Intake of total, animal and plant proteins, and their food sources in 10 countries in the European Prospective Investigation into Cancer and Nutrition

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Objective: To describe dietary protein intakes and their food sources among 27 redefined centres in 10 countries participating in the European Prospective Investigation into Cancer and Nutrition (EPIC).
Methods: Between 1995 and 2000, 36 034 persons, aged between 35 and 74 years, were administered a standardized 24-h dietary recall (24-HDR) using a computerized interview software programme (EPIC-SOFT). Intakes (g/day) of total, animal and plant proteins were estimated using the standardized EPIC Nutrient Database (ENDB). Mean intakes were adjusted for age, and weighted by season and day of recall.
Results: Mean total and animal protein intakes were highest in the Spanish centres among men, and in the Spanish and French centres among women; the lowest mean intakes were observed in the UK health-conscious group, in Greek men and women, and in women in Potsdam. Intake of plant protein was highest among the UK health-conscious group, followed by some of the

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Italian centres and Murcia, whereas Sweden and Potsdam had the lowest intake. Cereals contributed to the highest proportion of plant protein in all centres. The combined intake of legumes, vegetables and fruit contributed to a greater proportion of plant protein in the southern than in the northern centres. Total meat intake (with some heterogeneity across subtypes of meat) was, with few exceptions, the most important contributor to animal protein in all centres, followed by dairy and fish products.
Conclusions: This study shows that intake of protein, especially of animal origin, differs across the 10 European countries, and also shows some differences in food sources of protein across Europe.

Introduction

Dietary protein is an important macronutrient, contributing to around 15–20% of the total dietary energy intake in Western countries (CDC, 2004; Elmadfa and Weichselbaum, 2005).

Protein, which contributes essential amino acids, is vital for human metabolism, and protein energy malnutrition is a major issue in developing countries, especially among children (WHO, 2000). Protein deficiency is, however, rare in the Western world, where the mean intake from a mixed diet is usually considerably in excess of recommended protein and amino acid intakes, especially among meat eaters (WHO/FAO/UNU, 2008). Protein-related health issues in the Western world are, therefore, mainly focused on the potential beneficial or harmful effects of high protein intake and whether the source of protein is of importance in relation to disease risk.

As protein is considered to increase thermogenesis and satiety more than other macronutrients, attention has lately turned to its potential beneficial effects on weight loss and maintenance (Halton and Hu, 2004), but evidence regarding this issue is still inconclusive (Nordmann *et al.*, 2006).

Another issue that is still unclear is whether all sources of protein have the same impact on disease outcomes. As an example, one study indicated that plant proteins had a protective effect against coronary heart disease mortality compared with animal proteins, whereas no clear association with cancer incidence and mortality was observed for any subtype of protein (Kelemen *et al.*, 2005).

The association between protein and cancer risk has often been assessed on the basis of the food sources of protein rather than on the nutrient itself. Two of the main contributors to animal protein, red and processed meat, have been found to be consistently positively associated with risk of colorectal cancer (WCRF/AICR, 2007). The main explanation behind this association may, however, not be directly related to animal proteins, but to haem iron and endogenous *N*-nitroso components present in high concentrations in red and processed meat (Kuhnle and Bingham, 2007). In contrast, some researchers have suggested that other important sources of animal proteins, such as fish, may reduce the risk of colorectal cancer (Geelen *et al.*, 2007) without being able to disentangle any specific beneficial effect of proteins.

In the European Prospective Investigation into Cancer and Nutrition (EPIC) calibration study, a standardized computer-assisted 24-h dietary recall (24-HDR) was administered to almost 37 000 participants on the basis of a representative subsample from 23 centres across 10 European countries, redefined into 27 centres for specific dietary analyses in EPIC (Slimani *et al.*, 2002a). Recently, the EPIC Nutrient Database (ENDB) has harmonized the national nutrient databases, making it possible to compare protein intakes and sources of animal and plant proteins between participating countries (Slimani *et al.*, 2007).

In this descriptive paper, we examine the distribution of intakes of total protein and subtypes of protein across the 27 redefined EPIC centres and different population subgroupings. Furthermore, the contribution to protein intake from different food sources is evaluated.

Materials and methods

Study cohort

The EPIC calibration study is nested within EPIC, which is an ongoing prospective cohort study designed to investigate the associations between diet, lifestyle and cancer throughout 10 Western European countries, namely, Denmark, France, Germany, Greece, Italy, Norway, Spain, Sweden, the Netherlands and the United Kingdom (Riboli and Kaaks, 1997; Riboli *et al.*, 2002). The cohort comprises approximately 370 000 women and 150 000 men, aged 20–85 years, enrolled between 1992 and 2000. Participants were mostly recruited from the general population residing within defined geographical areas, with some exceptions: women members of a health insurance scheme for state school employees (France); women attending breast cancer screening (Utrecht, the Netherlands); blood donors (centres in Italy and Spain); and a cohort consisting predominantly of ovo-lacto vegetarians and vegans ('health-conscious' cohort in Oxford, UK) (Riboli *et al.*, 2002). A total of 19 of the 27 redefined EPIC

centres had both female and male participants, and 8 centres had only female participants.

Data presented in this paper were derived from the EPIC calibration study (conducted between 1995 and 2000), in which an approximately 8% stratified random sample (on age, gender and centre, and weighted for expected cancer cases in each stratum) of the total cohort completed a standardized, computer-assisted 24-HDR. The calibration study was conducted to improve the comparability of food-frequency-derived dietary data across the EPIC centres and to correct for potential measurement errors arising from country- or centre-specific bias and random and systematic within-person errors (Willett, 1998; Ferrari *et al.*, 2004). Previous publications outline in detail the rationale, methodology and population characteristics of the 24-HDR calibration study (Kaaks *et al.*, 1994, 1995; Slimani *et al.*, 2002a; Ferrari *et al.*, 2008). Approval for the study was obtained from the ethical review boards of the International Agency for Research on Cancer (Lyon, France) and from all local recruiting institutions. All participants provided written informed consent.

Measurements of diet and other lifestyle factors

The 24-HDR was obtained by face-to-face interviews, except in Norway, where a telephone interview was conducted (Brustad *et al.*, 2003). A computerized interview software programme (EPIC-soft) was developed for the calibration study (Slimani *et al.*, 1999, 2000).

Intakes (g/day) of total protein were estimated from the 24-HDRs using, as starting point, country-specific nutrient databases, which were standardized across countries as far as possible to allow calibration at the nutrient level. The ENDB project outlines in detail the methods used to standardize the national nutrient data sets across the 10 countries: EPIC foods were matched to national databases, the nutrient values of unavailable foods were derived and missing values were imputed (Slimani *et al.*, 2007).

All reported foods were classified as being of 100% animal origin (defined as $\geqslant$95% animal origin); 100% plant origin (defined as $\geqslant$95% plant origin); mixed origin; non-organic; or unknown quantities of animal/plant origin (for example, ready-to-eat dishes and cakes without any clear declaration, or containing ingredients of mixed or unknown origin). On the basis of this information, it was possible to estimate the intake of protein of animal and plant origin. In cases in which the origin was unclear (for example, in ready-to-eat dishes and cakes), protein origin was classified as 'unknown'.

Data on other lifestyle factors, including educational level, total physical activity and smoking history, considered in this analysis were collected at baseline through standardized questionnaires and clinical examinations, and have been described for the calibration sample elsewhere (Riboli *et al.*, 2002; Slimani *et al.*, 2002a; Friedenreich *et al.*, 2007; Haftenberger *et al.*, 2002a, b). Data on age, as well as on body weight and height, were self-reported by participants during the 24-HDR interview. The mean time interval between these baseline questionnaire measures and the 24-HDR interview varied by country, from 1 day to 3 years later (Slimani *et al.*, 2002a).

Statistical methods

A total of 36 034 subjects with 24-HDR data were included in the analyses, after a systematic exclusion of 960 subjects under 35 and over 74 years of age because of low participation of patients in these age categories.

Data are presented as mean (least square means) intakes and s.e. (standard errors), stratified by study centre, gender and age groups, and ordered according to a geographical south–north gradient. Intakes of total protein, animal, plant and unknown proteins are presented on the basis of main protein-providing food groups. The food classification used was adapted from the EPIC-Soft food subgroups described in detail elsewhere (Slimani *et al.*, 2000, 2002b). Food groups that contributed large amounts of protein were further split into subgroups.

'Minimally adjusted' intakes were adjusted for age (except when stratified by age) and were weighted by season and day of the week of recall using generalized linear models to control for different distributions of 24-HDR interviews across seasons and days of the week.

We examined the independent effect of adjustment for several potential confounders—including height, weight, total energy intake, body mass index (BMI), smoking status, highest educational level and physical activity—on centre ranking and on the R^2 of the model as an estimation of the variability of protein intake that is explained by the potential confounder. In 'fully adjusted' models, we decided to retain, in addition to the co-variables used in the 'minimally adjusted' model, total energy intake, weight and height. The tables on total protein, animal, plant and unknown mean intakes using the fully adjusted models are available in the Appendix. In this model, tests for gender differences in protein intake were also conducted. We also performed stratified analyses to describe differences in intakes of protein and its subgroups on the basis of BMI category ($<$25, 25–30 and $\geqslant$30 kg/m^2), educational level (none/primary, secondary/technical and university), physical activity (inactive, moderately inactive, moderately active and active) and smoking status (never, former and current smoker). These factors were selected *a priori*, as it was thought that protein intakes might differ in these subgroups. In the stratified analyses, gender- and country-specific 'minimally adjusted' mean intakes were presented across variables of interest. Stratification was also performed for season (spring, summer, autumn and winter) and day of the week of the 24-HDR (Monday to Thursday versus Friday to Sunday). These analyses were weighted for either day or season, and were adjusted for age. If fewer than 20 persons were represented in a cross-classification (for example,

centre, gender and age group), the least square mean and s.e. are not presented in the table. Analyses were performed using SAS (version 9.1, SAS Institute, Cary, NC, USA).

Results

Minimal adjusted mean intake of total protein and protein of animal, plant or of unknown origin

Centre-specific mean total protein intakes, stratified by gender, centre and age, and weighted by season and day of the week of recall, are presented in Table 1. For both men and women, the highest mean daily intake of protein was seen in San Sebastian (men 144 g, women 94 g) and the lowest in the UK health-conscious group (men 72 g, women 60 g).

Mean intakes and s.e. of protein of animal, plant and of unknown origin, stratified on the basis of gender and centre, are presented in Table 2. (Further stratifications according to age groups are presented on the EPIC website (http://epic.iarc.fr).) As for total protein, the highest intake of animal protein was reported in San Sebastian (men 105 g/day, women 67 g/day) and the lowest among the UK health-conscious participants (17 g/day for both men and women), because their specific eating patterns involve a very low consumption of animal foods (ovo-lacto vegetarians) or none (vegans). Among the remaining centres, the lowest intake of animal protein was seen in Greek men (52 g/day) and in women in Greece and Potsdam (37 g/day).

