2 (-4.1, -2.2)	-2.6 (-3.5, -1.8)	-2.5 (-3.5, -1.4)
Total carbohydrate						
Women	51.3 (50.0)	53.5 (49.9)	51.7 (50.0)	51.9 (50.0)	50.3 (50.0)	48.1 (50.0)
Men	54.4 (49.8)	55.9 (49.6)	57.7 (49.4)	57.9 (49.4)	56.5 (49.6)	53.9 (49.8)
Mean difference	-3.1 (-4.4, -1.7)	-2.4 (-3.6, -1.3)	-6.0 (-7.1, -4.9)	-6.0 (-7.0, -5.0)	-6.2 (-7.1, -5.4)	-5.8 (-6.9, -4.7)
Total sugar						
Women	65.8 (47.4)	66.1 (47.3)	68.5 (46.5)	69.7 (46.0)	72.6 (44.6)	74.3 (43.7)
Men	50.2 (50.0)	48.2 (50.0)	47.6 (49.9)	47.8 (50.0)	49.9 (50.0)	51.3 (50.0)
Mean difference	15.6 (14.3, 16.9)	17.9 (16.8, 19.1)	20.9 (19.9, 22.0)	21.9 (21.0, 22.9)	22.6 (21.8, 23.5)	22.9 (21.9, 24.0)
Fibre						
Women	97.5 (15.5)	97.6 (15.3)	97.4 (15.9)	97.3 (16.1)	96.8 (17.5)	96.3 (18.9)
Men	96.1 (19.5)	96.6 (18.1)	96.4 (18.6)	96.5 (18.3)	96.0 (19.5)	95.5 (20.6)
Mean difference	1.4 (1.0, 1.9)	1.0 (0.6, 1.4)	1.0 (0.6, 1.4)	0.8 (0.5, 1.2)	0.8 (0.5, 1.1)	0.7 (0.3, 1.2)
Protein						
Women	15.4 (36.1)	14.7 (35.4)	14.5 (35.2)	14.0 (34.7)	12.2 (32.7)	12.0 (32.5)
Men	19.2 (39.4)	19.8 (39.9)	20.7 (40.5)	20.2 (40.1)	18.2 (38.6)	17.0 (37.6)
Mean difference	-3.8 (-4.7, -2.8)	-5.1 (-6.0, -4.2)	-6.2 (-7.0, -5.4)	-6.2 (-6.9, -5.5)	-6.0 (-6.6, -5.4)	-5.0 (-5.8, -4.3)

Data are percentage non-adherence (standard deviation) and women minus men mean difference (95% confidence interval).

eTable 4: Odds ratio (men versus women) and 95% confidence intervals for non-adherence to macronutrient intake recommendations, by age

	Age group						P-value for interaction
	40-44	45-49	50-54	55-59	60-64	65-69	
N							
Women	12728	16617	19772	22665	27490	15807	
Men	9723	11736	13765	17322	23752	17264	
Total Fat	0.87 (0.83, 0.92)	0.88 (0.84, 0.93)	0.91 (0.87, 0.95)	0.90 (0.86, 0.94)	0.90 (0.86, 0.93)	0.82 (0.78, 0.86)	0.343
Saturated Fat	0.95 (0.90, 1.01)	0.95 (0.90, 0.99)	0.93 (0.88, 0.97)	0.97 (0.93, 1.01)	0.96 (0.93, 1.8)	0.93 (0.89, 0.98)	0.898
Polyunsaturated Fat	1.11 (1.05, 1.17)	1.10 (1.05, 1.16)	1.08 (1.03, 1.12)	1.14 (1.09, 1.18)	1.12 (1.08, 1.16)	1.11 (1.06, 1.16)	0.649
Total carbohydrate	1.13 (1.07, 1.19)	1.10 (1.05, 1.16)	1.27 (1.22, 133)	1.28 (1.23, 1.33)	1.29 (1.24, 1.33)	1.26 (1.21, 1.32)	<0.001
Total sugar	0.52 (0.50, 0.55)	0.48 (0.45, 0.50)	0.42 (0.40, 0.44)	0.40 (0.38, 0.41)	0.38 (0.36, 0.39)	0.37 (0.35, 0.38)	<0.001
Fibre	0.62 (0.53, 0.72)	0.70 (0.61, 0.80)	0.71 (0.63, 0.81)	0.76 (0.68, 0.85)	0.79 (0.72, 0.87)	0.83 (0.74, 0.92)	0.037
Protein	1.30 (1.21, 1.40)	1.43 (1.35, 1.52)	1.54 (1.45, 1.63)	1.56 (1.48, 1.64)	1.60 (1.52, 1.68)	1.51 (1.41, 1.60)	0.072

Odds ratios were adjusted for Townsend deprivation index and ethnicity

eTable 5: Non-adherence (%) to dietary recommendations by socioeconomic status and sex

	SES				
	Most Deprived	**SES 2**	**SES 3**	**SES 4**	**Least Deprived**
N					
Women	40367	28387	21267	15873	9046
Men	34142	22922	16527	12219	7627
Energy Intake					
Women	42.5 (49.4)	42.5 (49.4)	42.9 (49.5)	42.1 (49.4)	40.3 (49.0)
Men	31.2 (46.3)	31.5 (46.4)	32.7 (46.9)	33.3 (47.1)	32.3 (46.8)
Mean difference	11.3 (10.6, 12.0)	11.3 (10.2, 11.8)	10.2 (9.3, 11.2)	8.8 (7.7, 10.0)	8.0 (6.5, 9.5)
Total Fat					
Women	33.8 (47.3)	34.4 (47.5)	36.0 (48.0)	36.1 (48.0)	38.0 (48.5)
Men	31.1 (46.3)	32.0 (46.7)	32.5 (46.8)	33.0 (47.0)	33.9 (47.3)
Mean difference	2.7 (2.1, 3.4)	2.4 (1.6, 3.2)	3.5 (2.5, 4.5)	3.1 (2.0, 4.3)	4.1 (2.6, 5.6)
Saturated Fat					
Women	65.8 (47.4)	66.0 (47.4)	66.2 (47.3)	66.1 (47.3)	66.1 (47.3)
Men	65.0 (47.7)	65.1 (47.7)	65.2 (47.6)	63.9 (48.0)	63.0 (48.3)
Mean difference	0.8 (0.1, 1.4)	0.9 (0.1, 1.7)	1.0 (0.3, 2.0)	2.2 (1.1, 3.3)	3.1 (1.7, 4.6)
Polyunsaturated Fat					
Women	56.5 (49.6)	56.3 (49.6)	56.7 (49.6)	57.6 (49.4)	59.1 (49.2)
Men	58.9 (49.2)	59.5 (49.1)	59.9 (49.0)	60.1 (49.0)	60.7 (48.8)
Mean difference	-2.4 (-3.1, -1.7)	-3.3 (-4.2, -2.4)	-3.2 (-4.2, -2.2)	-2.5 (-3.6, -1.3)	-1.4 (-3.1, -0.1)
Total carbohydrate					
Women	51.2 (50.0)	50.7 (50.0)	51.7 (50.0)	51.3 (50.0)	50.2 (50.0)
Men	56.2 (49.6)	56.2 (49.6)	56.7 (49.5)	56.4 (49.6)	54.6 (49.8)
Mean difference	-5.0 (-5.7, -4.3)	-5.5 (-6.4, -4.6)	-5.0 (-6.0, -4.0)	-5.1 (-6.3, -3.9)	-4.4 (-5.9, -2.9)
Total sugar					
Women	71.5 (45.2)	70.9 (45.4)	69.2 (46.2)	67.7 (46.8)	64.7 (47.8)
Men	49.8 (50.0)	49.6 (50.0)	48.5 (50.0)	48.8 (50.0)	48.2 (50.0)
Mean difference	21.7 (21, 22.3)	-5.5 (-6.4, -4.6)	-5.0 (-6.0, -4.0)	-5.1 (-6.3, -3.9)	-4.4 (-5.9, -2.9)
Fibre					
Women	97.3 (16.2)	97.4 (16.0)	97.0 (17.2)	96.9 (17.4)	96.6 (18.0)
Men	96.6 (18.2)	96.2 (19.2)	96.2 (19.0)	95.5 (20.7)	95.1 (21.5)
Mean difference	0.7 (0.5, 1.0)	1.2 (0.9, 1.5)	0.7 (0.4, 1.1)	1.4 (0.9, 1.8)	1.5 (0.9, 2.1)
Protein					
Women	11.4 (31.8)	12.7 (33.2)	14.0 (34.7)	16.9 (37.5)	20.1 (40.1)
Men	17.2 (37.8)	18.5 (38.8)	19.5 (39.6)	21.2 (40.9)	24.1 (42.8)
Mean difference	-5.8 (-6.3, -5.3)	-5.8 (-6.5, -5.2)	-5.5 (-6.3, -4.8)	-4.3 (-5.2, -3.3)	-4.0 (-5.2, -2.7)

