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Low body mass index in non-meat eaters: the possible roles of animal fat, dietary fibre and alcohol

PN Appleby[1], M Thorogood[2], JI Mann[3] and TJ Key[1]

[1]*Imperial Cancer Research Fund Cancer Epidemiology Unit, Gibson Building, Radcliffe Infirmary, Oxford OX2 6HE, UK;* [2]*Department of Public Health and Policy, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK;* [3]*Department of Human Nutrition, University of Otago, Dunedin, New Zealand*

OBJECTIVE: To examine the associations of diet and other lifestyle factors with body mass index (BMI) using data from the Oxford Vegetarian Study.
SUBJECTS: 1914 male and 3378 female non-smokers aged 20–89 y at recruitment to the study.
MEASUREMENTS: All subjects completed a diet/lifestyle questionnaire at recruitment giving details of their usual diet and other characteristics including height and weight, smoking and drinking habits, amount of exercise, occupation and reproductive history. Answers to the food frequency questionnaire were used to classify subjects as either meat eaters or non-meat eaters, and to estimate intakes of animal fat and dietary fibre. Subjects were further classified according to their alcohol consumption, exercise level, social class, past smoking habits and parity.
RESULTS: Mean BMI was lower in non-meat eaters than in meat eaters in all age groups for both men and women. Overall age-adjusted mean BMIs in kg/m^2 were 23.18 and 22.05 for male meat eaters and non-meat eaters respectively ($P < 0.0001$) and 22.32 and 21.32 for female meat eaters and non-meat eaters respectively ($P < 0.0001$). In addition to meat consumption, dietary fibre intake, animal fat intake, social class and past smoking were all independently associated with BMI in both men and women; alcohol consumption was independently associated with BMI in men, and parity was independently associated with BMI in women. After adjusting for these factors, the differences in mean BMI between meat eaters and non-meat eaters were reduced by 36% in men and 31% in women.
CONCLUSIONS: Non-meat eaters are thinner than meat eaters. This may be partly due to a higher intake of dietary fibre, a lower intake of animal fat, and only in men a lower intake of alcohol.

Keywords: body mass index; vegetarians; animal fat; dietary fibre; alcohol

Introduction

The role of diet composition in the control of body weight is controversial.[1] One of the most consistent observations in relation to diet and body mass index (BMI) is that, on average, Western vegetarians have a lower BMI than non-vegetarians.[2–4] Although this may be partly attributable to non-dietary differences in lifestyle, it is likely that the composition of the vegetarian diets plays a major role. However, as far as we are aware, no attempt has been made to determine which dietary and other lifestyle factors may account for this difference.

In this analysis, we describe the difference in BMI between meat eaters and non-meat eaters in the Oxford Vegetarian Study, and explore how much of this difference can be explained by differences in the consumption of animal fat, dietary fibre and alcohol. The analysis has been restricted to the large number of non-smokers in this study in order to eliminate possible confounding by current smoking habits.

Correspondence: Mr PN Appleby.
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Subjects and methods

Subjects were recruited between September 1980 and January 1984 as described elsewhere.[5] 11 140 subjects living throughout the UK were recruited, each of whom completed a questionnaire concerning their diet, lifestyle (including smoking habits, alcohol consumption and amount of exercise), occupation, medical history, reproductive history (women only), height and weight. In particular, subjects were asked to state how frequently they ate each of a range of foods, on a scale ranging from never eaten to eaten $\geq$10 times per week. Twenty-eight foods and food groups were included in the food frequency questionnaire, including 13 vegetables and fruits, six cereal foods, seven animal foods, tea and coffee. The answers provided were used to group subjects according to their diet (meat eaters and non-meat eaters), intake of animal fat (estimated from their consump-

tion of meat, eggs, milk and cheese using food composition tables for fat[6]) and intake of dietary fibre (estimated from their consumption of cereals, fruit and vegetables using food composition tables for dietary fibre;[7] details are available from the authors on request). Subjects were further grouped according to their alcohol consumption, amount of exercise, social class, past smoking habits and, for women only, parity. The estimate of dietary fibre intake from the questionnaire used in this study has been shown to be strongly correlated with dietary fibre intake estimated from a three-week diet diary ($r = 0.83$).[8] The estimate of animal fat intake from the questionnaire has not been validated, but there is a highly significant correlation between this variable and serum cholesterol concentration in this population (partial correlation coefficient after adjusting for age and gender: $r = 0.21$, $n = 2084$, $P < 0.001$; unpublished data). The limitations of the questionnaire (a limited range of foods, little information on portion sizes) meant that we were unable to estimate total food energy intake or intakes of nutrients other than those described above.