For plant protein, the highest mean intake was seen in the UK health-conscious group (men 51 g/day, women 39 g/day). Among the remaining centres, the highest mean intake was reported in Ragusa (men 42 g/day, women 27 g/day) and the lowest in Malmö (men 26 g/day, women 20 g/day). The mean intake of protein of unknown origin was generally low, ranging from 2 to 8 g/day; it was the lowest in Greece and in the Southern Spanish centres, and the highest in the Netherlands and in the UK general population. Within each centre, men had higher absolute intakes than did women of both total protein and different subgroups of protein. Looking across age groups, a tendency towards a lower intake of total protein in older people and a higher intake in younger age groups was observed in most but not all centres. The same tendency, although less clear, was present for animal and plant protein (data not shown but available on the EPIC website (http://epic.iarc.fr)). Figures 1a and b show the minimal adjusted mean intake of total and subtypes of protein expressed as a percentage of total energy (%en), stratified by gender and centre. In most centres, energy from protein contributed 15–20% in both genders. A particularly high percentage of energy intake from total protein was noted in some of the Northern Spanish centres (20–21%en) and from animal protein in the Northern Spanish (14–15%en) and French centres (11–12%en), in contrast to low values in the UK health-conscious group (12–13%en of total protein and 3–4%en from animal protein). The energy percentage from plant protein was fairly stable in most centres and in both genders (about 5–6%en), except in the UK health-conscious population, in which it was higher (8–9%en). The contribution to the total energy of protein of unknown origin was very marginal in all centres (0.3–1.5%en). More details on main nutrient energy sources are provided in a separate paper (Ocké *et al*, 2009).

Influence of adjustment for potential confounders

To evaluate whether the observed differences in protein intake could be ascribed to systematic differences in body composition and energy intake between the EPIC centres, further adjustments for body height, weight and total energy intake were performed. The fully adjusted mean intakes of total protein, animal, plant and unknown protein, stratified on the basis of gender and age groups and adjusted for age (in analyses not stratified on age), energy, height and weight and weighted by day of 24-HDR and season, are shown in the Appendix (Tables A1–A4).

After adjustment, the estimated mean intake of total protein was still highest in the Northern Spanish centres and lowest in the UK health-conscious group. Although most centres were not influenced, a notable impact on the estimated mean protein intake was observed in the Greek centre and in UK health-conscious men, where energy adjustment especially increased the mean intake considerably. In contrast, decreases in mean intake were observed in women and men in Aarhus and in men in Varese and San Sebastian. The same result was observed for animal and plant proteins. Compared with the minimally adjusted models, less clear systematic differences in intake across age groups were observed. To test for any gender-specific effect on protein intake, we tested for an interaction between gender and centre in a fully adjusted model. Gender differences were present for total protein and for both subgroups for both absolute (g/day) and relative (%en) protein intake ($P<0.0001$).

Dietary sources of protein

Not counting the UK health-conscious group, animal protein accounted for 55–73% of total protein and plant protein accounted for 24–39% (Table 2). In contrast, in the UK health-conscious group, total protein was mostly of plant origin (men 70%, women 65%), and only 23–29% of it was of animal origin. The reverse extreme was observed in men in San Sebastian, with a proportion of 73% animal protein and 24% plant protein. A small percentage of the protein was considered to be of unknown origin (with contribution from cakes being an important factor in all centres), ranging from 2 to 9% of total protein.

Tables 3a and b show the dietary contributors (%) to intake of animal and plant protein in men and women. Dietary

Table 1 Minimally adjusted[a] mean daily intake of total protein by centre ordered from south to north, gender and age group

Country and centre	*Men*											*Women*										
	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}
		M	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*			*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	
Greece	1311	88.5	1.0	98.1	3.1	99.3	2.1	84.1	1.9	79.1	1.7	0.08	1373	62.2	0.7	65.5	2.0	66.5	1.3	59.3	1.3	56.9	1.5	0.09
Spain																								
Granada	214	111.3	2.6	—	—	116.7	5.4	113.2	3.5	97.5	5.8	0.67	300	75.1	1.6	76.3	4.0	80.5	2.6	70.2	2.5	78.1	5.0	0.85
Murcia	243	107.7	2.4	120.8	7.5	112.0	4.3	106.2	3.3	93.3	8.3	0.01	304	81.0	1.6	86.5	3.1	81.2	2.6	80.4	2.6	—	—	0.05
Navarra	444	119.8	1.8	131.6	7.7	130.7	3.0	115.3	2.5	100.5	5.4	0.05	271	86.1	1.6	86.9	4.3	87.8	2.7	86.0	2.5	—	—	0.17
San Sebastian	490	144.0	1.7	141.0	4.0	149.9	2.3	146.5	3.2	140.2	8.5	0.84	244	94.4	1.7	102.2	3.7	99.3	2.8	89.5	2.9	—	—	0.02
Asturias	386	131.5	1.9	134.8	7.2	134.4	3.2	127.5	2.8	138.3	5.2	0.89	324	91.6	1.5	97.0	3.7	94.6	2.5	89.0	2.4	86.0	5.5	0.01
Italy																								
Ragusa	168	110.3	2.9	—	—	117.3	4.3	102.5	4.5	—	—	0.16	138	75.7	2.3	86.7	3.8	68.5	4.3	78.1	4.1	—	—	0.18
Naples													403	73.9	1.3	87.5	4.4	72.0	2.1	72.3	2.1	77.6	4.4	0.47
Florence	271	107.5	2.3	117.6	7.2	112.1	3.9	108.9	3.2	—	—	0.11	784	76.4	1.0	82.9	3.3	74.5	1.7	76.7	1.3	75.0	3.8	0.28
Turin	676	100.7	1.4	103.5	4.7	106.1	2.4	99.1	2.1	97.1	5.5	0.17	392	74.7	1.4	80.7	4.3	72.8	2.3	75.6	1.9	—	—	0.24
Varese	327	109.4	2.1	—	—	109.8	4.6	108.4	2.5	108.6	7.0	0.32	794	73.5	1.0	79.5	3.1	76.0	1.6	71.5	1.4	68.6	2.9	0.00
France																								
South coast													620	85.6	1.1			87.4	1.8	84.0	1.7	82.1	2.3	0.10
South													1425	83.0	0.7			82.3	1.1	83.7	1.1	80.7	1.6	0.64
North-East													2059	85.1	0.6			86.3	0.9	85.4	0.9	79.4	1.4	0.25
North-West													631	86.0	1.1			87.7	1.7	84.1	1.6	83.4	2.6	0.24
Germany																								
Heidelberg	1034	91.9	1.2	99.1	3.1	95.3	1.8	90.8	1.7	—	—	0.75	1087	68.2	0.8	72.3	1.4	70.0	1.5	66.7	1.4	—	—	0.38
Potsdam	1233	89.7	1.1	100.9	3.1	89.4	2.2	89.8	1.4	81.1	4.2	0.06	1061	62.7	0.8	64.4	1.6	64.0	1.6	63.4	1.2	56.9	5.3	0.16
The Netherlands																								
Bilthoven	1024	102.3	1.2	107.9	2.3	107.5	1.8	104.1	2.0	—	—	0.18	1086	74.6	0.8	77.7	1.5	76.7	1.3	74.3	1.6	—	—	0.68
Utrecht													1870	80.5	0.6			80.3	1.1	80.7	1.0	76.7	1.3	0.39
United Kingdom																								
General population	402	91.2	1.9	99.1	6.1	94.8	3.3	86.8	3.4	87.5	3.4	0.07	570	70.8	1.1	75.1	3.4	72.1	1.9	70.2	2.1	66.6	2.4	0.01
Health-conscious	114	72.1	3.5	—	—	65.9	5.7	71.6	5.4	—	—	0.97	197	59.8	1.9	58.2	6.1	55.2	3.2	63.3	3.0	64.6	5.3	0.20
Denmark																								
Copenhagen	1356	95.5	1.0			93.8	1.6	96.9	1.3	87.2	5.1	0.54	1484	72.1	0.7			72.4	1.2	71.4	0.9	67.9	3.3	0.19
Aarhus	567	97.8	1.6			99.0	2.2	99.0	2.2	—	—	0.33	510	77.0	1.2			77.7	1.7	76.3	1.7	—	—	0.29
Sweden																								
Malmö	1421	92.9	1.0			97.2	3.0	90.5	1.6	85.8	1.4	0.06	1711	70.7	0.7			73.2	1.3	67.9	1.1	67.7	1.0	0.31
Umeå	1344	94.7	1.0	106.4	3.5	96.4	1.9	91.5	1.4	91.3	3.0	0.08	1574	72.0	0.7	75.6	1.7	73.3	1.2	70.5	1.0	67.2	2.2	0.00
Norway																								
South and East													1004	75.6	0.9	78.8	2.1	76.6	1.0	78.0	2.1			0.8
North and West													793	75.6	1.0	80.9	2.2	77.2	1.2	73.3	2.5			0.0

Abbreviations: M, mean; s.e., standard error; —, if fewer than 20 persons are present in a certain age group, mean intake is not presented.
[a]Adjusted for age (when not stratified for age), and weighted by season and day of recall.

Table 2 Minimally adjusted[a] mean daily intake of protein of animal origin, plant origin, or mixed/unknown origin (g/day) and percentage of total protein by centre and gender