Data are percentage non-adherence (standard deviation) and women minus men mean difference (95% confidence interval).

eTable 6: Odds ratio (men versus women) and 95% confidence intervals for non-adherence to macronutrient intake recommendations, by socioeconomic status

	SES					P-value for interaction
	Least Deprived	SES 2	SES 3	SES 4	Most deprived	
N						
Women	40367	28387	21267	15873	9046	
Men	34142	22922	16527	12219	7627	
Total Fat	0.88 (0.85, 0.91)	0.90 (0.86, 0.93)	0.86 (0.82, 0.89)	0.87 (0.83, 0.91)	0.84 (0.79, 0.89)	0.033
Saturated Fat	0.97 (0.94, 0.99)	0.96 (0.93, 0.99)	0.96 (0.92, 0.99)	0.91 (0.86, 0.95)	0.87 (0.82, 0.93)	<0.001
Polyunsaturated Fat	1.10 (1.07, 1.13)	1.14 (1.11, 1.19)	1.14 (1.09, 1.19)	1.11 (1.05, 1.16)	1.07 (1.01, 1.14)	0.857
Total carbohydrate	1.22 (1.19, 1.26)	1.25 (1.20, 1.29)	1.22 (1.17, 1.27)	1.23 (1.17, 1.29)	1.19 (1.12, 1.27)	0.871
Total sugar	0.40 (0.38, 0.41)	0.40 (0.39, 0.42)	0.42 (0.40, 0.44)	0.45 (0.43, 0.48)	0.51 (0.48, 0.54)	<0.001
Fibre	0.78 (0.72, 0.85)	0.68 (0.62, 0.75)	0. 80 (0.72, 0.90)	0.69 (0.61, 0.78)	0.68 (0.58, 0.79)	0.013
Protein	1.61 (1.55, 1.68)	1.57 (1.49, 1.64)	1.49 (1.42, 1.58)	1.32 (1.25, 1.41)	1.26 (1.17, 1.35)	<0.001

Odds ratios were adjusted for age and ethnicity

STROBE Statement—checklist of items that should be included in reports of observational studies

All items are addressed in the manuscript, tables, and supporting materials

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Page 1 and 2**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Page 5**
Objectives	3	State specific objectives, including any prespecified hypotheses **Page 5**
Methods		
Study design	4	Present key elements of study design early in the paper **Page 6**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Page 6**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Page 6, supplementary table 1**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Page 6, 7**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Page 6, 7**
Bias	9	Describe any efforts to address potential sources of bias **Page 6, 7**
Study size	10	Explain how the study size was arrived at **Page 6**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Page 6, 7**

Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Page 6**
		(*b*) Describe any methods used to examine subgroups and interactions **Page 7, 8**
		(*c*) Explain how missing data were addressed **Page 6**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **Page 6**
		(*e*) Describe any sensitivity analyses **Page 7**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Page 10**
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Page 10**
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time **Page 10**
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Page 10, 11, Tables**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Page 10, 11**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Page 12**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias

		Page 4
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Page 12-14**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Page 12-14**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Page 15**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Sex differences in macronutrient intake and adherence to dietary recommendations: findings from the UK Biobank

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Sex differences in macronutrient intake and adherence to dietary recommendations: findings from the UK Biobank

Elizabeth Bennett[1,2], Sanne A.E. Peters [1], Mark Woodward[1, 3, 4]

Affiliations:

[1] The George Institute for Global Health, University of Oxford, UK

[2] School of Medicine, Faculty of Medicine, Nursing and Health Sciences, Flinders University, Australia

[3] The George Institute for Global Health, University of New South Wales, Sydney, Australia

[4] Department of Epidemiology, John Hopkins University, Baltimore, Maryland, USA

Correspondence to: Dr Sanne Peters, The George Institute for Global Health University of Oxford, Le Gros Clark Building, South Parks Road, Oxford OX1 3QX, sanne.peters@georgeinstitute.ox.ac.uk

Abstract

Objectives: To characterise gender differences in macronutrient intakes and adherence to dietary recommendations in the United Kingdom (UK) Biobank population.

Design: Cross-sectional population-based study

Setting: United Kingdom Biobank Resource

Participants: 210,106 (52.5% women) individuals with data on dietary behaviour.

Main outcome measures: Men-minus-women mean differences in nutrient intake in grams and as a percentage of energy and men-to-women odds ratios in non-adherence, adjusting for age, socioeconomic status and ethnicity.

Results: There were gender differences in energy intake and distribution. Men had greater intakes of energy, and were less likely to have energy intakes above the estimated average requirement (EAR) compared to women. Small, but significant, gender differences were found in the intakes of all macronutrients. Men had greater absolute intakes of all macronutrients while females had greater intakes of all macronutrients as a percentage of energy. Women were more likely to have intakes that exceeded recommendations for total fat, saturated fat and total sugar. Men were less likely to achieve the minimum recommended intakes for protein, polyunsaturated fat and total carbohydrate. The overwhelming majority of men and women were non-adherent to fibre recommendations. All observed gender differences in dietary intakes were moderated by age and some were moderated by socioeconomic status.

Conclusions: Although the macronutrient composition of the diets of men and women are similar, there are significant gender differences in adherence to dietary recommendations, particularly for sugar. However, given the increased focus on food groups and dietary patterns for nutritional policy, these differences alone may not be useful for policy and health promotion. Future studies that are able to explore the gender differences in intakes of different food groups that are risk factors for diet-related diseases are warranted in order to improve the current understanding of the differential impact of diet on health in women and men.

Strengths and Limitations

- The availability of 24-hour recall data on dietary behaviour from over 200,000 individuals permits a comprehensive evaluation of sex differences in dietary behaviours.
- Self-reported dietary data can be subject to recall bias, social desirability bias, and underreporting, which may be sex differential.
- Given that over 90% of the participants in the UK Biobank are Caucasian, the present analyses cannot be generalised to other ethnic groups.
- The cross-sectional nature of our analyses precluded the examination of associations between dietary behaviours and health outcomes.

Introduction

Poor quality diet is a leading cause of morbidity and mortality worldwide and the leading risk factor for non-communicable diseases (NCDs) (1-3). Worldwide, the burden of NCD is expected to further increase with population ageing and increasing rates of obesity, together with other diet-related risk factors. Even modest dietary changes are associated with meaningful reductions in cardiovascular disease morbidity and mortality, type 2 diabetes, specific cancer sites and their major risk factors, including hypercholesterolaemia, hypertension, and obesity (4-9).

In the UK and elsewhere, adults continue to consume too much saturated fat, sugar, red and processed meat and sugar-sweetened beverages, while intakes of fruit, vegetables, oily fish and fibre are insufficient (10). Recent analyses indicate that there is little or no evidence of change in the problematic nutrition patterns in UK adults, suggesting that current strategies to improve diet are insufficient at a population level (10-12).

It is widely recognised that sex differences in dietary intakes and dietary behaviour exist, however these are not well characterised (13-18). Previous analyses of dietary intakes in the UK have relied on estimates from the National Diet and Nutrition Survey, a small study limited by well-documented under-reporting, or from estimates of expenditure intakes, which may not accurately reflect actual consumption (10, 19). These national estimates did not examine sex differences as a primary outcome, nor their variation across age and sociodemographic subpopulations.

Optimising dietary habits to improve population health requires systematically identified and evaluated data (20). Thus, a better understanding of dietary patterns of nutrient consumption by men and women is crucial to establish priorities for dietary guidelines and to inform, design and implement strategies for reducing diet-related disease. Identification of sex disparities in dietary intakes and adherence to dietary guidelines can help to subsequently facilitate improvement in population nutrition strategies.

In this study, we therefore aimed to characterise sex differences in macronutrient intakes and adherence to dietary recommendations in the UK Biobank, which includes the largest dietary survey in the UK to date (21).

Methods

Study population

Cross-sectional data were used from the UK Biobank, a large-scale, prospective cohort study among 502 712 men and women aged 40-69 at baseline (21). Between 2006 and 2010, participants attended one of the 22 centres across the UK for detailed baseline assessment that involved collection of questionnaire data, physical measurements, and biological samples. All participants provided electronic informed consent.