The analyses described here are restricted to the 5292 subjects (1914 men and 3378 women) who were aged 20–89 y at recruitment, were non-smokers and had complete data for diet group, intake of animal fat and dietary fibre, alcohol consumption, amount of exercise, social class, past smoking habits and parity. (Although diet group was known for all subjects, and 80% of subjects were non-smokers, incomplete information from the questionnaire meant that we were unable to calculate intake of animal fat and/or dietary fibre for many subjects.) Diet group was classified as meat eater ($n = 2445$) or non-meat eater ($n = 2847$). The non-meat eaters were mainly vegetarians ($n = 2166$), but also included 480 subjects who ate fish, but not meat, and 201 vegans who did not eat any meat, fish, milk, cheese or eggs. However, the numbers of fish eaters and vegans were both small compared with the number of vegetarians, and a preliminary analysis of the data showed that there was no significant difference in BMI between these three groups. Therefore, the fish eaters were grouped with the vegetarians and vegans as non-meat eaters. Subjects were divided into thirds for both animal fat and dietary fibre. The cut points were 42.56, 60.80 g animal fat per day and 23.93, 33.64 g dietary fibre per day for men, and 36.94, 54.86 g animal fat per day and 21.54, 29.64 g dietary fibre per day for women. Alcohol consumption was classified according to whether the subject consumed less than one unit of alcohol per week on average (designated 'non/occasional drinker'), 1–7 units per week, or > 7 units per week. Leisure time exercise level was classified as either 'high' or 'low' according to whether or not the subject reported doing sport/keep fit or running/cycling for 15 min continuously two or more times per week. Social class was determined on the basis of the subject's occupation (or, where applicable for women, that of their spouse) and subjects were divided into one of three groups: social classes I and II; social classes III, IV and V; and 'unclassified', a mixed group consisting of students, retired persons and others who could not be classified. Subjects were classified as either 'ex-smoker' or 'never smoker' according to whether or not they had smoked previously. All current smokers and non-smokers with unknown past smoking habits were excluded in order to simplify the analysis and because adjusting for smoking using a multi-level factor might not be adequate to fully allow for the effects of smoking on BMI. However, ex-smokers were included in the analysis in order to retain as many subjects as possible and because we were confident that a two-level factor would be adequate to adjust for any differences between never smokers and ex-smokers. Female subjects were classified as either nulliparous or parous according to whether or not they had any liveborn children. All subjects were further divided by age at recruitment into one of seven groups: 20–29, 30–39, 40–49, 50–59, 60–69, 70–79 and 80–89 y, respectively.

Data analysis

All calculations were performed using SPSS.[9] Mean BMI values were calculated separately for men and women by diet and age group, and according to the various diet/lifestyle factors after adjusting for age at recruitment. The effect of the diet/lifestyle factors, other than diet group, on the difference in age-adjusted mean BMI between meat eaters and non-meat eaters, was investigated using analysis of covariance. Two-tailed *P*-values were used to compare mean age, animal fat and dietary fibre intakes by diet group, and one-tailed *P*-values were used to assess chi-square tests of association and F-tests arising from the analyses of covariance.

Results

Characteristics of the subjects by gender and diet group are shown in Table 1. 51% of the men and 44% of the women were meat eaters. There was no significant difference in mean age between diet groups for either gender. However, a higher proportion of non-meat eaters were to be found in the youngest age group (20–29 y) and in the older age groups, this association being statistically significant for women ($P < 0.001$). Only 1% of both men and women were clinically obese with a BMI of $\geq 30\,kg/m^2$. Altogether, 16% of men and 10% of women were overweight or obese (BMI $\geq 25\,kg/m^2$). A higher proportion of meat eaters than non-meat eaters were overweight or obese (21% *vs* 10% of men and 13% *vs* 8% of women), whereas a lower proportion of meat eaters had a BMI $< 20\,kg/m^2$ (9% *vs* 17% of men and 18% *vs* 33% of women). These associations were highly statistically significant ($P < 0.00001$ for both