Country and centre	*Men*									*Women*								
	N	*Animal protein*			*Plant protein*			*Unknown protein*			N	*Animal protein*			*Plant protein*			*Unknown protein*		
		M	*s.e.*	*% of total protein*[b]	*M*	*s.e.*	*% of total protein*	*M*	*s.e.*	*% of total protein*		*M*	*s.e.*	*% of total protein*	*M*	*s.e.*	*% of total protein*	*M*	*s.e.*	*% of total protein*
Greece	1311	52.3	0.9	59	34.7	0.4	39	1.6	0.2	2	1373	36.5	0.6	59	24.1	0.3	39	1.6	0.2	3
Spain																				
Granada	214	75.3	2.2	68	34.1	1.0	31	2.0	0.5	2	300	49.9	1.4	66	23.1	0.6	31	2.1	0.4	3
Murcia	243	66.2	2.1	61	38.8	0.9	36	2.7	0.5	3	304	51.4	1.4	63	27.2	0.6	34	2.4	0.4	3
Navarra	444	82.7	1.5	69	34.6	0.7	29	2.6	0.4	2	271	60.7	1.4	70	23.3	0.6	27	2.2	0.4	3
San Sebastian	490	105.2	1.5	73	33.9	0.7	24	4.9	0.4	3	244	66.8	1.5	71	24.0	0.7	25	3.7	0.4	4
Asturias	386	92.9	1.7	71	33.5	0.7	25	5.1	0.4	4	324	63.7	1.3	70	23.3	0.6	25	4.7	0.3	5
Italy																				
Ragusa	168	60.8	2.5	55	41.9	1.1	38	7.7	0.6	7	138	42.7	2.0	56	27.4	0.9	36	5.6	0.5	7
Naples											403	43.4	1.2	59	26.6	0.5	36	3.9	0.3	5
Florence	271	61.2	2.0	57	40.1	0.9	37	6.2	0.5	6	784	44.8	0.8	59	26.7	0.4	35	4.8	0.2	6
Turin	676	58.0	1.3	58	36.5	0.5	36	6.1	0.3	6	392	44.6	1.2	60	25.1	0.5	34	5.0	0.3	7
Varese	327	67.4	1.8	62	36.0	0.8	33	6.0	0.4	5	794	43.8	0.8	60	24.2	0.4	33	5.5	0.2	7
France																				
South coast											620	56.7	1.0	66	25.6	0.4	30	3.3	0.2	4
South											1425	54.5	0.6	66	25.1	0.3	30	3.4	0.2	4
North-East											2059	56.4	0.5	66	24.5	0.2	29	4.2	0.1	5
North-West											631	58.1	0.9	68	24.4	0.4	28	3.4	0.2	4
Germany																				
Heidelberg	1034	57.6	1.0	63	29.3	0.4	32	5.0	0.2	5	1087	41.6	0.7	61	22.5	0.3	33	4.2	0.2	6
Potsdam	1233	56.6	0.9	63	28.1	0.4	31	5.0	0.2	6	1061	36.5	0.7	58	21.5	0.3	34	4.7	0.2	7
The Netherlands																				
Bilthoven	1024	61.9	1.1	61	32.3	0.5	32	8.1	0.3	8	1086	44.1	0.7	59	24.2	0.3	32	6.4	0.2	9
Utrecht											1870	49.3	0.6	61	24.0	0.2	30	7.2	0.1	9
United Kingdom																				
General population	402	52.5	1.6	58	30.7	0.7	34	7.9	0.4	9	570	40.6	1.0	57	24.2	0.4	34	6.0	0.3	8
Health-conscious	114	16.5	3.0	23	50.8	1.3	70	4.8	0.7	7	197	17.1	1.7	29	38.7	0.8	65	4.1	0.4	7
Denmark																				
Copenhagen	1356	61.7	0.9	65	28.5	0.4	30	5.2	0.2	5	1484	44.5	0.6	62	23.6	0.3	33	4.0	0.2	6
Aarhus	567	60.8	1.4	62	31.0	0.6	32	6.0	0.3	6	510	46.4	1.1	60	25.8	0.5	34	4.8	0.3	6
Sweden																				
Malmö	1421	60.4	0.9	65	26.3	0.4	28	6.2	0.2	7	1711	46.0	0.6	65	19.6	0.3	28	5.1	0.2	7
Umeå	1344	60.0	0.9	63	27.7	0.4	29	6.9	0.2	7	1574	45.2	0.6	63	21.7	0.3	30	5.0	0.2	7
Norway																				
South and East											1004	45.7	0.8	60	24.9	0.3	33	4.9	0.2	6
North and West											793	46.5	0.9	62	24.1	0.4	32	5.0	0.2	7

Abbreviations: M, mean; s.e., standard error.

[a]Adjusted for age and weighted by season and day of recall.

[b]Percentage (%) of total protein is calculated as minimal adjusted animal, plant or unknown protein/minimal adjusted total protein (Table 1) × 100. This estimate deviates slightly from percentages obtained from a model with the percentage of total protein from animal protein, plant protein and unknown origin as the dependent variables and then adjusted for age and weighted by season and day of recall.

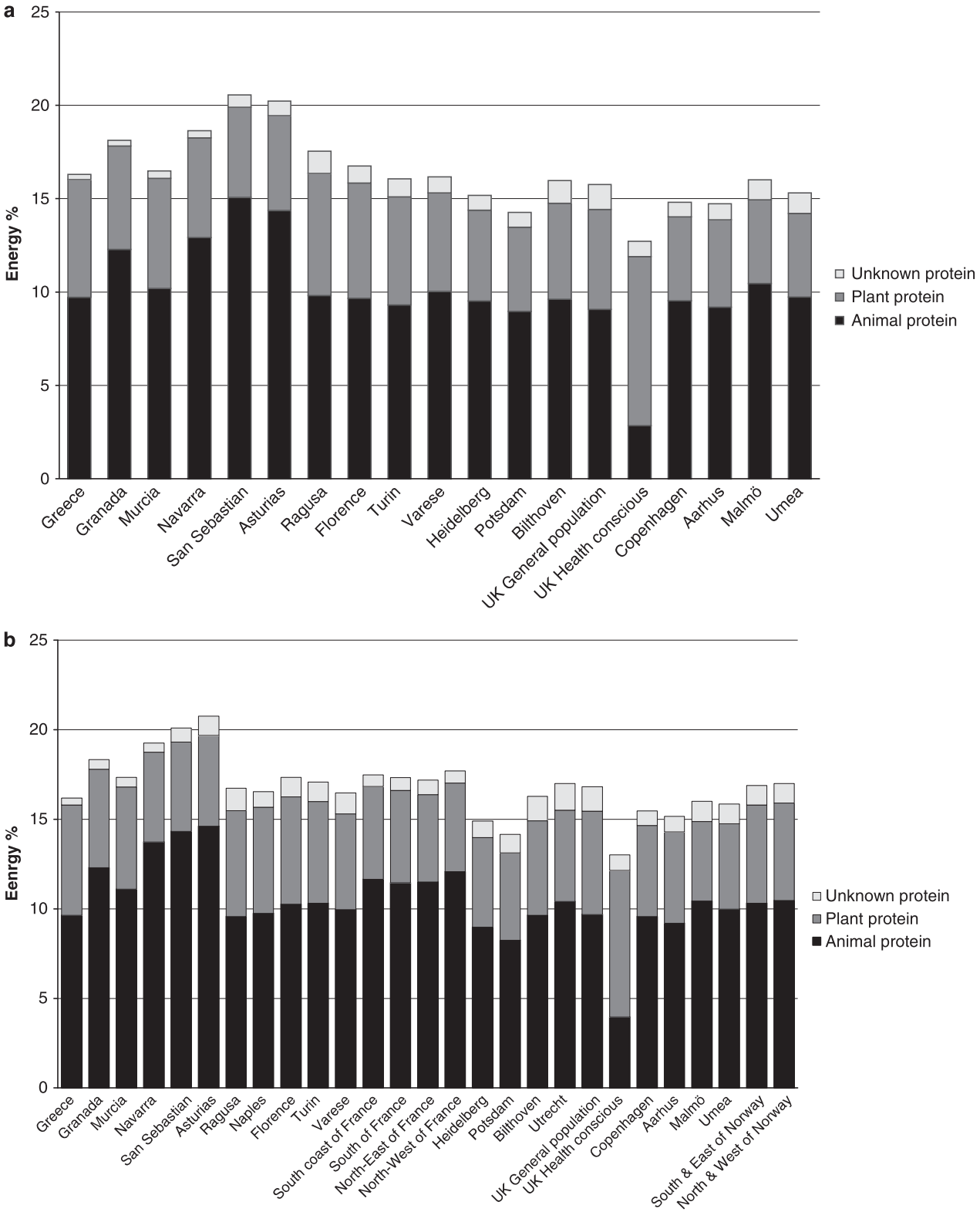

Figure 1 Minimally adjusted mean intake of subtypes of protein expressed as percentage of total energy, stratified by centre, adjusted for age and weighted by season and day of dietary recall (**a**) men and (**b**) women.

Table 3a Percentage contribution[a] of main food groups or subgroups to the intake of animal protein, adjusted for age and weighted for day of the week and season

Country and centre	*Men* *Dietary food groups*								*Women* *Dietary food groups*							
	Main group Dairy	*Main group Total meat*	*Subgroup Red meat*	*Subgroup Poultry*	*Subgroup Proc-meat*	*Main group Fish*	*Main group Eggs*	*Total %*[b]	*Main group Dairy*	*Main group Total meat*	*Subgroup Red meat*	*Subgroup Poultry*	*Subgroup Proc-meat*	*Main group Fish*	*Main group* Eggs	*Total %*[b]
Greece	31.2	41.3	26.7	8.7	3.5	23.6	2.4	98.6	38.1	38.1	22.5	11.0	3.3	19.4	3.0	98.6
Spain																
Granada	24.2	43.3	16.5	13.3	12.8	25.0	4.3	96.8	30.1	38.5	15.2	11.3	11.3	24.2	4.3	97.1
Murcia	17.9	51.5	20.3	14.3	15.0	22.7	4.8	97.0	27.3	44.0	14.4	16.9	10.7	21.4	4.8	97.4
Navarra	13.1	55.9	26.4	11.1	16.1	22.2	6.4	97.7	24.8	44.9	16.8	13.1	13.2	22.5	5.2	97.4
San Sebastian	12.4	56.2	30.2	12.0	11.0	23.8	6.2	98.7	22.9	45.9	22.2	12.6	9.5	23.9	6.0	98.7
Asturias	17.9	50.3	23.8	9.4	15.6	24.3	5.3	97.8	26.9	44.7	19.4	11.8	11.1	21.0	5.4	98.0
Italy																
Ragusa	27.6	59.1	27.4	22.0	7.8	8.7	2.8	98.2	27.3	55.0	38.5	9.1	6.9	13.3	3.3	99.0
Naples									35.6	47.1	28.0	9.6	8.9	10.0	3.0	95.7
Florence	24.3	60.0	27.6	18.7	10.3	10.9	2.7	97.9	29.8	57.1	26.5	18.1	9.2	8.2	2.9	98.0
Turin	27.6	57.7	24.0	18.8	12.9	10.0	2.9	98.2	30.3	56.5	29.1	15.3	10.3	7.5	3.5	97.8
Varese	27.3	64.1	30.0	15.9	16.5	4.8	1.3	97.5	31.8	54.9	24.0	16.0	14.0	7.5	2.9	97.1
France																
South coast									35.4	44.7	18.0	13.8	9.3	14.4	3.0	97.5
South									34.0	46.9	22.8	13.2	9.0	12.6	3.3	96.8
North-East									33.3	47.3	22.9	12.2	9.3	13.6	3.2	97.4
North-West									29.8	46.6	20.0	14.5	10.2	17.8	3.3	97.5
Germany																
Heidelberg	22.7	64.2	28.8	9.4	24.7	5.7	3.0	95.5	32.9	52.3	21.5	11.9	18.0	7.0	3.3	95.5
Potsdam	22.5	62.4	23.2	8.5	29.7	7.0	3.2	95.1	28.9	51.6	20.4	9.4	20.9	9.7	4.4	94.6
The Netherlands																
Bilthoven	29.1	62.2	32.9	8.3	20.4	4.4	3.3	99.0	36.5	52.9	28.4	7.8	15.8	5.6	4.2	99.2
Utrecht									41.6	49.0	26.0	8.8	13.9	4.6	3.9	99.2
United Kingdom																
General population	29.3	55.3	22.1	17.3	15.1	10.3	3.0	97.9	31.3	50.4	18.8	19.2	11.3	12.6	3.4	97.8
Health-conscious	49.0	27.7	11.1	8.0	7.3	7.5	6.3	90.6	50.5	25.4	3.9	13.5	8.0	14.1	3.8	93.7
Denmark																
Copenhagen	29.1	55.6	34.1	8.7	11.9	10.6	3.9	99.2	33.4	48.5	29.0	10.0	8.3	12.7	4.3	98.9
Aarhus	32.2	53.1	33.0	7.2	11.8	9.8	3.8	98.9	36.7	47.6	26.3	11.5	8.3	9.6	4.7	98.6
Sweden																
Malmö	31.8	51.2	28.8	6.1	15.1	11.4	3.5	97.9	35.5	46.0	24.1	7.3	13.7	11.7	4.4	97.5
Umeå	38.2	45.2	21.9	3.7	14.4	9.6	3.8	96.9	40.3	42.3	18.7	4.9	14.1	10.6	3.8	96.9
Norway																
South and East									34.7	45.7	16.7	10.2	16.1	12.4	4.5	97.3
North and West									32.7	41.2	18.4	4.6	16.8	18.8	4.1	96.8

Abbreviation: Proc-meat, processed meat.
[a]Percentage (%) contribution of animal protein is calculated as minimal adjusted mean animal protein intake from a food group/minimal adjusted total animal protein intake (Table 2) × 100.
[b]Contribution from the presented food groups. Remaining values that add up to 100% comes from different minor sources that are not listed.