Dietary data collection

Information about dietary behaviour was collected using 24-hour dietary recall questionnaires.(22)
The questionnaires contained questions on the intake of over 200 food and drink items, grouped into broad categories, over the last 24 h. Where the foods did not match the items listed exactly, participants were encouraged to try and choose a food or a combination of foods that most closely resembles what they had; and to not duplicate food items. Participants were asked whether what they ate and drank yesterday was typical, and if not, the reason; and whether they routinely followed a special diet, and if so, what kind of diet. So that the replies could be coded automatically to provide estimated daily nutrient intake, open-ended questions were avoided, although some free text boxes were available for use when the options listed did not cover a particular food item. The e-mail invitations were issued on specific days of the week in order to capture variations in intake between week days and week-end days. For the first and second round of e-mail invitations, participants were allowed 3 days to complete the questionnaire, after which time the link had expired; this was extended to 14 days for the third and fourth round of e-mail invitations. These questionnaires were first introduced as part of the assessment visit towards the end of the recruitment phase, and were also completed remotely via the internet for those participants who have provided UK Biobank with e-mail addresses.

Nutritional data

The nutrient intakes for each participant were calculated using the UK food composition database (23). Each food and beverage listed in the questionnaire was assigned a portion size based on the unit listed in the questionnaire (24). The percentage of energy intake of macronutrients was determined by, first, multiplying the consumption by the metabolizable energy conversion factors and, second, dividing the resulting kilojoule contribution by the total energy intake.

Adherence to dietary guidelines

Adherence to dietary guidelines was assessed by comparing the intakes of macronutrients to recommendations from the most recent UK government guidelines (17, 25, 26). For energy, the maximum recommended values are 10,460 kJ for men and 8,368 kJ for women (Table 1). Finally, the recommended intake for protein is 0.75g per kg of body weight for both sexes. Energy intakes more than four standard deviations from the mean were considered implausible, thus excluding 547 women and 413 men (27, 28).

Statistical methods

Baseline characteristics are presented as means (standard deviations) for continuous variables and as percentages for categorical variables. General linear models were used to obtain the men-minus-women differences and 95% confidence intervals (CI) in mean energy and macronutrient intake. Logistic regression analyses were used to compute the men-to-women odds ratios (ORs) for adherence to recommended dietary intakes. All analyses were adjusted for age, ethnicity, and socioeconomic status (SES), measured using the Townsend deprivation index, a measure of material deprivation within a population. Five SES groups were defined using the quintiles of the Townsend deprivation index in England from the 2001 Census (29). Subgroup analyses were performed by age group, socioeconomic status, and body mass index (BMI). All analyses were conducted using Stata version 14.0.(30)

Results

Of the 210,106 participants with 24-hour dietary recall data, the mean age at recruitment was 56 years and 55% was women. On average, men were more likely to be a current or previous smoker, to be overweight or obese, and to have a history of diabetes, cardiovascular disease and hypertension (Table 2).

Energy and macronutrient intakes

Men had a significantly ($p<0.05$) higher energy and macronutrient intake than women, with a mean difference in total energy intake of 1358 kJ per day. However, 42% of women consumed more energy than recommended, compared with 32% of men.

Intake of macronutrients as a percentage of energy intake was greater for women than for men for all macronutrients, with the largest difference being for total sugar intake (22.5% of total energy intake in men compared to 24.2% in women). Sex differences in energy and macronutrient intake decreased with age (Figure 1 and eTable 1). Total energy intake was 1555kJ greater in men than women in participants aged 40-44 years compared to 1157kJ in participants aged 64-69 years old. The differences in total fat, saturated fat and polyunsaturated intakes decreased by 3.8g, 1.6g and 0.5g respectively, between the youngest and oldest participants (p-value for interaction between sex and age < 0.01 for all macronutrients). The differences in carbohydrate, sugar, fibre, and protein intakes decreased by 15.1g, 11g, 0.3g, and 4.1g, respectively, between the youngest and oldest participants (p-values for interaction < 0.01). Sex differences in dietary intakes did not differ materially by socioeconomic status, with the exceptions of sugar and protein intake (eTable 2). The sex difference in sugar intake was 8.5g in the least deprived group and 13.3g in the most deprived group. The sex difference in protein intake was 8.2 g in the least deprived group and 10.3g in the most deprived group. Sex differences in energy and macronutrient intake were smaller among obese individuals, compared to those with a healthy BMI (eTable 3). The sex difference in total fat and sugar intake,

respectively, were 11.5g and 13.2 g among those with a healthy BMI compared to 9.6g and 5.9g among those with obesity.

Adherence to dietary guidelines

Non-adherence to macronutrient intake recommendations was high in both men and women for most macronutrients. More than half of all participants did not adhere to recommendations for the intake of total sugar, fibre, saturated fat, carbohydrate, and polyunsaturated fat (Figure 2). Women were significantly more likely than men to exceed recommended intakes of total sugar (male to female OR for non-adherence: 0.42 [95%CI: 0.41; 0.43]), total fat (0.72 [0.70; 0.77]), and saturated fat (0.95 [0.93; 0.97]). Men were more likely than women to have intakes of polyunsaturated fat (1.36 [1.29; 1.43]), carbohydrates (1.22, [1.20; 1.25]) and protein (1.48 [1.45; 1.52]), that were under the recommended amounts. Women were significantly more likely than men to have fibre intake below the recommended guidelines (0.74 [0.70; 0.77]), although even then more than 96% of men failed to eat a sufficient amount of fibre.

Non-adherence to dietary guidelines varied by age in both men and women, with evidence that the magnitude of the sex difference in non-adherence increased with age for total carbohydrate and total sugar (Figure 3 and eTables 4 and 5). For fibre, the sex difference in non-adherence was lower among older than among younger participants. The sex difference in non-adherence varied by socioeconomic status for all macronutrients, except polyunsaturated fat and total carbohydrate (eTable 6 and 7). Sex differences in non-adherence to dietary guidelines varied across BMI categories for all macronutrients, except fats (eTable 8 and 9).

Discussion

This large study of over 200,000 men and women from the UK Biobank showed that there are some notable sex differences in macronutrient intakes and adherence to dietary recommendations. While adherence to recommended dietary guidelines was suboptimal in both sexes, women were significantly more likely than men to exceed recommended intakes of total sugar, total fat, and saturated fat, whereas men were more likely to have intakes under the recommended amounts of polyunsaturated fat, carbohydrate, and protein. Sex differences in energy and macronutrient intakes varied by age and socioeconomic status, suggesting the need for tailored interventions to optimise dietary behaviour in men and women across the life-course.

The sex differences in energy intake reported here are consistent with the well-established sex differences in energy intake due to differences in physiological composition (26). The National Diet and Nutrition Survey (NDNS), an annual nationally representative survey of 500 adults, found that men have greater absolute intakes of all macronutrients, as was found in this study. The most recent NDNS data found that men consume a greater percentage of total energy from sugar than women, while women consume more fat, saturated fat, carbohydrate and protein as percentage of total energy than men. Apart from sugar intakes, this is consistent with the results of this study where women had greater intakes of all macronutrients. Several analyses of NDNS data have found significant underreporting in this study with a higher rate of underreporting of energy intake in women (19, 31). Hence, our observation that more women than men exceeded their estimated average energy requirement may be an underestimate of the true sex difference in excess energy intake.

Overall, women were more likely to exceed macronutrient recommendations that were *maximum* amounts (i.e. total fat, saturated fat and sugar) while men were less likely to achieve macronutrient recommendations that were *minimum* amounts (i.e. carbohydrate, protein, polyunsaturated fat). This is contrary to the general assumption that women would be more likely to adhere to dietary recommendations and have a higher quality diet (32-34). Most notably, over 20% more women than men exceeded the recommended daily intake of total sugar. There are currently no studies in the UK that examine adherence to dietary guidelines, so it is difficult to place these results in context of the current literature. However, these findings suggest different areas of focus may be useful in targeting adherence to dietary guidelines in men and women, particularly for sugar. Several studies have shown that women have a higher intake of sugar compared to men (35-37). A potential explanation for this difference may be that women in the UK consume

more fruit than men (10). Fruit is a source of natural sugar and therefore would result in increased total sugar without increasing free or added sugar intake. However, there is also evidence that women consume more foods high in added sugars than men, such as cookies, chocolate, and ice-cream (38-40). A recent UK governmental report found there is robust evidence that adherence to sugar recommendations would result in substantial cost and health benefits (41). Therefore, future studies should examine sex differences in dietary sources of sugar to identify key foods for policy targeting.