Table 1 Characteristics by gender and diet group

	Men			*Women*		
Diet/lifestyle characteristic	*Meat eater (n = 975)*	*Non-meat (n = 939)*	*Total (n = 1914)*	*Meat eater (n = 1470)*	*Non-meat (n = 1908)*	*Total (n = 3378)*
Age at recruitment						
20–29	314 (32%)	317 (34%)	631 (33%)	482 (33%)	733 (38%)	1215 (36%)
30–39	333 (34%)	291 (31%)	624 (33%)	484 (33%)	530 (28%)	1014 (30%)
40–49	126 (13%)	108 (12%)	234 (12%)	193 (13%)	214 (11%)	407 (12%)
50–59	80 (8%)	82 (9%)	162 (8%)	166 (11%)	205 (11%)	371 (11%)
60–69	91 (9%)	93 (10%)	184 (10%)	98 (7%)	138 (7%)	236 (7%)
70–79	31 (3%)	42 (4%)	73 (4%)	42 (3%)	71 (4%)	113 (3%)
80–89	0 (0%)	6 (1%)	6 (0%)	5 (0%)	17 (1%)	22 (1%)
Mean (s.d.)	38.2 (14.1)	39.2 (15.2)	38.7 (14.7)	38.0 (13.8)	37.8 (15.1)	37.9 (14.5)
Comparison of means		*P > 0.1*			*P > 0.1*	
Body mass index (kg/m^2)						
< 20.0	91 (9%)	163 (17%)	254 (13%)	265 (18%)	622 (33%)	887 (26%)
20.0– < 25.0	676 (69%)	684 (73%)	1360 (71%)	1010 (69%)	1137 (60%)	2147 (64%)
25.0– < 30.0	187 (19%)	89 (9%)	276 (14%)	166 (11%)	129 (7%)	295 (9%)
≥ 30.0	21 (2%)	3 (0%)	24 (1%)	29 (2%)	20 (1%)	49 (1%)
Test of association		*P < 0.00001*			*P < 0.00001*	
Mean (s.d.) animal fat intake (g/d)	61.9 (20.9)	38.6 (23.1)	50.5 (24.9)	55.4 (19.6)	38.0 (21.4)	45.5 (22.3)
Comparison of means		*P < 0.00001*			*P < 0.00001*	
Mean (s.d.) dietary fibre intake (g/d)	25.2 (9.4)	34.3 (10.7)	29.7 (11.0)	22.8 (8.2)	29.2 (9.5)	26.4 (9.5)
Comparison of means		*P < 0.00001*			*P < 0.00001*	
Alcohol consumption						
Non/occasional drinker	126 (13%)	337 (36%)	463 (24%)	300 (20%)	777 (41%)	1077 (32%)
1–7 units per week	298 (31%)	298 (32%)	596 (31%)	796 (54%)	842 (44%)	1638 (48%)
> 7 units per week	551 (57%)	304 (32%)	855 (45%)	374 (25%)	289 (15%)	663 (20%)
Test of association		*P < 0.00001*			*P < 0.00001*	
Amount of exercise						
Low	614 (63%)	549 (58%)	1163 (61%)	1092 (74%)	1371 (72%)	2463 (73%)
High	361 (37%)	390 (42%)	751 (39%)	378 (26%)	537 (28%)	915 (27%)
Test of association		*P = 0.05*			*P = 0.12*	
Social class						
I–II	578 (59%)	534 (57%)	1112 (58%)	800 (54%)	963 (50%)	1763 (52%)
III–V	236 (24%)	249 (27%)	485 (25%)	445 (30%)	581 (30%)	1026 (30%)
Unclassified	161 (17%)	156 (17%)	317 (17%)	225 (15%)	364 (19%)	589 (17%)
Test of association		*P = 0.47*			*P < 0.01*	
Past smoking						
Never smoker	576 (59%)	535 (57%)	1111 (58%)	1024 (70%)	1339 (70%)	2363 (70%)
Ex-smoker	399 (41%)	404 (43%)	803 (42%)	446 (30%)	569 (30%)	1015 (30%)
Test of association		*P = 0.38*			*P = 0.77*	
Parity						
Nulliparous				668 (45%)	1112 (58%)	1780 (53%)
Parous				802 (55%)	796 (42%)	1598 (47%)
Test of association					*P < 0.00001*	

men and women). Meat eaters consumed significantly more animal fat than non-meat eaters and significantly less dietary fibre. Meat eaters were significantly more likely to be alcohol drinkers, and to drink more than seven units of alcohol per week, than non-meat eaters, and marginally less likely to have a high level of exercise. There was no association between diet group and social class among men, but women who ate meat were significantly more likely to belong to social classes I and II, and less likely to be unclassifiable, than those who did not eat meat. Women who ate meat were significantly more likely to be parous than women who did not.