Table 3b Percentage contribution[a] of main food groups to the intake of plant protein, adjusted for age and weighted for day of the week and season

Country and centre	*Men* *Dietary food groups*								*Women* *Dietary food groups*							
	Potatoes	*Vegetables*	*Legumes*	*Fruits*	*Cereals*	*Cakes*	*Non-alcoholic drinks*	*Total %*[b]	*Potatoes*	*Vegetables*	*Legumes*	*Fruits*	*Cereals*	*Cakes*	*Non-alcoholic drinks*	*Total %*[b]
Greece	3.0	12.7	7.6	7.3	62.2	2.0	1.7	96.5	3.2	14.9	6.5	8.9	57.0	4.3	2.4	97.3
Spain																
Granada	5.7	9.5	9.1	10.9	48.6	2.8	2.0	88.6	5.9	12.9	6.6	13.6	46.5	3.2	2.5	91.3
Murcia	5.7	13.4	8.2	15.6	44.4	4.8	1.1	93.2	5.9	24.2	6.2	14.0	35.2	7.6	1.4	94.5
Navarra	4.8	10.8	10.9	9.0	51.3	2.6	1.1	90.7	4.8	12.9	8.4	14.7	42.6	5.5	2.2	91.0
San Sebastian	6.6	11.0	14.5	10.1	44.5	2.5	0.7	89.9	6.4	14.4	12.8	12.5	40.1	3.6	2.0	91.8
Asturias	8.1	7.0	15.6	9.0	46.5	3.0	1.4	90.6	7.8	7.0	12.9	13.8	41.3	6.5	2.5	91.8
Italy																
Ragusa	3.3	8.4	3.3	6.6	69.1	1.4	1.1	93.1	2.2	10.1	5.3	9.2	58.9	4.7	1.5	91.9
Naples									2.9	13.0	3.7	7.4	60.7	3.5	2.7	93.8
Florence	3.0	10.6	3.9	5.7	65.2	2.2	1.5	92.1	2.8	14.0	3.6	8.1	58.7	3.1	3.0	93.3
Turin	3.3	13.1	2.0	6.8	64.6	2.5	1.6	93.9	2.9	17.2	1.2	9.2	56.3	3.8	2.7	93.3
Varese	3.0	11.7	1.6	6.7	66.9	2.3	2.2	94.3	3.5	12.2	2.7	9.6	58.2	4.0	3.3	93.6
France																
South coast									2.5	15.5	2.9	10.4	52.8	3.8	3.1	90.8
South									4.1	13.1	1.9	9.1	56.2	3.9	2.9	91.2
North-East									4.7	13.1	1.8	9.6	53.1	4.4	3.5	90.3
North-West									5.7	12.8	1.6	10.0	54.6	3.4	3.6	91.9
Germany																
Heidelberg	7.4	9.6	1.4	5.8	42.3	4.8	13.1	84.5	7.3	12.4	1.4	9.1	42.3	5.9	11.0	89.4
Potsdam	9.0	9.4	1.3	7.3	42.0	5.4	9.3	83.7	8.6	12.5	1.1	10.1	40.3	6.4	10.8	89.9
The Netherlands																
Bilthoven	10.3	7.9	1.3	10.3	53.6	2.0	4.9	90.3	9.2	9.4	1.2	9.2	52.0	3.4	6.7	91.2
Utrecht									8.7	9.6	1.3	11.9	51.2	3.2	6.7	92.5
United Kingdom																
General population	8.1	10.9	2.1	5.8	57.1	3.0	3.6	90.5	6.8	12.4	2.3	7.6	52.0	4.3	4.4	89.8
Health-conscious	5.0	9.0	3.8	13.1	41.5	2.2	2.1	76.8	5.4	11.0	3.6	12.7	39.7	3.8	2.1	78.3
Denmark																
Copenhagen	8.6	9.2	0.3	4.3	58.8	1.6	8.6	91.5	7.0	11.0	0.3	6.9	57.5	3.1	8.3	94.0
Aarhus	9.1	8.0	0.1	4.6	60.4	2.0	8.3	92.4	6.8	9.7	0.1	7.4	57.9	4.2	8.1	94.2
Sweden																
Malmö	9.8	6.4	1.9	4.4	56.0	3.8	4.3	86.7	8.4	9.3	0.9	6.8	51.3	5.4	5.0	87.1
Umeå	10.3	4.9	0.5	3.8	60.4	6.3	3.1	89.3	7.9	7.5	1.0	5.8	56.3	8.1	3.7	90.2
Norway																
South and East									5.7	7.5	0.4	7.8	59.0	4.7	7.9	92.9
North and West									7.2	6.7	0.3	7.8	58.6	5.4	6.8	92.9

[a]Percentage (%) contribution of plant protein is calculated as minimal adjusted mean plant protein intake from a food group/minimal adjusted total plant protein intake (Table 2) × 100.
[b]Contribution from the presented food groups. Remaining values that add up to 100% comes from different minor sources that are not listed.

contributors to total protein and unknown protein are available on the EPIC website (http://epic.iarc.fr).

Animal protein

For animal protein, the most important contributing food groups were meat (red meat, poultry, game, processed meat and offal), fish (fish and fish products, molluscs and crustaceans) and dairy products (milk, yoghurt, cheese, cream and dairy cream dessert), which together accounted for 84–96% of animal protein (Table 3a). In addition, eggs contributed 1–6%.

Total meat intake provided the highest contribution to animal protein in all centres, except for the UK health-conscious group and in Greek women, ranging from 39% (Granada) to 57% (Florence) in women and from 41% (Greece) to 64% (Heidelberg and Varese) in men, with some heterogeneity when subtypes of meat were compared. In most centres, the dominant type of meat was red meat, whereas the contribution from poultry varied from <5% of mean animal protein intake in the northern centres of Norway and Sweden to 15–22% in the UK general population and in some Italian centres. The contribution of processed meat to mean animal protein intake also varied markedly across centres, from 3% in Greece to 25–30% in German men.

Dairy products provided the second largest contribution to animal protein after meat, except for Spanish men, and women in San Sebastian (where fish came second), for Greek women (where meat and dairy contributed the same) and for the UK health-conscious group (where dairy products were the main contributors to animal protein).

The mean animal protein intake from fish represented around 5% in the Netherlands, but around 19% or more for women in Spain, Greece and North-West Norway. A similar result was observed for men.

Plant protein

For plant protein, the most important food group was cereals (contributing 42–69% in men and 35–61% in women), but potatoes, vegetables, legumes and fruits also contributed to vegetable protein, with differing importance across centres (Table 3b).

The lowest contribution from cereals (<50%) was observed in Spain (except for men in Navarra, 51%), Germany and in the UK health-conscious group, whereas the highest contributions (>60% for men and >55% for women) were reported in Italy and Greece, and in most of the Scandinavian centres. The contribution from vegetables varied from 5% in Umeå to 13% in Murcia and Turin for men and from 7% in North-West Norway to 24% in Murcia for women. With few exceptions, lower contributions of protein from vegetables were reported in Northern Europe. Among women, vegetables constituted the second highest contributor to plant protein in a majority of centres (clearest exceptions were Umeå and Norway), whereas a more mixed picture was observed for men. After cereals, legumes were the most important contributors to plant protein among men in most Spanish centres; for both men and women, a clear south–north gradient was present for legumes, with the highest contribution in Greece and Spain (6–16%), and the lowest in Scandinavian countries (<1%, except for men in Malmö, 2%). No clear south–north trend was observed for the contribution of fruit, but lower contributions were generally seen in Scandinavian countries for both genders. However, when pooled into one group, the contribution from vegetables, fruits and legumes showed a clear south–north gradient; the contribution was >30% for women and >26% for men in Spain and Greece, between 20 and 30% for women and between 15 and 26% for men in Italy, France, Germany, the United Kingdom and the Netherlands, whereas it was <20% (women) and <15% (men) in Scandinavian countries.

Potatoes contributed 5–10% of plant protein in most countries except in Greece, Italy and France, where the figures were below 5% in almost all centres. An indication of a south–north gradient was seen for potatoes in men, being the second largest contributor to plant protein among men in most of the Scandinavian centres.

Cakes contributed to plant protein in some countries (women 3–8%, men 1–6%) and also non-alcoholic beverages (women 1–11%, men 1–13%, with a maximum in Germany for both genders, followed by Denmark).

Stratified analyses

No systematic differences in total protein intakes were observed when the participants were stratified according to BMI (Table 4a). However, when the origin of protein was considered, the highest mean intake of plant protein was observed in the lowest BMI group in a majority of countries, whereas a slight tendency towards a higher intake of animal protein was seen in the highest BMI group, although this was less consistent than that for plant protein.

When stratifying on the basis of educational level, we saw a clear trend among women for plant protein (Table 4b), wherein the highest intake was seen among women with the highest educational level in most countries (apart from Greece), whereas the lowest intake was primarily observed among the least educated. For men, there was an indication of south–north differences. In southern countries, a lower intake of plant protein was observed among the most educated men, whereas in the more northern countries, the lowest intake of plant protein was reported among the least educated. For animal protein, no clear differences across educational levels were observed for women, whereas among men, the highest intake was mainly observed among the least educated.