Although this research provides valuable insights into sex differences in dietary behaviour in the UK, there is a move nutritional research and policy towards focusing on the food groups and diet patterns opposed to individual macronutrients (42). Sex differences in food groups, dietary patterns and overall dietary quality were not examined in this study, as this information was not available at the time of analysis. Furthermore, this research does not consider micronutrients, within-individual correlations of different diet components, or that there might be synergistic or antagonistic effects of nutrients that are consumed together. Future studies should investigate these components as this information may provide a more detailed and holistic analysis of sex differences in diet and would be in line with an increased focus on dietary patterns in nutritional interventions (42). In particular, further exploration of the dietary sources (i.e. fruit and vegetables or processed foods) of sugar will be vital in understanding the association between sex differences in sugar intake.

In conclusion, adherence to UK dietary recommendations for macronutrient intake is suboptimal, particularly for fibre, and varies considerably by sex, particularly for sugar. Given the increased focus on food groups and dietary patterns for nutritional policy, these differences alone may not be suitable for policy and health promotion. Future studies that are able to explore the sex differences in intakes of different food groups that are risk factors for NCDs are warranted in order to improve the current understanding of the differential impact of diet on health in women and men.

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This research has been conducted using the UK Biobank Resource

Disclosures

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Funding

None

Conflicts of interests

None

Ethics and permission

UK Biobank has obtained Research Tissue Bank approval from its governing Research Ethics Committee, as recommended by the National Research Ethics Service. No separate ethics approval was required. Permission to use the UK Biobank Resource was approved by the Access Sub-Committee of the UK Biobank Board.

Contributions of authors

EB performed statistical analyses and wrote the first draft of the article. MW and SP conceived the research and produced the final version of the article.

Data sharing statement

The UK Biobank holds the data used in this article.

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Figure legend

Figure 1: Energy (kJ) and macronutrient (g) intakes per year of age by sex
The points represent the age-specific mean daily dietary intake (blue for men, red for women) at different ages. The dashed lines represent the recommended daily intake (blue for men, red for women, orange for men and women). The solid lines represent the linear model relating dietary intake to age (blue for men, red for women).

Figure 2: Adjusted odds ratios (men versus women) for non-adherence to macronutrient intake recommendations
Analyses are adjusted for age, socioeconomic status and ethnicity. Points represent odds ratios and horizontal lines indicate the corresponding 95% confidence intervals.

Figure 3: Non-adherence to dietary recommendations per year of age by sex
The points represent the age-specific non-adherence (blue for men, red for women) at different ages. The solid lines represent the linear model relating non-adherence to age (blue for men, red for women).

Table 1: Recommended dietary intake of energy and macronutrients for adults in the UK

	Recommended daily intake
Energy	
Men	<10, 460 kJ
Women	< 8363 kJ
Fat	
Total Fat	<35% EI
Saturated Fat	<11% EI
Polyunsaturated Fat	6-11% EI
Carbohydrates	
Carbohydrate	>50% EI
Total Sugars	
Men	<120g
Women	<90g
Fibre	≥30g
Protein	0.75g per kg body weight

EI: Energy intake

Table 2: Baseline characteristics of study participants

	Men	Women	Men to women difference [a] (95% CI)
n	93562	115079	
Demographic variables			
Age, years (SD)	56.6 (8.0)	55.6 (7.8)	0.9 (1.0, 0.9)
Ethnicity, white	89, 618 (95.8)	109,982 (95.6)	0.9 (0.9, 1.0)
Socioeconomic status			
Least deprived	34,142 (36.5)	40, 367 (35.1)	1.4 (1.0, 1.8)
Most deprived	7,637 (8.2)	9, 046 (7.9)	0.3 (-0.07, -0.02)
Smoking status, non-smoker	48, 041 (51.4)	69, 713 (60.6)	-9.2 (-9.7, -8.8)
BMI, kg/m^2 (SD)	27.5 (4.1)	26.5 (5.0)	1.0 (1.04, 0.86)
Overweight or obese	67,100 (71.7)	63, 809 (55.5)	16.2 (15.9, 16.7)
History of DM	5,513 (5.9)	3,415 (3.0)	2.9 (2.8, 3.1)
History of CVD	4,130 (4.4)	1,470(1.3)	2.7 (2.5, 2.7)
History of Hypertension	26, 678 (28.5)	24, 006 (20.9)	7.6 (7.2, 8.0)
Dietary macronutrient intake			
Energy (kJ)	9525.1 (2673)	8168.0 (2211)	1357.1 (1336.1, 1378.0)
% above EAR	31.9	42.4	10.5 (10.0, 10.6)
Fats (g)			
Total Fat	83.3 (31)	72.6 (27)	10.9 (10.6, 11.1)
% EI	32.0	32.5	-0.5 (-0.6, -0.4)
Saturated Fat	32.2 (12)	27.8 (10)	4.4 (4.3, 4.5)
% EI	12.3	12.4	-0.1 (-1.1, -0.6)
Polyunsaturated fat	15.2 (6)	13.5 (7)	1.7 (1.6, 1.8)
% EI	5.8	6.0	-0.2 (0.22, 0.18)
Carbohydrates (g)			
Total sugar	125.4 (61)	115.5 (34)	9.9 (9.4, 10.2)
% EI	22.5	24.2	-1.7 (-1.8, -1.6)
Total carbohydrate	271.1 (92)	237.9 (68)	33.2 (32.5, 33.9)
% EI	48.6	49.6	-1.0 (-1.1, -0.9)
Fibre	16.6 (6)	16.1	0.5 (0.4, 0.6)
Total protein (g)	86.9 (28)	78.0 (24)	8.9 (8.7, 9.1)
% EI	15.7	16.5	-0.8 (-0.81, -0.75)

Abbreviations: g: grams; SD: standard deviation; 95% CI: 95% confidence interval, BMI; body mass index; DM; diabetes mellitus; CVD; cardiovascular disease kJ; kilojoules; EAR; estimated average requirement; EI: Energy intake

Continuous variables are expressed as means and standard deviation while categorical variables are expressed as a n and percentages

a- Sex difference calculated as Men-Women, adjusted for age, socioeconomic status and ethnicity

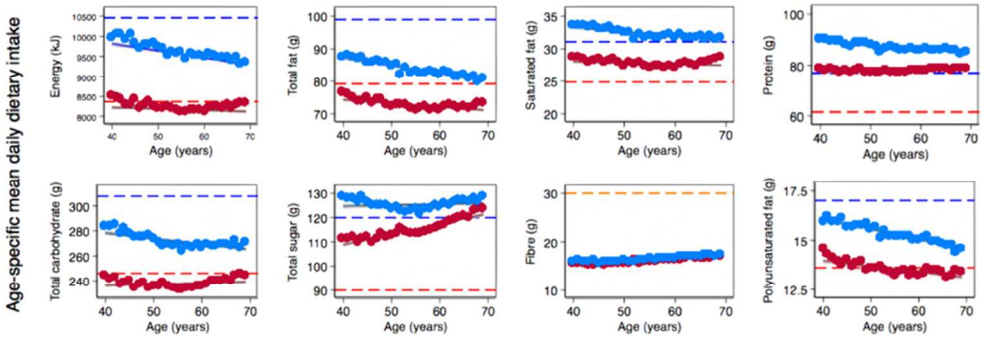
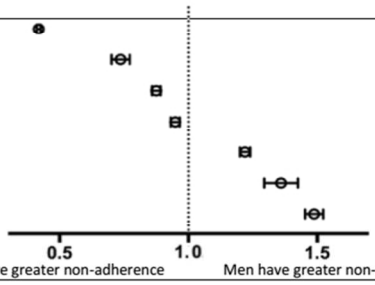


Figure 1

81x50mm (300 x 300 DPI)

Macronutrient	Percentage non-adherence (±SE)		Adjusted OR (95% CI)
	Men	Women	
Total sugar	49.2 (0.2)	69.9 (0.1)	0.42 (0.41, 0.43)
Fibre	96.2 (0.2)	97.1 (0.1)	0.74 (0.70, 0.77)
Total fat	32.0 (0.2)	35.0 (0.1)	0.88 (0.86, 0.89)
Saturated fat	64.8 (0.2)	66.0 (0.1)	0.95 (0.93, 0.97)
Total carbohydrates	56.2 (0.2)	51.1 (0.1)	1.22 (1.20, 1.25)
Polyunsaturated fat	64.8 (0.2)	66.0 (0.1)	1.36 (1.29, 1.43)
Protein	19.0 (0.1)	13.6 (0.1)	1.48 (1.45, 1.52)



Analyses are adjusted for age and Townsend deprivation index.