Overall mean BMI was 22.6 kg/m^2 for men and 21.8 kg/m^2 for women, values towards the lower end of the normal range. Mean BMI was consistently lower for non-meat eaters than for meat eaters in all age groups for which data were available, and the difference between the diet groups increased with increasing age among the women (Figure 1).

Table 2 shows mean BMI by gender and diet/lifestyle factor. Age-adjusted mean BMI was significantly higher among meat eaters than non-meat eaters (23.18 *vs* 22.05 kg/m^2 for men, 22.32 *vs* 21.32 kg/m^2 for women; both $P < 0.0001$). BMI increased with increasing intake of animal fat, and decreased with increasing intake of dietary fibre, for both men and women ($P < 0.0001$ for each combination of diet factor and gender). Increasing alcohol consumption was associated with increased BMI for both genders, especially among men ($P < 0.0001$ for men, $P = 0.009$ for women). There was no difference in age-adjusted mean BMI between 'low' and 'high' exercise men, but 'high' exercise women had a lower

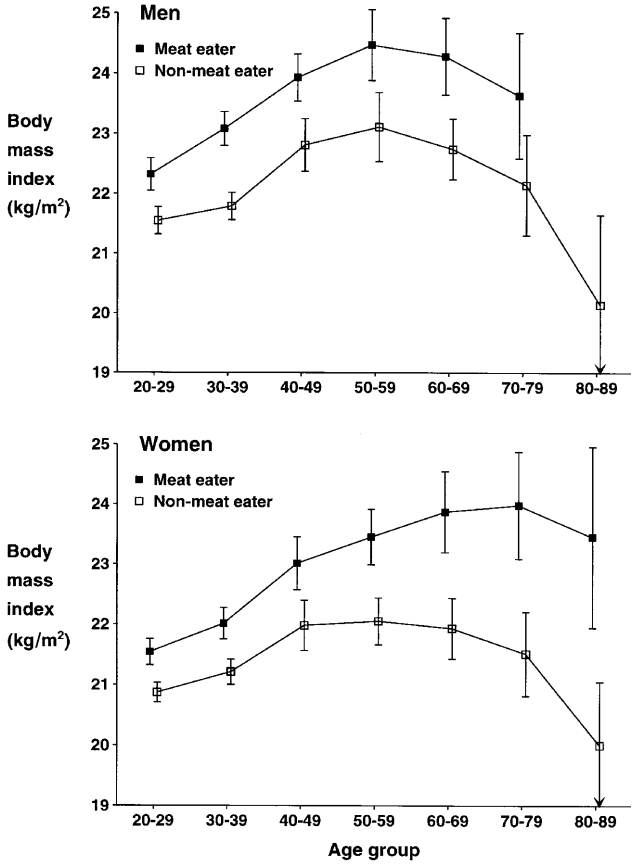

Figure 1 Mean body mass index by diet and age group (showing 95% confidence intervals). Note: There were no male meat eaters aged 80–89.

age-adjusted mean BMI than 'low' exercise women ($P = 0.051$). Age-adjusted mean BMI was highest for social classes III–V and lowest among unclassified persons for both men and women ($P = 0.002$ for men, $P = 0.003$ for women), and was significantly higher for ex-smokers compared with never smokers ($P < 0.0001$ for both men and women), and for parous women compared with nulliparous women ($P < 0.0001$).

When each of the diet/lifestyle factors were adjusted for each other, as well as for age, significant differences in mean BMI remained between diet groups, thirds of animal fat and dietary fibre, and social class and past smoking categories for both men and women. Differences in mean BMI with respect to alcohol consumption remained for men, but became non-significant for women, as did the small association with exercise, while the association with parity among women remained.