No clear differences across physical activity levels were seen for intake of total protein or its subgroups (Table 4c), except for a weak indication of a higher intake of plant and

Table 4a Minimally adjusted[a] mean daily intake of total, animal and plant protein by country and BMI groups

Country	Men						Women					
	BMI < 25 kg/m²		BMI 25–30 kg/m²		BMI ⩾ 30 kg/m²		BMI < 25 kg/m²		BMI 25–30 kg/m²		BMI ⩾ 30 kg/m²	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
						Total protein						
Greece	89.6	2.5	88.8	1.4	88.0	2.0	63.0	1.5	64.7	1.2	59.0	1.2
Spain	123.6	2.1	126.7	1.2	127.0	1.9	87.8	1.2	85.8	1.1	81.1	1.5
Italy	107.2	1.7	104.8	1.3	99.4	2.8	74.8	0.8	73.9	0.9	76.7	1.3
France							84.3	0.5	84.8	0.9	89.0	1.8
Germany	89.3	1.5	90.1	1.1	93.8	1.8	65.4	0.8	65.0	1.1	67.5	1.4
The Netherlands	97.1	2.1	103.7	1.7	106.0	3.1	77.8	0.7	78.9	0.8	78.7	1.3
UK general population	88.3	3.2	93.0	2.6	92.2	5.3	69.9	1.6	72.9	1.9	68.9	3.1
UK health-conscious	70.0	4.0	74.0	7.7	—	—	58.5	2.2	64.3	4.7	—	—
Denmark	94.1	1.4	95.3	1.2	103.7	2.2	72.7	0.8	74.1	1.1	73.8	1.6
Sweden	97.9	1.2	92.3	1.0	91.1	2.0	72.4	0.7	70.7	0.8	69.1	1.2
Norway							76.8	0.8	73.0	1.3	76.0	2.5
						Animal protein						
Greece	52.4	2.2	52.8	1.2	51.7	1.7	39.0	1.3	38.4	1.0	33.0	1.1
Spain	83.8	1.8	88.1	1.0	90.5	1.7	60.1	1.1	58.8	1.0	54.1	1.4
Italy	62.3	1.5	61.1	1.2	56.6	2.5	43.3	0.7	44.1	0.8	46.7	1.2
France							55.3	0.4	57.5	0.8	61.8	1.6
Germany	54.4	1.3	56.8	1.0	61.5	1.6	38.8	0.7	38.8	0.9	41.1	1.3
The Netherlands	55.3	1.8	63.5	1.4	68.7	2.7	46.3	0.6	47.8	0.7	49.8	1.1
UK general population	50.3	2.8	53.7	2.3	54.2	4.6	40.0	1.4	42.9	1.7	37.1	2.7
UK health-conscious	13.3	3.5	21.2	6.7	—	—	14.7	1.9	25.5	4.1	—	—
Denmark	59.0	1.3	61.1	1.1	68.7	1.9	43.8	0.7	46.0	0.9	46.7	1.4
Sweden	62.1	1.1	59.3	0.9	61.2	1.8	45.8	0.6	45.5	0.7	44.8	1.1
Norway							46.3	0.7	45.8	1.1	46.9	2.2
						Plant protein						
Greece	35.1	0.9	34.5	0.5	34.8	0.8	22.1	0.6	24.7	0.5	24.7	0.5
Spain	35.7	0.8	34.8	0.4	33.5	0.7	25.0	0.5	23.7	0.4	23.8	0.6
Italy	38.5	0.7	37.5	0.5	36.5	1.1	26.2	0.3	25.1	0.4	25.6	0.5
France							25.4	0.2	23.4	0.3	23.5	0.7
Germany	29.5	0.6	28.5	0.4	27.8	0.7	22.3	0.3	21.6	0.4	21.7	0.6
The Netherlands	34.1	0.8	31.6	0.6	30.5	1.2	24.9	0.3	23.7	0.3	22.0	0.5
UK general population	31.0	1.2	31.0	1.0	29.1	2.0	24.3	0.6	24.2	0.8	24.0	1.2
UK health-conscious	52.5	1.5	46.5	2.9	—	—	40.1	0.9	33.5	1.8	—	—
Denmark	29.9	0.6	28.7	0.5	29.6	0.8	24.8	0.3	23.8	0.4	22.8	0.6
Sweden	28.7	0.5	26.3	0.4	25.2	0.8	21.3	0.3	20.3	0.3	19.4	0.5
Norway							25.5	0.3	22.4	0.5	23.8	1.0

Abbreviations: BMI, body mass index; s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age, and weighted by season and day of recall.

total protein among men in the two most active groups compared with that in the less active groups.

No clear differences in intake of total and animal protein across smoking status groups were present, but the lowest intake of plant protein was observed primarily among current smokers of both genders (Table 4d).

Protein intake was also evaluated according to season and day of the 24-HDR. In all countries, the mean intake of total and animal protein was higher on weekends than on weekdays (except in UK health-conscious men and women, and in Dutch women for animal protein) (Table 4e). For plant proteins, the difference between working days and weekend was less pronounced and no clear tendency was observed. A different pattern was observed in the UK health-conscious group, in which the mean intake of plant protein was notably higher at weekends than on working days, whereas intake of animal protein was highest on working days. In contrast to day of the week, no clear trend was observed with regard to the mean intake of protein according to seasons (results not shown).

Discussion

In this study, some variations were observed across centres in intakes and food sources of total protein, and protein of animal and plant origin. Despite variations in absolute intakes, the intake of animal protein compared with plant

Table 4b Minimally adjusted[a] mean daily intake of total, animal and plant protein by country and educational level

Country	*Men*						*Women*					
	None/primary		*Tech/professional/ secondary*		*University*		*None/primary*		*Tech/professional/ secondary*		*University*	
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*
						Total protein						
Greece	86.4	1.6	91.1	2.0	90.3	2.0	59.3	1.0	63.5	1.3	67.5	1.7
Spain	129.2	1.1	126.0	1.9	113.9	2.5	85.2	0.8	90.2	2.1	87.2	2.4
Italy	110.2	2.2	103.1	1.2	107.0	3.1	75.3	1.0	75.2	0.7	72.1	1.6
France							82.3	1.2	84.6	0.6	85.0	0.7
Germany	93.9	1.5	91.0	1.4	87.9	1.3	67.0	1.2	63.8	0.8	68.3	1.2
The Netherlands	101.9	3.2	104.3	1.6	96.5	2.3	79.0	1.1	78.4	0.6	77.3	1.2
UK general population	94.3	5.2	91.3	2.7	86.0	3.8	74.3	2.7	71.5	1.7	72.5	2.7
UK health-conscious	—	—	71.7	6.9	65.3	4.9	—	—	62.1	3.3	58.1	2.8
Denmark	97.1	1.6	95.7	1.4	95.7	1.6	73.1	1.2	73.1	0.8	74.8	1.8
Sweden	94.4	1.2	94.3	1.2	93.5	1.5	68.7	0.8	71.8	0.7	73.7	1.0
Norway							72.3	1.5	76.2	0.8	79.3	1.7
						Animal protein						
Greece	48.7	1.4	54.7	1.7	56.0	1.7	32.1	0.9	40.0	1.2	42.5	1.5
Spain	89.9	1.0	89.3	1.7	78.2	2.2	57.9	0.7	63.4	1.9	60.1	2.1
Italy	64.1	1.9	59.7	1.0	63.5	2.7	45.3	0.9	44.4	0.6	40.5	1.4
France							55.2	1.0	55.9	0.5	56.1	0.6
Germany	60.2	1.3	56.7	1.2	55.1	1.1	41.0	1.0	37.7	0.7	40.7	1.1
The Netherlands	62.2	2.8	64.5	1.4	55.3	2.0	48.3	1.0	47.9	0.6	44.5	1.1
UK general population	56.4	4.5	52.8	2.4	47.1	3.3	44.1	2.4	41.2	1.5	41.2	2.4
UK health-conscious	—	—	13.6	6.0	15.4	4.3	—	—	16.6	2.9	19.4	2.5
Denmark	62.5	1.4	60.8	1.2	61.4	1.4	45.1	1.0	44.7	0.7	45.4	1.6
Sweden	61.3	1.0	60.0	1.0	59.6	1.3	44.2	0.7	45.9	0.7	46.5	0.8
Norway							45.2	1.3	46.8	0.7	46.1	1.5
						Plant protein						
Greece	36.3	0.6	34.4	0.8	32.7	0.8	25.9	0.4	21.9	0.5	22.7	0.7
Spain	35.6	0.4	33.3	0.7	31.5	0.9	24.2	0.3	23.5	0.8	24.6	0.9
Italy	40.6	0.8	37.0	0.5	36.4	1.2	25.5	0.4	25.6	0.3	26.6	0.6
France							23.5	0.5	25.0	0.2	25.1	0.3
Germany	28.6	0.6	29.3	0.5	28.0	0.5	21.3	0.5	21.8	0.3	23.2	0.5
The Netherlands	32.3	1.2	31.7	0.6	32.9	0.9	22.8	0.4	23.7	0.3	26.6	0.5
UK general population	29.5	2.0	31.0	1.0	30.7	1.5	23.0	1.1	24.7	0.7	25.3	1.1
UK health-conscious	—	—	54.7	2.6	44.3	1.9	—	—	41.5	1.3	34.5	1.1
Denmark	28.9	0.6	29.5	0.5	29.2	0.6	23.5	0.5	24.2	0.3	25.5	0.7
Sweden	26.9	0.4	27.1	0.5	27.6	0.6	19.5	0.3	20.7	0.3	22.1	0.4
Norway							22.3	0.6	24.5	0.3	27.9	0.7

Abbreviations: s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age, and weighted by season and day of recall.

protein was mostly seen in a ratio of around 1.5–3 to 1. The only centre that deviated from this was the UK health-conscious group, in which a low intake of meat products resulted in a reverse ratio with a two to three times higher intake of plant protein than animal protein. Thus, they had the lowest total and animal protein intake, but the highest intake of plant protein across all centres.

Owing to cultural differences in eating habits previously reported in the same populations (Slimani *et al.*, 2002b), it was expected that the predominant food items contributing to protein intake across the 27 participating centres would differ. This was clearly seen for plant protein, in which a south–north gradient was present when contributions from vegetables, legumes and fruits were combined. Legume consumption was almost non-existent in Northern Europe, whereas it contributed to a notable percentage in Spain and Greece (women 6–13%, men 8–16%). In contrast, potatoes were of more importance in Nordic countries, especially among men (9–10%).

Apart from the UK health-conscious group, total meat intake contributed the highest proportion to animal protein, as already observed in other studies (Smit *et al.*, 1999), but clear differences were seen in eating patterns across Europe with regard to the types of meat consumed (Linseisen *et al.*, 2002). Processed meat was a very important contributor in Germany and the Netherlands, but was negligible in the

Table 4c Minimally adjusted[a] mean daily intake of total, animal and plant protein by country and physical activity level[b]