OR: odds ratio; SE: standard error; 95% CI: 95% confidence interval

Figure 2

76x50mm (300 x 300 DPI)

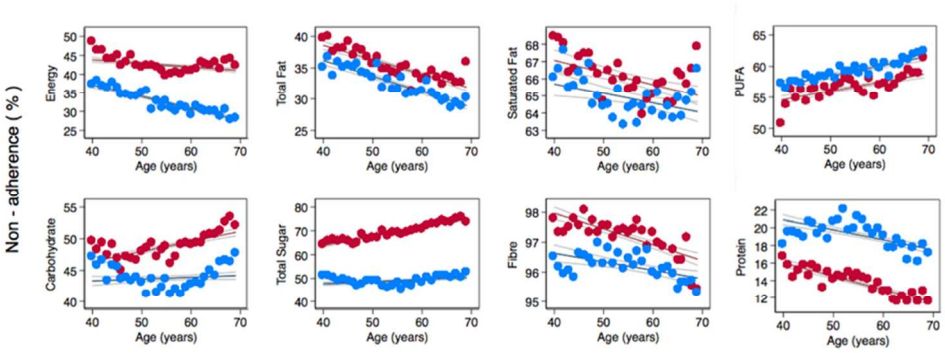


Figure 3

82x50mm (300 x 300 DPI)

Supplementary appendix

eTable 1 Energy and macronutrient intake by age and sex

	Age group					
	40-44	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**
N						
Women	12728	16617	19s772	22665	27490	15807
Men	9723	11736	13765	17322	23752	17264
Energy Intake						
Women	8293.5 (2367.6)	8220.8 (2298.2)	8138.6 (2223.8)	8069.1 (2157.4)	8153.0 (2156.3)	8216.0 (2212.4)
Men	9848.1 (2931.7)	9697.8 (2825.8)	9544.8 (2720.5)	9471.0 (2621.5)	9446.4 (2534.3)	9372.6 (2530.9)
Mean difference	-1554.6 (-1623.8, -1485.3)	-1477.0 (-1536.7, -1417.1)	-1406.2 (-1459.2, -1353.1)	-1401.9 (-1448.8, -1355.1)	-1293.4 (-1334.0, -1252.7)	-1156.6 (-1208.0, -1105.1)
Total Fat						
Women	75.0 (28.8)	73.9 (28.0)	72.4 (27.2)	71.4 (26.3)	71.9 (26.3)	72.5 (26.4)
Men	87.4 (34.6)	85.8 (33.6)	83.7 (32.4)	82.8 (31.3)	82.2 (30.4)	81.1 (29.9)
Mean difference	-12.4 (-13.2, -11.5)	-11.8 (-12.6, -11.1)	-11.3 (-12.0, -10.7)	-11.3 (-11.9, -10.7)	-10.2 (-10.7, -9.7)	-8.6 (-9.2, -8.0)
Saturated Fat						
Women	28.4 (11.9)	28.2 (11.8)	27.6 (11.5)	27.2 (11.3)	27.6 (11.3)	28.1 (11.6)
Men	33.6 (14.7)	33.0 (14.3)	32.1 (13.7)	31.9 (13.5)	31.8 (13.2)	31.7 (13.2)
Mean difference	-5.2 (-5.5, -4.8)	-4.8 (-5.1, -4.5)	-4.5 (-4.8, -4.2)	-4.7 (-4.9, -4.4)	-4.2 (-4.4, -4.0)	-3.6 (-3.8, -3.3)
PUFA						
Women	14.1 (7.2)	13.8 (7.0)	13.5 (6.8)	13.4 (6.5)	13.4 (6.6)	13.3 (6.6)
Men	16.0 (8.2)	15.7 (8.0)	15.4 (7.8)	15.1 (7.5)	15.0 (7.4)	14.7 (7.3)
Mean difference	-1.9 (-2.1, -1.7)	-1.9 (-2.1, -1.8)	-1.9 (-2.0, -1.7)	-1.8 (-1.9, -1.7)	-1.6 (-1.8, -1.5)	-1.4 (-1.6, -1.3)
Total carbohydrate						
Women	240.6 (78.7)	237.0 (77.0)	236.1 (75.6)	234.2 (73.6)	238.4 (74.1)	243.0 (77.8)
Men	282.1 (94.5)	275.8 (92.5)	269.7 (88.5)	267.6 (86.2)	268.7 (83.5)	269.4 (85.1)
Mean difference	-41.5 (-43.8, -39.2)	-38.8 (-40.8, -36.8)	-33.6 (-35.3, -31.8)	-33.4 (-35.0, -31.9)	-30.3 (-31.7, -29.0)	-26.4 (-28.2, -24.6)
Total sugar						
Women	111.3 (46.2)	111.8 (46.2)	114.0 (45.9)	114.5 (44.6)	118.2 (45.3)	121.8 (48.4)
Men	127.8 (55.8)	125.2 (54.1)	123.1 (51.4)	123.4 (50.2)	125.7 (49.2)	127.4 (50.5)
Mean difference	-16.6 (-17.9, -15.2)	-13.4 (-14.6, -12.2)	-9.2 (-10.2, -8.1)	-8.8 (-9.8,-7.9)	-7.5 (-8.3, -6.7)	-5.6 (-6.7, -4.5)
Fibre						
Women	15.4 (6.5)	15.4 (6.2)	15.9 (6.3)	16.1 (6.2)	16.6 (6.3)	16.9 (6.5)
Men	16.1 (7.0)	16.0 (6.8)	16.2 (6.9)	16.6 (6.7)	17.0 (6.7)	17.3 (6.8)
Mean difference	-0.7 (-0.8, -0.5)	-0.5 (-0.7, -0.4)	-0.3 (-0.5, -0.2)	-0.4 (-0.5, -0.3)	-0.4 (-0.5, -0.3)	-0.4 (-0.5, -0.2)
Protein						
Women	77.9 (24.6)	77.8 (23.7)	77.5 (22.9)	77.4 (22.1)	78.5 (22.0)	78.6 (22.1)
Men	89.9 (30.4)	88.5(29.2)	87.0 (27.6)	86.2 (26.1)	86.0 (25.0)	85.7 (24.9)
Mean difference	-12.0 (-12.7, -11.2)	-10.7 (-11.3, -10.1)	-9.5 (-10.1, -9.0)	-8.8 (-9.2, -8.3)	-7.5 (-7.9, -7.1)	-7.1 (-7.6, -6.6)

Data are mean kJ for energy and grams for macronutrients (standard deviation) for continuous variables in women and men. Mean difference is the women minus men difference (95% confidence interval).

eTable 2 Energy and macronutrient intake by socioeconomic status and sex

	SES				
	Most Deprived	**SES 2**	**SES 3**	**SES 4**	**Least Deprived**
N					
Women	40367	28387	21267	15873	9046
Men	34142	22922	16527	12219	7627
Energy Intake					
Women	8177.3 (2134.6)	8168.1 (2167.3)	8200.7 (2248.6)	8164.2 (2349.7)	8055.7 (2456.5)
Men	9501.6 (2551.2)	9533.9 (2608.6)	9561.9 (2668.2)	9575.8 (2816.5)	9449.0 (3019.0)
Mean difference	-1324.2 (-1357.9, -1290.6)	-1365.7 (-1407.1, -1324.4)	-1361.1 (1410.8, -1311.5)	-1411.7 (-1472.1, -1351.2)	-1393.3 (-1476.4, -1310.1)
Total Fat					
Women	72.3 (26.2)	72.5 (26.4)	73.1 (27.1)	73.1 (28.4)	72.4 (29.4)
Men	83.0 (30.5)	83.3 (31.3)	83.9 (31.8)	83.8 (33.1)	82.7 (35.1)
Mean difference	*-10.7 (-11.1, -10.2)*	*-10.8 (-11.3, -10.3)*	*-10.8 (-11.4, -10.2)*	*-10.7 (-11.5, -10.0)*	*-10.4 (-11.4, -9.4)*
Saturated Fat					
Women	27.7 (11.2)	27.8 (11.3)	27.9 (11.5)	27.9 (12.0)	27.7 (12.5)
Men	32.1 (13.2)	32.2 (13.4)	32.4 (13.8)	32.2 (14.2)	31.9 (15.2)
Mean difference	*-4.4 (-4.6, -4.2)*	*-4.4 (-4.7, -4.2)*	*-4.5 (-4.8, -4.3)*	*-4.3 (-4.6, -4.0)*	*-4.2 (-4.6, -3.8)*
Polyunsaturated Fat					
Women	13.5 (6.6)	13.5 (6.6)	13.6 (6.8)	13.5 (6.9)	13.3 (7.2)
Men	15.2 (7.4)	15.2 (7.6)	15.2 (7.5)	15.4 (8.0)	15.0 (8.1)
Mean difference	*-1.7 (-1.8, -1.6)*	-1.7 (-1.8, -1.6)	*-1.6 (-1.7, -1.5)*	*-1.9 (-2.1, -1.7)*	*-1.7 (-1.9, -1.4)*
Total carbohydrate					
Women	238.2 (72.6)	238.1 (73.9)	238.3 (77.1)	237.5 (79.8)	235.5 (84.2)
Men	270.6 (83.8)	271.6 (85.3)	271.1 (88.2)	272.0 (92.2)	270.3 (99.9)
Mean difference	*-32.5 (-33.6, -31.3)*	*-33.5 (34.9, -32.1)*	*-32.8 (-34.5, -31.1)*	*-34.5 (-36.6, -32.5)*	*-34.8 (-37.6, -32.0)*
Total sugar					
Women	116.7 (44.5)	115.8 (44.8)	115.0 (46.4)	114.2 (47.9)	113.2 (51.7)
Men	125.2 (49.0)	125.5 (49.7)	124.8 (51.4)	125.6 (54.5)	126.5 (60.2)
Mean difference	*-8.5 (-9.2, -7.9)*	*-9.7 (-10.5, -8.8)*	*-9.8 (-10.8, -8.8)*	*-11.4 (-12.6, -10.7)*	*-13.3 (-15.0, -11.6)*
Fibre					
Women	16.3 (6.1)	16.2 (6.2)	16.2 (6.5)	15.9 (6.6)	15.5 (6.9)
Men	16.8 (6.5)	16.7 (6.7)	16.5 (6.8)	16.6 (7.2)	16.0 (7.7)
Mean difference	*-0.5 (-0.6, -0.4)*	*-0.6 (-0.7, -0.5)*	*-0.3 (-0.4, -0.2)*	*-0.7 (-0.8, -0.5)*	*-0.5 (-0.7, -0.3)*
Protein					
Women	78.7 (21.7)	78.1 (22.0)	77.9 (23.1)	77.1 (24.4)	75.8 (25.4)
Men	86.9 (25.2)	87.0 (25.9)	86.8 (27.1)	87.0 (29.0)	86.1 (31.2)
Mean difference	*8.2 (-8.5, -7.8)*	*-8.8 (-9.3, -8.4)*	*-8.9 (-9.4, -8.4)*	*-9.9 (-10.5, -9.2)*	*-10.4 (-11.2, -9.5)*