Table 3 shows the age-adjusted mean difference in BMI between meat eaters and non-meat eaters in men and women, and the effects on the difference of adjusting both separately and simultaneously for the other diet/lifestyle factors. The difference in age-adjusted mean BMI between meat eaters and non-meat eaters was reduced by 36% (from 1.13 to 0.73 kg/m^2) for men and by 31% (from 0.99 to 0.69 kg/m^2) for women after adjusting for all the other diet/lifestyle factors. For men, the greatest reduction in the difference in age-adjusted mean BMI between diet groups, was obtained by adjusting for dietary fibre (18% reduction), followed by alcohol consumption (15%) and animal fat (11%). Among women, the difference in age-adjusted mean BMI was reduced the most, by adjusting for dietary fibre (19% reduction), followed by animal fat (7%) and parity (3%).

When the non-meat eaters were divided into those who had followed their diet for five years or less and those who had not eaten meat for more than five years, the age-adjusted mean BMI values and their standard errors were 22.17 (s.e.m. 0.125) and 21.97 (0.101) kg/m^2 for men and 21.40 (0.096) and 21.27 (0.080) kg/m^2 for women, respectively. Thus, age-adjusted mean BMI was only marginally lower among 'long-term' non-meat eaters than among those who had recently given up meat, and these differences were not statistically significant ($P = 0.483$ and $P = 0.822$, respectively).

Discussion

Values of the mean BMI in this analysis are considerably lower than the means of 24.9 kg/m^2 for men and 24.6 kg/m^2 for women in a representative sample aged 16–64 y reported in the Dietary and Nutritional Survey of British Adults.[10] Although there is a tendency to overestimate height and underestimate weight in surveys where these are self-reported,[11] resulting in an underestimate of BMI, this is unlikely to account for the large differences noted. We suggest that the relatively low mean BMI is largely attributable to the skewed social class distribution of the cohort and the generally health conscious nature of the subjects.

Mean BMI was lower in non-meat eaters than in meat eaters among men and women at all ages, and the age-adjusted differences were 1.13 and 0.99 kg/m^2 in men and women, respectively. These are equivalent to differences of 3.6 and 2.7 kg, respectively, for men and women of average height in this population (1.78 and 1.64 m, respectively).

The seven diet/lifestyle factors considered here account for 36% and 31% in men and women, respectively, of the difference in age-adjusted mean BMI between meat eaters and non-meat eaters, with adjustment for dietary fibre having the greatest effect. However, the difference remains statistically significant even after adjustment for these factors. This could be because the dietary factors are measured with substantial error, making it impossible to adjust adequately for their effect. It may also be that other factors not considered in this analysis, account for some of the difference in BMI between non-meat eaters and meat eaters, or that leaner individuals are

Table 2 Mean (s.e.m.) body mass index (kg/m^2) by gender and diet/lifestyle factor