Country	*Men*								*Women*							
	Inactive		*Moderately inactive*		*Moderately active*		*Active*		*Inactive*		*Moderately inactive*		*Moderately active*		*Active*	
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*
								Total protein								
Greece	91.0	2.7	84.1	1.7	91.5	1.7	92.8	3.8	63.4	2.9	61.1	1.7	62.1	0.9	63.5	2.3
Spain	121.1	2.0	121.6	1.7	131.1	1.5	130.4	2.3	87.2	3.2	85.2	2.0	85.0	0.8	90.0	2.8
Italy	102.5	2.0	101.8	1.7	108.8	1.7	109.2	3.2	73.9	1.7	74.1	1.1	74.9	0.7	77.0	1.8
France									84.3	1.0	85.1	0.5	83.0	1.0	87.2	3.0
Germany	84.2	1.9	90.6	1.6	92.4	1.2	92.8	2.5	63.1	1.4	65.8	1.1	66.1	0.9	68.4	2.2
The Netherlands	94.7	3.4	101.6	2.5	101.6	1.8	107.0	2.7	77.6	2.0	78.8	1.1	77.6	0.7	80.3	1.2
UK general population	81.6	4.7	93.2	3.5	94.1	3.0	88.1	4.7	71.5	2.9	70.3	2.1	69.1	1.7	78.5	3.4
UK health-conscious	—	—	60.8	6.6	76.8	5.5	—	—	59.2	4.0	60.1	3.8	59.8	2.8	—	—
Denmark	95.4	1.7	93.8	1.6	98.9	1.5	95.8	2.2	74.5	1.2	72.0	1.0	73.5	1.1	75.2	2.4
Sweden[c]	97.0	2.3	90.2	1.6	95.0	1.7	98.5	5.1	71.3	1.6	70.2	1.1	70.9	1.1	68.5	3.1
								Animal protein								
Greece	55.5	2.3	50.0	1.5	52.9	1.5	55.9	3.3	39.9	2.5	37.1	1.5	36.0	0.8	36.1	2.0
Spain	84.0	1.7	84.7	1.5	91.2	1.3	91.4	2.0	59.6	2.8	59.0	1.7	57.6	0.7	62.9	2.4
Italy	59.7	1.8	58.2	1.5	63.8	1.5	64.6	2.8	43.5	1.5	42.4	1.0	44.6	0.6	46.7	1.6
France									56.5	0.9	56.5	0.4	53.7	0.8	58.4	2.6
Germany	53.0	1.7	56.4	1.4	58.5	1.0	57.9	2.2	37.3	1.2	39.4	0.9	39.8	0.8	39.9	1.9
The Netherlands	57.9	2.9	62.0	2.2	61.3	1.5	63.9	2.3	46.3	1.7	47.8	0.9	47.2	0.6	47.8	1.0
UK general population	44.2	4.1	53.9	3.1	55.3	2.6	48.9	4.1	39.2	2.5	40.6	1.8	40.5	1.5	44.5	3.0
UK health-conscious	—	—	15.4	5.8	17.6	4.8	—	—	19.9	3.5	17.2	3.3	14.6	2.5	—	—
Denmark	62.4	1.5	59.1	1.4	63.0	1.3	61.1	2.0	46.1	1.0	44.4	0.9	44.5	1.0	44.8	2.1
Sweden[c]	63.8	2.0	58.0	1.4	62.1	1.5	65.8	4.5	46.8	1.4	45.9	0.9	45.5	1.0	43.0	2.7
								Plant protein								
Greece	34.3	1.0	32.4	0.6	37.0	0.6	35.5	1.5	22.0	1.1	22.3	0.7	24.5	0.4	26.1	0.9
Spain	33.6	0.7	33.4	0.6	35.9	0.6	35.6	0.9	24.2	1.2	23.1	0.8	24.4	0.3	23.8	1.1
Italy	35.8	0.8	37.3	0.6	38.9	0.7	39.6	1.2	24.9	0.7	26.2	0.4	25.7	0.3	25.3	0.7
France									24.3	0.4	24.8	0.2	25.8	0.4	23.6	1.2
Germany	26.3	0.7	29.6	0.6	28.6	0.4	30.1	0.9	21.4	0.5	22.2	0.4	21.9	0.3	23.2	0.8
The Netherlands	30.0	1.3	31.6	1.0	32.5	0.7	33.6	1.0	23.9	0.8	24.3	0.4	23.7	0.3	24.9	0.5
UK general population	29.7	1.8	30.9	1.3	31.4	1.1	30.6	1.8	25.7	1.1	23.8	0.8	23.4	0.7	26.5	1.3
UK health-conscious	—	—	39.3	2.5	56.0	2.1	—	—	36.3	1.6	37.4	1.5	41.4	1.1	—	—
Denmark	28.0	0.6	28.8	0.6	30.7	0.6	29.3	0.8	24.2	0.5	23.3	0.4	24.9	0.4	25.5	0.9
Sweden[c]	26.7	0.9	26.1	0.6	26.4	0.7	27.5	1.9	19.6	0.6	19.3	0.4	20.1	0.4	20.8	1.2

Abbreviations: s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age, and weighted by season and day of recall.
[b]As no physical activity level was measured in Norway, this country is not represented in the table.
[c]Umeå is not part of this analysis, as no physical activity level was measured.

Greek diet. The contribution of fish to animal protein varied considerably across countries, as also observed for total fish intake (Welch *et al.*, 2002), although without any clear north–south gradient or a relationship with proximity to the sea, as high contributions from fish were seen in coastal and inland regions in Spain, Greece and Norway, whereas intakes were low in the Netherlands. The different intake patterns of these two animal protein sources are of special interest, as they have been ascribed important roles in diet–disease associations. Processed meat has recently been judged as one of the most cancer-promoting food items (WCRF/AICR, 2007), whereas fish is considered to have beneficial effects in heart disease (He *et al.*, 2004; Whelton *et al.*, 2004) and also potentially in some cancer sites (Norat *et al.*, 2005; Geelen *et al.*, 2007), although possibly because of factors other than protein. Studies of the association between (animal or plant) protein and disease incidence may consequently be less reliable if the contributing protein sources are not evaluated in addition to total protein intakes.

Socioeconomic status is known to influence dietary habits (Lallukka *et al.*, 2007), and in this study, lifestyle factors seemed primarily to influence the intake of plant protein. A lower intake of plant protein was seen among current smokers and among people with a high BMI, whereas a higher intake was observed among well-educated women and among well-educated men in the northern countries. It has been previously shown that socioeconomic status is

Table 4d Minimally adjusted[a] mean daily intake of total, animal and plant protein by country and smoking status

Country	*Men*						*Women*					
	Never smoker		*Former smoker*		*Current smoker*		*Never smoker*		*Former smoker*		*Current smoker*	
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*
						Total protein						
Greece	92.2	2.0	84.2	1.8	91.1	1.9	62.1	0.9	57.5	3.0	64.8	1.8
Spain	129.3	1.6	123.7	1.7	125.4	1.4	84.8	0.8	87.0	2.4	87.8	1.9
Italy	106.9	1.8	102.7	1.5	106.7	2.0	74.2	0.7	76.0	1.2	75.3	1.1
France							85.2	0.5	83.9	0.9	83.0	1.5
Germany	88.4	1.5	89.8	1.2	95.3	1.7	66.0	0.8	64.6	1.1	65.9	1.4
The Netherlands	100.0	2.4	104.4	1.9	100.5	2.0	79.7	0.8	77.4	0.9	77.5	1.0
UK general population	89.6	3.1	93.4	2.8	89.8	4.5	71.8	1.5	69.6	2.1	69.6	3.6
UK health-conscious	68.3	5.6	74.0	5.5	—	—	58.8	2.4	61.7	3.4	—	—
Denmark	96.3	1.6	96.0	1.4	96.2	1.5	73.6	0.9	73.5	1.2	72.7	1.2
Sweden	94.2	1.1	92.8	1.2	95.4	1.6	71.8	0.6	70.2	1.0	71.2	1.1
Norway							76.4	1.1	74.7	1.1	76.5	1.3
						Animal protein						
Greece	55.4	1.7	48.4	1.5	55.0	1.6	35.2	0.8	33.0	2.6	42.6	1.6
Spain	89.9	1.4	85.2	1.5	88.2	1.3	57.2	0.7	62.9	2.1	61.3	1.6
Italy	63.2	1.6	59.1	1.3	62.1	1.7	43.6	0.6	44.4	1.1	45.3	1.0
France							56.3	0.4	55.8	0.8	56.0	1.4
Germany	54.2	1.3	56.3	1.0	62.4	1.5	39.2	0.7	38.4	1.0	40.8	1.2
The Netherlands	59.6	2.1	62.7	1.7	62.1	1.7	47.6	0.7	46.6	0.8	48.2	0.9
UK general population	51.2	2.7	53.8	2.5	52.1	3.9	41.9	1.3	39.4	1.9	37.9	3.2
UK health-conscious	14.3	4.8	15.5	4.8	—	—	16.5	2.1	17.2	3.0	—	—
Denmark	61.5	1.4	60.9	1.2	62.3	1.3	44.6	0.8	45.3	1.0	45.2	1.1
Sweden	59.7	1.0	59.6	1.1	62.8	1.4	45.6	0.6	44.2	0.9	46.8	0.9
Norway							45.3	1.0	45.5	1.0	48.9	1.1
						Plant protein						
Greece	35.4	0.8	34.3	0.7	34.5	0.7	25.4	0.3	22.5	1.2	20.5	0.7
Spain	35.6	0.6	34.9	0.6	33.6	0.6	24.6	0.3	22.2	1.0	23.1	0.7
Italy	37.5	0.7	37.2	0.6	38.4	0.8	25.7	0.3	26.2	0.5	25.2	0.4
France							25.2	0.2	24.3	0.4	23.2	0.6
Germany	28.4	0.6	29.0	0.4	28.2	0.6	22.0	0.3	22.3	0.4	20.8	0.6
The Netherlands	32.6	0.9	33.3	0.7	30.7	0.8	24.5	0.3	24.1	0.3	23.1	0.4
UK general population	30.8	1.2	31.6	1.1	29.1	1.7	24.1	0.6	24.1	0.8	25.5	1.4
UK health-conscious	49.5	2.1	53.2	2.1	—	—	38.5	0.9	39.9	1.3	—	—
Denmark	29.3	0.6	30.1	0.5	28.2	0.6	24.8	0.3	24.3	0.5	22.8	0.5
Sweden	27.6	0.4	27.0	0.5	25.8	0.6	21.1	0.3	20.8	0.4	19.5	0.4
Norway							25.8	0.4	24.2	0.4	22.9	0.5

Abbreviations: s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age, and weighted by season and day of recall.

related positively to the intake of plant protein (Hulshof *et al.*, 2003). In the southern countries, in contrast, the highest intake of plant protein among men was seen among those belonging to the lowest educational levels. This north–south difference among men may stem from the fact that consumption of legumes is common at all social levels in Southern Europe, and may be particularly high in less economically advantaged groups owing to low cost, whereas it may reflect health consciousness in the northern countries.

The population average protein requirement for healthy adults is estimated at 0.66 g/kg body weight and the recommended safe lower level of protein intake was subsequently estimated at 0.83 g/kg body weight in the recently published report on protein and amino acid requirements in human nutrition (WHO/FAO/UNU, 2008). In relative terms, the recommended safe lower level corresponds to around 8–10%en.