Data are mean kJ for energy and grams for macronutrients (standard deviation) for continuous variables in women and men. Mean difference is the women minus men difference (95% confidence interval).

eTable 3: Energy and macronutrient intake by body mass index and sex

	BMI group			
	Underweight (<18.5kg/m²)	**Normal Weight (18.5- 25kg/m²)**	**Overweight (25 – 30 kg/m²)**	**Obese (>30 kg/m²)**
N				
Women	939	50300	40333	23218
Men	195	26248	46050	20768
Energy Intake				
Women	8231.7 (72.9)	8199.1 (9.6)	8112.3 (11.0)	8202.6 (15.7)
Men	9707.9 (196.4)	9643.8 (15.7)	9495.0 (12.3)	9452.1 (19.8)
Mean difference	-1476.2 (-1836.1, -1116.4)	-1444.6 (-1478.8, -1410.5)	-1382.6 (-1415.4, -1349.9)	-1249.5 (-1298.5, -1200.5)
Total Fat				
Women	74.5 (0.9)	72.7 (0.1)	71.8 (0.1)	74.0 (0.2)
Men	87.5 (2.5)	84.2 (0.2)	82.7 (0.1)	83.6 (0.2)
Mean difference	-13.0 (-17.5, -8.4)	-11.5 (-11.9, -11.1)	-10.9 (-11.3, -10.6)	-9.6 (-10.2, -9.0)
Saturated Fat				
Women	28.6 (0.4)	27.6 (0.1)	27.5 (0.1)	28.6 (0.1)
Men	34.1 (1.1)	32.3 (0.1)	31.9 (0.1)	32.6 (0.1)
Mean difference	-5.6 (-7.6, -3.5)	-4.7 (-4.9, -4.5)	-4.4 (-4.6, -4.3)	-4.0 (-4.2, -3.7)
Polyunsaturated Fat				
Women	13.8 (0.2)	13.5 (0.03)	13.4 (0.03)	13.7 (0.05)
Men	16.0 (0.6)	15.5 (0.05)	15.1 (0.04)	15.1 (0.05)
Mean difference	-2.2 (-3.2, -1.1)	-2.0 (-2.1 -1.8)	-1.7 (-1.8 -1.6)	-1.4 (-1.6, -1.3)
Total carbohydrate				
Women	246.0 (2.5)	239.9 (0.3)	235.4 (0.4)	237.5 (0.5)
Men	286.3 (6.6)	281.5 (0.5)	269.1 (0.4)	262.3 (0.6)
Mean difference	-40.3 (-52.5, -28.0)	-41.6 (-42.7, -40.4)	-33.7 (-34.8, -32.6)	-24.8 (-26.4, -23.2)
Total sugar				
Women	119.2 (1.6)	117.2 (0.2)	114.6 (0.2)	113.6 (0.3)
Men	133.5 (3.8)	130.3 (0.3)	125.2 (0.2)	119.5 (0.4)
Mean difference	-14.3 (-22.0, -6.7)	-13.2 (-13.9 -12.5)	-10.5 (-11.2. -9.9)	-5.9 (-6.9, -5.0)
Fibre				
Women	17.6 (0.2)	16.4 (0.03)	15.9 (0.03)	15.6 (0.04)
Men	17.3 (0.6)	17.4 (0.04)	16.5 (0.03)	16.0 (0.05)
Mean difference	0.2 (-0.9, 1.3)	-1.05 (-1.15, 0.95)	-0.5 (-0.6, -0.4)	-0.1 (-0.2, 0.0)
Protein				
Women	74.9 (0.7)	76.6 (0.1)	78.2 (0.1)	80.6 (0.2)
Men	83.2 (1.8)	86.0 (0.2)	86.6 (0.1)	88.7 (0.2)
Mean difference	-8.3 (-11.8, -4.7)	-9.4 (-9.7, -9.0)	-8.4 (-8.7, -8.04)	-8.0 (-8.6, -7.5)

Data are mean kJ for energy and grams for macronutrients (standard deviation) for continuous variables in women and men. Mean difference is the women minus men difference (95% confidence interval).