	Men		*Women*	
Diet/lifestyle factor	*Adjusted for age*	*Adjusted for age and other factors*	*Adjusted for age*	*Adjusted for age and other factors*
Diet group				
Meat eater	23.18 (0.077)	22.98 (0.076)	22.32 (0.070)	22.14 (0.070)
Non-meat eater	22.05 (0.079)	22.25 (0.077)	21.32 (0.062)	21.46 (0.061)
F-test	*P < 0.0001*	*P < 0.0001*	*P < 0.0001*	*P < 0.0001*
Animal fat[a]				
Low	22.15 (0.098)	22.39 (0.094)	21.39 (0.081)	21.55 (0.080)
Medium	22.66 (0.097)	22.67 (0.093)	21.91 (0.081)	21.88 (0.079)
High	23.05 (0.097)	22.81 (0.094)	21.96 (0.081)	21.84 (0.079)
F-test	*P < 0.0001*	*P = 0.018*	*P < 0.0001*	*P = 0.008*
Dietary fibre[b]				
Low	23.20 (0.097)	22.92 (0.094)	22.22 (0.081)	22.08 (0.080)
Medium	22.54 (0.097)	22.55 (0.094)	21.84 (0.081)	21.83 (0.079)
High	22.12 (0.097)	22.39 (0.094)	21.21 (0.081)	21.36 (0.079)
F-test	*P < 0.0001*	*P = 0.001*	*P < 0.0001*	*P < 0.0001*
Alcohol consumption				
*Non/occasional drinker	21.99 (0.113)	22.34 (0.110)	21.54 (0.083)	21.78 (0.081)
1–7 units per week	22.45 (0.100)	22.49 (0.097)	21.84 (0.068)	21.76 (0.066)
> 7 units per week	23.09 (0.083)	22.87 (0.081)	21.90 (0.106)	21.69 (0.104)
F-test	*P < 0.0001*	*P < 0.001*	*P = 0.009*	*P = 0.811*
Amount of exercise				
Low	22.63 (0.073)	22.59 (0.069)	21.81 (0.055)	21.80 (0.054)
High	22.62 (0.090)	22.67 (0.086)	21.60 (0.091)	21.64 (0.088)
F-test	*P = 0.927*	*P = 0.465*	*P = 0.051*	*P = 0.149*
Social class				
I–II	22.56 (0.074)	22.54 (0.071)	21.83 (0.065)	21.80 (0.064)
III–V	22.97 (0.112)	23.02 (0.107)	21.87 (0.085)	21.87 (0.083)
Unclassified	22.31 (0.139)	22.30 (0.133)	21.34 (0.113)	21.42 (0.110)
F-test	*P = 0.002*	*P < 0.001*	*P = 0.003*	*P = 0.018*
Past smoking				
Never smoker	22.39 (0.074)	22.42 (0.071)	21.63 (0.056)	21.63 (0.055)
Ex-smoker	22.94 (0.087)	22.90 (0.084)	22.05 (0.086)	22.05 (0.084)
F-test	*P < 0.0001*	*P < 0.0001*	*P < 0.0001*	*P < 0.0001*
Parity				
Nulliparous			21.54 (0.065)	21.60 (0.063)
Parous			22.00 (0.068)	21.93 (0.067)
F-test			*P < 0.0001*	*P = 0.002*

[a]Cut points: 42.56 and 60.80 g/d for men; 36.94 and 54.86 g/d for women.
[b]Cut points: 23.93 and 33.64 g/d for men; 21.54 and 29.64 g/d for women.

Table 3 Difference in age-adjusted mean body mass index (BMI) between meat eaters and non-meat eaters by gender, adjusting for other diet/lifestyle factors

	Men		*Women*	
Diet/lifestyle factor(s) adjusted for	*Difference in mean BMI (kg/m^2)*	*Reduction (increase) in age-adjusted difference*	*Difference in mean BMI (kg/m^2)*	*Reduction (increase) in age-adjusted difference*
Age alone	1.13	–	0.99	–
Age + Animal fat	1.01	11%	0.93	7%
Age + Dietary fibre	0.93	18%	0.80	19%
Age + Alcohol consumption	0.97	15%	0.98	2%
Age + Amount of exercise	1.14	(0%)	0.99	0%
Age + Social class	1.15	(2%)	0.98	1%
Age + Past smoking	1.15	(1%)	0.99	(0%)
Age + Parity			0.96	3%
Age + all other factors	0.73	36%	0.69	31%

more likely to adopt a meatless diet. Current smokers were excluded from the analysis, so that differences in current smoking habits cannot account for the difference in BMI.

The fact that there was no significant difference in age-adjusted BMI between long-term (>5 y) and short-term non-meat eaters suggests that the reduction in BMI on adopting a meatless diet is either achieved fairly quickly or, indeed, that it precedes the change of diet, which would be the case if leaner individuals are somehow predisposed to a vegetarian or semi-vegetarian diet. Unfortunately, we were unable to subdivide further by duration of meatless diet, so that we cannot tell how quickly the reduction is achieved. (Interestingly, a recent collaborative analysis of mortality in vegetarians, which included data from the Oxford Vegetarian Study, showed that the lower death rate for ischaemic heart disease among vegetarians compared with non-vegetarians was restricted to those who had followed their diet for more than five years.[3])