In the EPIC calibration study, the mean protein intake per kilogram body weight ranged between 0.91 and 1.83 g/kg across centres in a minimal-adjusted model and was not below 0.83 g/kg in any age group (except in Greek women aged 65–74 years: 0.82 g/kg). Energy percentages ranged from 12 to 23%en across men and women and across different age groups, and are thus above the recommended lower safe intake level, and within the recommended intake range of 10–35%en (US Food and Nutrition Board) and 10–20%en (Nordic Nutrition Recommendations) (Alexander *et al.*, 2004), and at the higher end of the WHO recommendations of 10–15%en (WHO/FAO, 2003). Both men and women in

Table 4e Minimally adjusted[a] mean daily intake of total, animal and plant protein by country and day of recall of 24-HDR

Country	*Men*				*Women*			
	Weekend Friday to Sunday		*Working days Monday to Thursday*		*Weekend Friday to Sunday*		*Working days Monday to Thursday*	
	Mean	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*	*Mean*	*s.e.*
				Total protein				
Greece	90.4	1.7	87.3	1.3	65.7	1.2	58.7	0.9
Spain	131.4	1.5	122.8	1.1	89.5	1.3	82.7	0.9
Italy	109.0	1.7	101.5	1.2	77.2	1.0	72.4	0.7
France					86.5	0.7	83.3	0.5
Germany	96.7	1.6	85.9	0.9	69.3	1.1	62.0	0.7
The Netherlands	103.9	2.0	100.5	1.5	79.0	0.8	77.9	0.6
UK general population	95.5	3.1	88.9	2.4	72.4	1.9	69.3	1.4
UK health-conscious	69.8	7.4	74.2	3.9	56.5	4.0	60.8	2.2
Denmark	99.9	1.7	93.7	1.0	76.0	1.2	71.1	0.7
Sweden	98.1	1.2	90.9	0.9	74.7	0.8	68.5	0.6
Norway					78.9	1.1	73.5	0.8
				Animal protein				
Greece	55.3	1.4	50.1	1.2	39.5	1.1	33.4	0.8
Spain	93.9	1.2	83.6	1.0	62.8	1.1	55.2	0.8
Italy	63.7	1.4	58.1	1.1	45.6	0.8	42.3	0.6
France					57.4	0.6	55.1	0.4
Germany	62.2	1.3	52.9	0.8	42.8	0.9	36.0	0.6
The Netherlands	63.1	1.6	60.5	1.4	46.9	0.7	47.7	0.6
UK general population	55.2	2.5	51.5	2.1	42.1	1.6	39.3	1.3
UK health-conscious	10.6	6.1	21.8	3.5	9.5	3.4	21.8	2.0
Denmark	63.6	1.4	60.0	0.9	46.7	1.0	43.4	0.6
Sweden	63.8	1.0	57.8	0.8	48.3	0.7	43.2	0.5
Norway					50.2	1.0	43.5	0.7
				Plant protein				
Greece	33.4	0.6	35.8	0.5	24.6	0.5	23.8	0.4
Spain	33.7	0.5	35.5	0.5	23.7	0.5	24.5	0.4
Italy	37.9	0.6	37.6	0.5	26.3	0.4	25.3	0.3
France					25.1	0.3	24.7	0.2
Germany	29.2	0.6	28.2	0.4	22.4	0.4	21.5	0.3
The Netherlands	32.0	0.7	32.5	0.6	24.1	0.3	24.0	0.3
UK general population	31.5	1.1	30.2	0.9	24.5	0.7	23.9	0.6
UK health-conscious	54.7	2.7	47.4	1.6	44.0	1.5	34.3	0.9
Denmark	30.3	0.6	28.6	0.4	24.2	0.4	24.0	0.3
Sweden	27.9	0.4	26.3	0.4	21.1	0.3	20.5	0.2
Norway					24.2	0.4	24.7	0.3

Abbreviations: s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age and weighted by season.

the UK health-conscious group had the lowest energy intake from protein (12–13%en) and also a rather low ratio of g protein/kg body weight. This indicates that a diet low in animal food items may result in a lower protein intake and may also be low in specific essential amino acids. The mean intake is, however, still within the recommended intake range.

Low protein intake in absolute terms might be due to a general or specific underreporting of diet. Among EPIC cohorts, Greek participants seem to have underreported total energy intake to a higher degree than other centres (Ferrari *et al*, 2002). Greek women also reported a rather low absolute intake of protein and a low ratio of g protein/kg body weight, whereas the %en level was normal. Adjustment for total energy intake increased the estimated mean intake considerably, indicating that protein intake in Greece for a fixed energy intake was not appreciably lower than that in the remaining centres. Thus, adjustment for total energy intake may take care of a part of the measurement errors included in nutrient intake data (Willett, 1998; Spiegelman, 2004) An overestimation of energy percentage from protein may, however, also be present, because of a possible relatively greater underestimation of fat and/or carbohydrate than protein (Heitmann and Lissner, 1995; Heitmann *et al.*, 2000).

Protein deficiency is not a big issue in developed countries, and it would be important to evaluate the upper tolerable intake level and determine whether the optimal level seen in relation to health is higher than the recommended level.

The latest WHO/FAO report concludes that current knowledge is still insufficient to permit clear recommendations for either a safe upper limit or an optimal intake level, and this is obviously an important subject for future research (WHO/FAO/UNU, 2008). Furthermore, no specific recommendations for different qualitative protein types or sources (such as those for fat and carbohydrate) exist as yet.

Comparable and detailed information on foods contributing to protein intake across countries is useful for conducting and interpreting the results of large multi-centre dietary studies. One of the strengths of this descriptive paper is the recent creation of the ENDB (Slimani *et al.*, 2007), which harmonized national databases, making it possible to compare the intake of different types of protein across 10 countries and 27 centres. Detailed information with regard to the animal and plant origin of all food items, from which intake of animal and plant protein has been estimated, provides important knowledge for future studies investigating the association between diseases and subgroups of protein. In all centres, a small amount of protein (as for example, from ready-to-eat dishes and cakes without any clear declaration, or containing ingredients of mixed or unknown origin) could not be classified as being from either animal or plant origin. The amounts were, however so relatively small that they would have only a limited influence on the ranking of the centres for animal or plant protein even if all unknown proteins were regarded as being of either plant or animal origin.

Furthermore, the large geographical span makes it possible to study how the different food patterns across Europe contribute to protein intake with different protein-providing food items.

This is the largest study to date describing intake of protein across several European countries. However, as not all the EPIC cohorts are population based, the results cannot be extrapolated to the general population of each region. Another limitation is that each participant provided only one 24-HDR. Intake can, therefore, be evaluated only at the group level.

In this study, we measured diet simultaneously across 10 European countries. These data highlight and quantify the variations and similarities in protein intakes between these countries, and will form the basis for future aetiological analyses on how different types of dietary protein are related to health and disease.

Conflict of interest

S Bingham received grant support from MRC Centre. The remaining authors have declared no financial interests.

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Appendix

Table A1 Fully adjusted[a] mean daily intake of total protein by centre ordered from south to north, gender and age group

Country and centre	*Men*											*Women*										
	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}
		M	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*			*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	
Greece	1311	98.0	0.7	100.2	2.2	104.3	1.5	96.1	1.3	94.3	1.2	0.25	1373	70.3	0.5	73.2	1.4	72.3	0.9	68.5	0.9	68.0	1.1	0.0
Spain																								
Granada	214	110.1	1.8	—	—	113.8	3.7	112.0	2.4	100.4	4.0	0.40	300	79.5	1.1	79.9	2.8	80.2	1.9	78.1	1.7	84.0	3.5	0.5
Murcia	243	103.0	1.7	108.6	5.1	104.0	2.9	103.2	2.3	93.5	5.7	0.06	304	78.2	1.1	82.3	2.2	77.2	1.8	77.5	1.8	—	—	0.3
Navarra	444	115.1	1.2	111.1	5.3	117.8	2.0	114.6	1.7	111.0	3.7	0.85	271	85.9	1.2	86.3	3.0	87.1	1.9	86.2	1.8	—	—	0.2
San Sebastian	490	133.1	1.2	126.5	2.7	134.5	1.6	136.6	2.2	136.0	5.8	0.16	244	91.8	1.2	95.6	2.6	91.8	2.0	92.4	2.1	—	—	0.1
Asturias	386	125.8	1.3	126.2	4.9	127.2	2.2	123.0	1.9	132.2	3.5	0.53	324	91.8	1.1	94.9	2.6	94.3	1.7	89.3	1.7	88.6	3.9	0.1
Italy																								
Ragusa	168	107.7	2.0	—	—	112.0	2.9	102.2	3.1	—	—	0.95	138	75.7	1.6	79.2	2.7	75.1	3.0	74.6	2.9	—	—	0.0
Naples													403	74.5	1.0	81.6	3.1	72.6	1.5	75.1	1.5	73.1	3.1	0.3
Florence	271	104.5	1.6	101.3	4.9	109.2	2.7	103.5	2.2	—	—	0.52	784	78.1	0.7	81.7	2.3	76.0	1.2	79.0	0.9	76.3	2.7	0.4
Turin	676	99.3	1.0	97.8	3.2	102.4	1.6	98.2	1.4	97.6	3.8	0.72	392	76.6	1.0	79.9	3.0	74.2	1.6	77.9	1.3	—	—	0.5
Varese	327	100.7	1.4	—	—	103.6	3.1	100.1	1.7	96.3	4.8	0.03	794	74.4	0.7	78.2	2.2	76.5	1.1	72.6	1.0	72.0	2.0	0.0
France																								
South coast													620	81.8	0.8			84.0	1.3	79.9	1.2	80.8	1.6	0.5
South													1425	80.7	0.5			80.2	0.8	81.2	0.8	80.0	1.1	0.9
North-East													2059	80.4	0.4			80.5	0.7	81.1	0.7	77.5	1.0	0.4
North-West													631	83.0	0.8			83.7	1.2	82.4	1.1	81.7	1.8	0.1
Germany																								
Heidelberg	1034	92.6	0.8	95.1	2.1	92.9	1.3	92.4	1.2	—	—	0.23	1087	67.6	0.6	68.8	1.0	67.4	1.1	67.9	1.0	—	—	0.3
Potsdam	1233	87.7	0.7	89.3	2.1	87.0	1.5	88.7	1.0	80.5	2.8	0.21	1061	63.6	0.6	64.9	1.2	62.8	1.1	64.3	0.9	57.8	3.7	0.2
The Netherlands																								
Bilthoven	1024	98.8	0.8	97.3	1.6	100.4	1.2	101.0	1.4	—	—	0.37	1086	73.1	0.6	72.0	1.0	74.0	0.9	74.9	1.1	—	—	0.1
Utrecht													1870	77.3	0.4			77.4	0.8	77.1	0.7	76.4	0.9	0.1
United Kingdom																								
General population	402	95.7	1.3	94.6	4.2	96.3	2.3	93.7	2.3	96.8	2.3	0.66	570	74.2	0.8	75.9	2.4	72.5	1.3	75.3	1.4	74.6	1.7	0.9
Health-conscious	114	81.7	2.4	—	—	80.5	3.9	80.0	3.7	—	—	0.43	197	58.9	1.4	59.4	4.3	55.8	2.2	60.4	2.1	63.1	3.7	0.3
Denmark																								
Copenhagen	1356	91.2	0.7			90.6	1.1	91.8	0.9	85.9	3.5	0.46	1484	69.9	0.5			69.8	0.8	69.6	0.6	70.1	2.3	0.5
Aarhus	567	90.1	1.1			90.2	1.5	90.9	1.5	—	—	0.35	510	69.6	0.8			68.6	1.2	70.5	1.2	—	—	0.1
Sweden																								
Malmö	1421	97.1	0.7			98.1	2.0	97.3	1.1	94.9	1.0	0.19	1711	71.6	0.5			72.6	0.9	70.3	0.8	70.8	0.7	0.5
Umeå	1344	94.2	0.7	94.0	2.4	95.0	1.3	93.4	1.0	94.4	2.1	0.92	1574	71.6	0.5	73.4	1.2	72.1	0.9	71.3	0.7	67.9	1.5	0.0
Norway																								
South and East													1004	76.1	0.6	76.7	1.4	76.1	0.7	78.9	1.5			0.5
North and West													793	77.0	0.7	77.4	1.5	78.1	0.8	75.1	1.8			0.5

Abbreviations: M, mean; s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age (when not stratified for age), total energy, weight and height, and weighted by season and day of recall.