eTable 4: Non-adherence (%) to dietary recommendations by age and sex

	Age group					
	40-44	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**
N						
Women	12728	16617	19772	22665	27490	15807
Men	9723	11736	13765	17322	23752	17264
Energy Intake						
Women	45.4 (49.8)	43.4 (49.6)	41.9 (49.3)	40.3 (49.0)	42.1 (49.4)	42.8 (49.5)
Men	37.3 (45.4)	34.8 (43.4)	32.7 (41.9)	31.1 (46.3)	30.3 (45.9)	29.2 (45.5)
Mean difference	8.1 (6.8, 9.4)	8.6 (7.4, 9.7)	9.2 (8.1, 10.2)	9.2 (8.2, 10.1)	11.9 (11.0, 12.7)	13.7 (12.6, 14.7)
Total Fat						
Women	38.5 (48.7)	37.7 (48.5)	35.2 (47.8)	33.9 (47.3)	33.4 (47.2)	33.6 (47.2)
Men	35.4 (47.8)	34.8 (47.6)	33.1 (47.0)	31.5 (46.5)	31.0 (46.3)	29.4 (45.5)
Mean difference	3.1 (1.9, 4.4)	2.9 (1.8, 4.0)	2.1 (1.1, 3.1)	2.4 (1.4, 3.3)	2.4 (1.6, 3.2)	4.2 (3.2, 5.2)
Saturated Fat						
Women	67.4 (46.9)	67.0 (47.0)	66.0 (47.4)	65.1 (47.7)	65.2 (47.6)	66.4 (47.2)
Men	66.3 (47.3)	65.7 (47.5)	64.2 (47.9)	64.4 (47.9)	64.2 (47.9)	64.9 (47.7)
Mean difference	1.1 (-0.1, 2.4)	1.3 (0.1, 2.4)	1.8 (0.7, 2.7)	0.7 (-0.2, 1.6)	1.0 (0.1, 1.8)	1.5 (0.5, 2.6)
PUFA						
Women	54.7 (49.8)	55.7 (49.7)	57.2 (49.5)	56.4 (49.6)	57.2 (49.5)	59.2 (49.1)
Men	57.3 (49.5)	58.2 (49.3)	59.0 (49.2)	59.6 (49.1)	59.8 (49.0)	61.7 (48.6)
Mean difference	-2.6 (-3.9, -1.2)	-2.5 (-2.6, -1.2)	-1.8 (-2.9, -0.7)	-3.2 (-4.1, -2.2)	-2.6 (-3.5, -1.8)	-2.5 (-3.5, -1.4)
Total carbohydrate						
Women	51.3 (50.0)	53.5 (49.9)	51.7 (50.0)	51.9 (50.0)	50.3 (50.0)	48.1 (50.0)
Men	54.4 (49.8)	55.9 (49.6)	57.7 (49.4)	57.9 (49.4)	56.5 (49.6)	53.9 (49.8)
Mean difference	-3.1 (-4.4, -1.7)	-2.4 (-3.6, -1.3)	-6.0 (-7.1, -4.9)	-6.0 (-7.0, -5.0)	-6.2 (-7.1, -5.4)	-5.8 (-6.9, -4.7)
Total sugar						
Women	65.8 (47.4)	66.1 (47.3)	68.5 (46.5)	69.7 (46.0)	72.6 (44.6)	74.3 (43.7)
Men	50.2 (50.0)	48.2 (50.0)	47.6 (49.9)	47.8 (50.0)	49.9 (50.0)	51.3 (50.0)
Mean difference	15.6 (14.3, 16.9)	17.9 (16.8, 19.1)	20.9 (19.9, 22.0)	21.9 (21.0, 22.9)	22.6 (21.8, 23.5)	22.9 (21.9, 24.0)
Fibre						
Women	97.5 (15.5)	97.6 (15.3)	97.4 (15.9)	97.3 (16.1)	96.8 (17.5)	96.3 (18.9)
Men	96.1 (19.5)	96.6 (18.1)	96.4 (18.6)	96.5 (18.3)	96.0 (19.5)	95.5 (20.6)
Mean difference	1.4 (1.0, 1.9)	1.0 (0.6, 1.4)	1.0 (0.6, 1.4)	0.8 (0.5, 1.2)	0.8 (0.5, 1.1)	0.7 (0.3, 1.2)
Protein						
Women	15.4 (36.1)	14.7 (35.4)	14.5 (35.2)	14.0 (34.7)	12.2 (32.7)	12.0 (32.5)
Men	19.2 (39.4)	19.8 (39.9)	20.7 (40.5)	20.2 (40.1)	18.2 (38.6)	17.0 (37.6)
Mean difference	-3.8 (-4.7, -2.8)	-5.1 (-6.0, -4.2)	-6.2 (-7.0, -5.4)	-6.2 (-6.9, -5.5)	-6.0 (-6.6, -5.4)	-5.0 (-5.8, -4.3)

Data are percentage non-adherence (standard deviation) and women minus men mean difference (95% confidence interval).

eTable 5: Odds ratio (men versus women) and 95% confidence intervals for non-adherence to macronutrient intake recommendations, by age

	Age group						P-value for interaction
	40-44	45-49	50-54	55-59	60-64	65-69	
N							
Women	12728	16617	19772	22665	27490	15807	
Men	9723	11736	13765	17322	23752	17264	
Total Fat	0.87 (0.83, 0.92)	0.88 (0.84, 0.93)	0.91 (0.87, 0.95)	0.90 (0.86, 0.94)	0.90 (0.86, 0.93)	0.82 (0.78, 0.86)	0.343
Saturated Fat	0.95 (0.90, 1.01)	0.95 (0.90, 0.99)	0.93 (0.88, 0.97)	0.97 (0.93, 1.01)	0.96 (0.93, 1.8)	0.93 (0.89, 0.98)	0.898
Polyunsaturated Fat	1.11 (1.05, 1.17)	1.10 (1.05, 1.16)	1.08 (1.03, 1.12)	1.14 (1.09, 1.18)	1.12 (1.08, 1.16)	1.11 (1.06, 1.16)	0.649
Total carbohydrate	1.13 (1.07, 1.19)	1.10 (1.05, 1.16)	1.27 (1.22, 133)	1.28 (1.23, 1.33)	1.29 (1.24, 1.33)	1.26 (1.21, 1.32)	<0.001
Total sugar	0.52 (0.50, 0.55)	0.48 (0.45, 0.50)	0.42 (0.40, 0.44)	0.40 (0.38, 0.41)	0.38 (0.36, 0.39)	0.37 (0.35, 0.38)	<0.001
Fibre	0.62 (0.53, 0.72)	0.70 (0.61, 0.80)	0.71 (0.63, 0.81)	0.76 (0.68, 0.85)	0.79 (0.72, 0.87)	0.83 (0.74, 0.92)	0.037
Protein	1.30 (1.21, 1.40)	1.43 (1.35, 1.52)	1.54 (1.45, 1.63)	1.56 (1.48, 1.64)	1.60 (1.52, 1.68)	1.51 (1.41, 1.60)	0.072

Odds ratios were adjusted for Townsend deprivation index and ethnicity

eTable 6: Non-adherence (%) to dietary recommendations by socioeconomic status and sex

	SES				
	Most Deprived	SES 2	SES 3	SES 4	Least Deprived
N					
Women	40367	28387	21267	15873	9046
Men	34142	22922	16527	12219	7627
Energy Intake					
Women	42.5 (49.4)	42.5 (49.4)	42.9 (49.5)	42.1 (49.4)	40.3 (49.0)
Men	31.2 (46.3)	31.5 (46.4)	32.7 (46.9)	33.3 (47.1)	32.3 (46.8)
Mean difference	11.3 (10.6, 12.0)	11.3 (10.2, 11.8)	10.2 (9.3, 11.2)	8.8 (7.7, 10.0)	8.0 (6.5, 9.5)
Total Fat					
Women	33.8 (47.3)	34.4 (47.5)	36.0 (48.0)	36.1 (48.0)	38.0 (48.5)
Men	31.1 (46.3)	32.0 (46.7)	32.5 (46.8)	33.0 (47.0)	33.9 (47.3)
Mean difference	2.7 (2.1, 3.4)	2.4 (1.6, 3.2)	3.5 (2.5, 4.5)	3.1 (2.0, 4.3)	4.1 (2.6, 5.6)
Saturated Fat					
Women	65.8 (47.4)	66.0 (47.4)	66.2 (47.3)	66.1 (47.3)	66.1 (47.3)
Men	65.0 (47.7)	65.1 (47.7)	65.2 (47.6)	63.9 (48.0)	63.0 (48.3)
Mean difference	0.8 (0.1, 1.4)	0.9 (0.1, 1.7)	1.0 (0.3, 2.0)	2.2 (1.1, 3.3)	3.1 (1.7, 4.6)
Polyunsaturated Fat					
Women	56.5 (49.6)	56.3 (49.6)	56.7 (49.6)	57.6 (49.4)	59.1 (49.2)
Men	58.9 (49.2)	59.5 (49.1)	59.9 (49.0)	60.1 (49.0)	60.7 (48.8)
Mean difference	-2.4 (-3.1, -1.7)	-3.3 (-4.2, -2.4)	-3.2 (-4.2, -2.2)	-2.5 (-3.6, -1.3)	-1.4 (-3.1, -0.1)
Total carbohydrate					
Women	51.2 (50.0)	50.7 (50.0)	51.7 (50.0)	51.3 (50.0)	50.2 (50.0)
Men	56.2 (49.6)	56.2 (49.6)	56.7 (49.5)	56.4 (49.6)	54.6 (49.8)
Mean difference	-5.0 (-5.7, -4.3)	-5.5 (-6.4, -4.6)	-5.0 (-6.0, -4.0)	-5.1 (-6.3, -3.9)	-4.4 (-5.9, -2.9)
Total sugar					
Women	71.5 (45.2)	70.9 (45.4)	69.2 (46.2)	67.7 (46.8)	64.7 (47.8)
Men	49.8 (50.0)	49.6 (50.0)	48.5 (50.0)	48.8 (50.0)	48.2 (50.0)
Mean difference	21.7 (21, 22.3)	-5.5 (-6.4, -4.6)	-5.0 (-6.0, -4.0)	-5.1 (-6.3, -3.9)	-4.4 (-5.9, -2.9)
Fibre					
Women	97.3 (16.2)	97.4 (16.0)	97.0 (17.2)	96.9 (17.4)	96.6 (18.0)
Men	96.6 (18.2)	96.2 (19.2)	96.2 (19.0)	95.5 (20.7)	95.1 (21.5)
Mean difference	0.7 (0.5, 1.0)	1.2 (0.9, 1.5)	0.7 (0.4, 1.1)	1.4 (0.9, 1.8)	1.5 (0.9, 2.1)
Protein					
Women	11.4 (31.8)	12.7 (33.2)	14.0 (34.7)	16.9 (37.5)	20.1 (40.1)
Men	17.2 (37.8)	18.5 (38.8)	19.5 (39.6)	21.2 (40.9)	24.1 (42.8)
Mean difference	-5.8 (-6.3, -5.3)	-5.8 (-6.5, -5.2)	-5.5 (-6.3, -4.8)	-4.3 (-5.2, -3.3)	-4.0 (-5.2, -2.7)