Clearly, the dietary factors studied here (dietary fibre and animal fat) are not the only ones likely to affect BMI. Unfortunately, the food frequency questionnaire paid little attention to either processed foods or sweets, both of which contribute substantial quantities of fat and refined sugar to the diet, or to sources of plant protein. For this reason, it was not possible to estimate total energy, carbohydrate or protein intake from the food frequency questionnaire. However, a previous analysis of dietary data from a subset of subjects in this study who completed a four-day diet diary showed no significant difference in total energy intake between diet groups, but that vegetarians consumed relatively more carbohydrate and less protein than non-vegetarians.[12] A study of lean and obese subjects showed that BMI was negatively correlated with carbohydrate intake ($r = -0.40$; $P < 0.01$) and positively correlated with protein intake ($r = 0.12$; NS), both expressed as a percentage of total energy.[13] Therefore, it is possible that some of the difference in BMI between non-meat eaters and meat eaters in this study may be attributable to a higher carbohydrate and lower protein intake in the former group. Other dietary factors which are likely to differ between meat and non-meat eaters, such as the type of fats consumed and the intake of various micronutrients, may also influence BMI.

There was a significant inverse association between dietary fibre intake and BMI in this analysis, the reduction in age-adjusted mean BMI between the bottom and top thirds of dietary fibre intake being 1.08 and 1.01 kg/m^2 in men and women, respectively. This observation is broadly consistent with results from other studies in which an inverse association between the intake of carbohydrate or high-carbohydrate foods and BMI has been noted,[13,14]

Conversely, there was a significant positive association between animal fat intake and BMI, with increases in age-adjusted BMI between the bottom and top thirds of animal fat intake of 0.90 and 0.57 kg/m^2 in men and women, respectively. A review of epidemiological studies of dietary fat and obesity showed that there is generally a positive association between fat intake and BMI in cross-sectional studies, and that low-fat diets in intervention studies usually result in a short-lived period of weight loss,[15] whilst a recent analysis of data from the Dietary and Nutritional Survey of British Adults found that high fat consumers tend to have a higher BMI than low fat consumers, although members of the former group are not necessarily overweight.[16]

Alcohol consumption was strongly associated with BMI in men for whom the age-adjusted mean BMI increased from 21.99 kg/m^2 in non-drinkers to 23.09 kg/m^2 in those consuming >7 units of alcohol per week. In women, however, the association between alcohol consumption and BMI disappeared after adjusting for the other diet/lifestyle factors. These results parallel those of the Dietary and Nutritional Survey of British Adults which showed alcohol drinking to be positively associated with BMI in men only.[10,16] A study of adult Finns also showed obesity to be positively associated with alcohol consumption in men,[17] although other studies have found no association between alcohol intake and BMI,[13,14,18] and even an inverse association in women.[19]

Among the lifestyle factors considered in this analysis, social class was associated with BMI in both men and women, with subjects of lower social class having a higher mean BMI than those of higher social class, reflecting the situation in Britain as a whole.[10] However in this analysis, those subjects whose social class was indeterminate (a group which included students, unemployed and retired persons, and women who simply described themselves as housewives without giving details of their spouse's occupation) had the lowest age-adjusted mean BMI.

Ex-smokers had a significantly higher BMI than never smokers, the difference in age-adjusted mean BMI being 0.55 and 0.42 kg/m^2 in men and women, respectively. These differences persisted after adjusting for the other diet/lifestyle factors. A study of adult Finns found a significantly increased risk of substantial weight gain among subjects who quit smoking during the course of the study, compared with those who did not smoke at any stage in both men and women.[17] In a study of hospital patients in Northern Italy, male ex-smokers had a higher age-adjusted mean BMI than never smokers, but in women the small number of ex-smokers were thinner than the never smokers.[14]

Parous women had a significantly higher BMI than nulliparous women, with a difference in age-adjusted mean BMI of 0.46 kg/m^2. A similar association between parity and weight gain, BMI or both has been found in several studies.[14,17,20–22]

The apparent lack of effect of amount of exercise on body mass in this analysis, suggests either that our rather crude grouping did not accurately reflect

subjects' true level of physical activity, or that subjects are well matched for exercise anyway. A study of adult Finns demonstrated an inverse relationship between physical activity and both the prevalence of obesity and a propensity for weight gain,[17] although inconsistent or null effects have been found in other studies.[21,23]

We believe that the lower body mass of the non-meat eaters compared with the meat eaters in this study (a difference of about one kg/m^2 for both men and women) is largely attributable to differences in the diet of the two groups, although we cannot exclude the possibility that leaner individuals are more likely to adopt a meatless diet. Our data also suggest that intakes of animal fat and dietary fibre, and alcohol consumption in men, each play a significant role in determining the body mass of an individual.

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