Data are percentage non-adherence (standard deviation) and women minus men mean difference (95% confidence interval).

eTable 7: Odds ratio (men versus women) and 95% confidence intervals for non-adherence to macronutrient intake recommendations, by socioeconomic status

	SES					P-value for interaction
	Least Deprived	SES 2	SES 3	SES 4	Most deprived	
N						
Women	40367	28387	21267	15873	9046	
Men	34142	22922	16527	12219	7627	
Total Fat	0.88 (0.85, 0.91)	0.90 (0.86, 0.93)	0.86 (0.82, 0.89)	0.87 (0.83, 0.91)	0.84 (0.79, 0.89)	0.033
Saturated Fat	0.97 (0.94, 0.99)	0.96 (0.93, 0.99)	0.96 (0.92, 0.99)	0.91 (0.86, 0.95)	0.87 (0.82, 0.93)	<0.001
Polyunsaturated Fat	1.10 (1.07, 1.13)	1.14 (1.11, 1.19)	1.14 (1.09, 1.19)	1.11 (1.05, 1.16)	1.07 (1.01, 1.14)	0.857
Total carbohydrate	1.22 (1.19, 1.26)	1.25 (1.20, 1.29)	1.22 (1.17, 1.27)	1.23 (1.17, 1.29)	1.19 (1.12, 1.27)	0.871
Total sugar	0.40 (0.38, 0.41)	0.40 (0.39, 0.42)	0.42 (0.40, 0.44)	0.45 (0.43, 0.48)	0.51 (0.48, 0.54)	<0.001
Fibre	0.78 (0.72, 0.85)	0.68 (0.62, 0.75)	0. 80 (0.72, 0.90)	0.69 (0.61, 0.78)	0.68 (0.58, 0.79)	0.013
Protein	1.61 (1.55, 1.68)	1.57 (1.49, 1.64)	1.49 (1.42, 1.58)	1.32 (1.25, 1.41)	1.26 (1.17, 1.35)	<0.001

Odds ratios were adjusted for age and ethnicity

eTable 8: Non-adherence (%) to dietary recommendations by body mass index and sex

	BMI Group			
	Underweight (<18.5kg/m²)	**Normal Weight (18.5- 25kg/m²)**	**Overweight (25 – 30 kg/m²)**	**Obese (>30 kg/m²)**
N				
Women	939	50300	40333	23218
Men	195	26248	46050	20768
Energy Intake				
Women	44.5 (1.6)	43.0 (0.2)	41.2 (0.2)	42.9 (0.3)
Men	31.8 (3.3)	32.9 (0.3)	31.3 (0.2)	31.9 (0.3)
Mean difference	12.7 (5.1, 2.0)	10.1 (9.3, 10.8)	9.9 (9.3, 10.6)	11.0 (10.1, 11.9)
Total Fat				
Women	39.8 (1.6)	34.2 (0.2)	34.0 (0.2)	38.3 (0.3)
Men	42.1 (3.5)	31.3 (0.3)	31.3 (0.2)	34.6 (0.3)
Mean difference	-2.2 (-9.7, 5.4)	2.9 (2.2, 3.6)	2.8 (2.1, 3.4)	3.6 (2.7, 4.5)
Saturated Fat				
Women	66.8 (1.5)	65.0 (0.2)	65.6 (0.2)	68.8 (0.3)
Men	64.1 (1.4)	63.7 (0.3)	64.4 (0.2)	67.0 (0.3)
Mean difference	2.7 (4.6, 10.0)	1.3 (0.6, 2.0)	1.2 (0.5, 1.8)	1.7 (0.9, 2.6)
Polyunsaturated Fat				
Women	54.7 (1.6)	56.5 (0.02)	57.2 (0.02)	57.1 (0.03)
Men	57.9 (3.5)	59.0 (0.03)	59.6 (0.02)	60.0 (0.03)
Mean difference	-3.2 (-10.9, 4.5)	-2.5 (-3.3 -1.8)	-2.4 (-3.1 -1.8)	-2.9 (-3.8, -1.9)
Total carbohydrate				
Women	54.3 (0.2)	49.9 (0.2)	48.2 (0.2)	47.6 (0.3)
Men	53.3 (0.4)	49.7 (0.3)	42.8 (0.2)	38.5 (0.6)
Mean difference	1.0 (-6.7, 8.7)	0.2 (-0.5, 0.9)	5.4 (-6.1, 4.7)	9.1(8.2, 10.0)
Total sugar				
Women	72.0 (1.5)	72.1 (0.2)	69.1 (0.2)	66.5 (0.3)
Men	56.4 (3.6)	54.2 (0.3)	49.1 (0.2)	43.3 (0.3)
Mean difference	15.6 (8.5, 22.6)	17.9 (17.2, 18.6)	20.0 (19.3, 20.6)	23.1(22.2, 24.1)
Fibre				
Women	94.2 (0.8)	97.1 (0.1)	97.4 (0.01)	97.0 (0.01)
Men	92.3 (1.9)	95.4 (0.1)	96.5 (0.01)	96.5 (0.01)
Mean difference	1.9 (-1.8, 0.6)	1.7 (1.4, 2.0)	0.9 (0.7, 1.1)	0.5 (0.1, 0.8)
Protein				
Women	2.4 (0.5)	6.1 (0.1)	13.0 (0.2)	30.6 (0.3)
Men	3.6 (1.3)	8.0 (0.2)	17.4 (0.2)	35.7 (0.3)
Mean difference	-1.1 (-3.6, 1.3)	-1.9 (-2.4, -1.6)	-4.4 (-4.8, -3.9)	-5.1 (-6.0, -4.3)

eTable 9: Odds ratio (men versus women) and 95% confidence intervals for non-adherence to macronutrient intake recommendations, by BMI

	BMI Group				
	Underweight (<18.5kg/m²)	**Normal Weight (18.5-25kg/m²)**	**Overweight (25 – 30 kg/m²)**	**Obese (>30 kg/m²)**	**P-value for interaction**
N					
Women	939	50300	40333	23218	
Men	195	26248	46050	20768	
Total Fat	1.09 (0.80, 1.50)	0.88 (0.85, 0.90)	0.88 (0.86, 0.91)	0.85 (0.82, 0.89)	0.789
Saturated Fat	0.89 (0.64, 1.23)	0.94 (0.91, 0.97)	0.95 (0.92, 0.98)	0.92 (0.89, 0.96)	0.977
Polyunsaturated Fat	1.14 (0.83, 1.56)	1.11 (1.08, 1.15)	1.10 (1.08, 1.14)	1.13 (1.08, 1.17)	0.603
Total carbohydrate	1.04 (0.76, 1.42)	1.01 (0.98, 1.04)	1.24 (1.21, 1.28)	1.45 (1.40, 1.51)	0.000
Total sugar	0.50 (0.37, 0.69)	0.46 (0.44, 0.47)	0.43 (0.42, 0.44)	0.39 (0.37, 0.40)	0.000
Fibre	0.73 (0.40, 1.32)	0.62 (0.57, 0.67)	0. 74 (0.68, 0.80)	0.86 (0.78, 0.96)	0.000
Protein	1.48 (0.63, 3.51)	1.35 (1.28, 1.43)	1.40 (1.35, 1.46)	1.26 (1.21, 1.31)	0.000

Odds ratios were adjusted for age, socioeconomic status and ethnicity

STROBE Statement—checklist of items that should be included in reports of observational studies

All items are addressed in the manuscript, tables, and supporting materials

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Page 1 and 2**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Page 5**
Objectives	3	State specific objectives, including any prespecified hypotheses **Page 5**
Methods		
Study design	4	Present key elements of study design early in the paper **Page 6**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Page 6**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Page 6, supplementary table 1**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Page 6, 7**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Page 6, 7**
Bias	9	Describe any efforts to address potential sources of bias **Page 6, 7**
Study size	10	Explain how the study size was arrived at **Page 6**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Page 6, 7**

Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Page 6**
		(*b*) Describe any methods used to examine subgroups and interactions **Page 7, 8**
		(*c*) Explain how missing data were addressed **Page 6**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **Page 6**
		(*e*) Describe any sensitivity analyses **Page 7**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Page 10**
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Page 10**
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time **Page 10**
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Page 10, 11, Tables**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Page 10, 11**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Page 12**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias

		Page 4
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Page 12-14**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Page 12-14**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Page 15**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.