Table A2 Fully adjusted[a] mean daily intake of animal protein by centre ordered from south to north, gender and age group

Country and centre	*Men*											*Women*										
	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}
		M	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*			*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	
Greece	1311	57.7	0.8	64.2	2.3	63.4	1.6	55.7	1.5	53.3	1.3	0.05	1373	40.8	0.6	46.3	1.5	44.0	1.0	37.7	1.0	37.1	1.2	0.0
Spain																								
Granada	214	73.9	1.9	—	—	77.9	4.0	75.9	2.6	64.8	4.3	0.86	300	52.1	1.2	51.9	3.1	53.5	2.0	50.7	1.9	54.1	3.9	0.7
Murcia	243	63.1	1.8	68.6	5.5	63.1	3.2	64.5	2.5	48.1	6.2	0.14	304	49.4	1.2	55.0	2.4	48.2	2.0	47.7	2.0	—	—	0.4
Navarra	444	79.4	1.3	76.0	5.7	82.4	2.2	78.5	1.9	75.6	4.0	0.79	271	60.4	1.3	61.3	3.3	60.8	2.1	60.5	1.9	—	—	0.1
San Sebastian	490	98.3	1.3	92.9	3.0	99.1	1.7	101.8	2.4	98.9	6.3	0.29	244	65.1	1.3	69.5	2.9	66.1	2.2	64.6	2.3	—	—	0.1
Asturias	386	89.0	1.4	85.3	5.3	90.8	2.4	86.9	2.1	93.5	3.8	0.28	324	63.6	1.2	67.0	2.8	67.3	1.9	60.7	1.9	54.8	4.3	0.1
Italy																								
Ragusa	168	59.0	2.2	—	—	61.6	3.2	53.7	3.3	—	—	0.61	138	42.6	1.8	50.7	3.0	40.4	3.3	36.6	3.2	—	—	0.5
Naples													403	43.5	1.1	51.7	3.4	42.2	1.7	43.1	1.6	43.2	3.4	0.3
Florence	271	59.5	1.7	54.7	5.3	64.5	2.9	57.7	2.4	—	—	0.99	784	45.8	0.8	49.5	2.5	43.3	1.3	46.8	1.0	45.9	2.9	0.6
Turin	676	57.3	1.1	54.3	3.5	60.2	1.8	56.5	1.5	54.7	4.1	0.88	392	45.8	1.1	49.8	3.3	42.9	1.8	47.3	1.5	—	—	0.5
Varese	327	62.4	1.5	—	—	63.5	3.4	61.7	1.8	63.1	5.2	0.28	794	44.3	0.8	47.0	2.4	46.0	1.2	42.6	1.1	43.7	2.3	0.2
France																								
South coast													620	54.9	0.8			57.1	1.4	53.0	1.3	53.8	1.8	0.4
South													1425	53.6	0.6			52.9	0.9	54.3	0.9	53.0	1.3	0.9
North-East													2059	54.0	0.5			53.7	0.7	55.0	0.7	51.5	1.1	0.6
North-West													631	56.8	0.8			57.6	1.3	56.1	1.3	55.8	2.0	0.3
Germany																								
Heidelberg	1034	57.9	0.9	59.5	2.3	57.7	1.4	58.2	1.3	—	—	0.21	1087	41.2	0.6	41.8	1.1	42.1	1.2	40.8	1.1	—	—	0.3
Potsdam	1233	55.2	0.8	57.4	2.3	54.6	1.6	56.0	1.0	48.8	3.1	0.16	1061	36.8	0.6	37.0	1.3	36.4	1.3	37.9	0.9	32.7	4.1	0.4
The Netherlands																								
Bilthoven	1024	59.8	0.9	56.8	1.7	61.3	1.4	62.4	1.5	—	—	0.42	1086	43.0	0.6	41.3	1.1	44.1	1.0	45.0	1.2	—	—	0.0
Utrecht													1870	47.3	0.5			47.1	0.8	47.5	0.7	46.3	1.0	0.5
United Kingdom																								
General population	402	55.5	1.4	53.2	4.5	53.5	2.5	54.8	2.5	58.7	2.5	0.09	570	42.6	0.9	43.2	2.6	40.4	1.4	43.1	1.6	45.0	1.9	0.4
Health-conscious	114	23.8	2.6	—	—	18.5	4.2	20.5	4.0	—	—	0.39	197	16.9	1.5	22.5	4.7	14.0	2.4	15.5	2.4	25.4	4.1	0.8
Denmark																								
Copenhagen	1356	59.2	0.8			58.5	1.2	60.0	1.0	53.9	3.8	0.49	1484	43.1	0.5			42.6	0.9	43.1	0.7	44.0	2.6	0.1
Aarhus	567	56.2	1.2			56.5	1.7	56.8	1.7	—	—	0.34	510	42.1	0.9			40.2	1.3	43.9	1.3	—	—	0.4
Sweden																								
Malmö	1421	63.3	0.8			64.8	2.2	63.5	1.2	61.6	1.1	0.07	1711	46.4	0.5			47.0	1.0	45.0	0.8	46.2	0.8	0.7
Umeå	1344	60.0	0.8	58.7	2.6	60.7	1.4	59.4	1.0	61.1	2.3	0.29	1574	44.9	0.5	45.1	1.3	45.4	0.9	45.2	0.8	41.8	1.7	0.3
Norway																								
South and East													1004	46.1	0.7	47.3	1.6	45.6	0.8	50.1	1.6			0.6
North and West													793	47.3	0.8	47.1	1.7	48.5	0.9	45.9	2.0			0.7

Abbreviations: M, mean; s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age (when not stratified for age), total energy intake, weight and height, and weighted by season and day of recall.

Table A3 Fully adjusted[a] mean daily intake of plant protein by centre ordered from south to north, gender and age group

Country and centre	*Men*											*Women*										
	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}
		M	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*			*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	
Greece	1311	38.0	0.3	33.6	1.0	38.3	0.7	38.2	0.6	38.8	0.5	0.17	1373	27.2	0.2	24.3	0.6	26.2	0.4	28.7	0.4	28.5	0.5	0.1
Spain																								
Granada	214	34.2	0.8	—	—	34.2	1.6	33.8	1.1	34.0	1.8	0.21	300	24.9	0.5	25.2	1.2	24.6	0.8	24.8	0.8	26.2	1.5	0.4
Murcia	243	37.5	0.7	38.4	2.3	38.2	1.3	36.5	1.0	40.4	2.5	0.66	304	26.6	0.5	25.0	1.0	26.5	0.8	28.0	0.8	—	—	0.9
Navarra	444	33.4	0.5	34.7	2.4	33.8	0.9	33.3	0.8	32.1	1.7	0.01	271	23.4	0.5	22.3	1.3	23.8	0.8	23.6	0.8	—	—	0.8
San Sebastian	490	30.5	0.5	30.3	1.2	30.5	0.7	31.2	1.0	31.1	2.6	0.10	244	23.2	0.5	21.0	1.1	23.0	0.9	24.6	0.9	—	—	0.1
Asturias	386	32.0	0.6	34.1	2.2	31.5	1.0	32.1	0.9	32.7	1.6	0.59	324	23.5	0.5	23.5	1.1	22.7	0.7	23.4	0.7	28.4	1.7	0.2
Italy																								
Ragusa	168	41.1	0.9	—	—	42.4	1.3	40.9	1.4	—	—	0.19	138	27.5	0.7	23.7	1.2	28.5	1.3	31.2	1.3	—	—	0.9
Naples													403	27.1	0.4	25.1	1.3	26.3	0.7	28.2	0.6	27.7	1.3	0.1
Florence	271	39.1	0.7	40.2	2.2	38.4	1.2	40.3	1.0	—	—	0.26	784	27.3	0.3	27.3	1.0	27.6	0.5	27.3	0.4	25.7	1.2	0.2
Turin	676	36.0	0.4	36.6	1.4	35.9	0.7	35.9	0.6	37.6	1.7	0.48	392	25.7	0.4	24.0	1.3	25.4	0.7	26.1	0.6	—	—	0.0
Varese	327	33.0	0.6	—	—	33.5	1.4	33.1	0.8	30.8	2.1	0.14	794	24.5	0.3	22.3	0.9	24.6	0.5	25.0	0.4	23.7	0.9	0.5
France																								
South coast													620	23.9	0.3			24.3	0.5	24.2	0.5	23.0	0.7	0.3
South													1425	23.9	0.2			23.9	0.3	23.9	0.4	24.2	0.5	0.5
North-East													2059	22.6	0.2			22.3	0.3	22.7	0.3	23.1	0.4	0.0
North-West													631	23.0	0.3			22.9	0.5	23.2	0.5	22.7	0.8	0.7
Germany																								
Heidelberg	1034	29.6	0.4	28.6	0.9	30.4	0.6	29.2	0.5	—	—	0.20	1087	22.3	0.3	22.9	0.4	21.5	0.5	22.2	0.4	—	—	0.4
Potsdam	1233	27.6	0.3	27.0	0.9	28.0	0.7	27.7	0.4	26.5	1.3	0.69	1061	22.0	0.3	22.6	0.5	21.5	0.5	21.9	0.4	19.7	1.6	0.1
The Netherlands																								
Bilthoven	1024	31.2	0.4	32.4	0.7	31.3	0.6	30.6	0.6	—	—	0.19	1086	23.8	0.3	24.0	0.4	23.5	0.4	23.8	0.5	—	—	0.2
Utrecht													1870	23.0	0.2			23.6	0.3	22.5	0.3	23.3	0.4	0.8
United Kingdom																								
General population	402	32.0	0.6	34.3	1.9	32.4	1.0	32.2	1.0	30.4	1.0	0.03	570	25.4	0.3	27.1	1.0	25.4	0.6	25.7	0.6	24.1	0.7	0.1
Health-conscious	114	52.8	1.1	—	—	57.2	1.7	55.1	1.6	—	—	0.48	197	38.0	0.6	32.3	1.9	38.4	1.0	40.7	0.9	32.9	1.6	0.9
Denmark																								
Copenhagen	1356	27.1	0.3			27.1	0.5	27.2	0.4	25.6	1.6	0.37	1484	22.9	0.2			23.2	0.4	22.8	0.3	22.2	1.0	0.0
Aarhus	567	28.4	0.5			28.6	0.7	28.4	0.7	—	—	0.29	510	23.3	0.4			24.0	0.5	22.7	0.5	—	—	0.0
Sweden																								
Malmö	1421	27.4	0.3			28.1	0.9	27.9	0.5	26.4	0.4	0.28	1711	20.0	0.2			20.6	0.4	20.0	0.3	19.8	0.3	0.2
Umeå	1344	27.4	0.3	27.4	1.1	27.5	0.6	27.4	0.4	26.5	0.9	0.22	1574	21.7	0.2	22.2	0.5	21.7	0.4	21.6	0.3	21.3	0.7	0.0
Norway																								
South and East													1004	25.0	0.3	24.7	0.6	25.1	0.3	24.5	0.6			0.9
North and West													793	24.5	0.3	24.4	0.7	24.4	0.4	24.5	0.8			0.3

Abbreviations: M, mean; s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented.
[a]Adjusted for age (when not stratified for age), total energy, weight and height, and weighted by season and day of recall.

Table A4 Fully adjusted[a] mean daily intake of protein of unknown source by centre ordered from south to north, gender and age group

Country and centre	*Men*											*Women*										
	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}	N	*All*		*35–44 years*		*45–54 years*		*55–64 years*		*65–74 years*		P_{trend}
		M	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*			*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	*M*	*s.e.*	
Greece	1311	2.3	0.2	2.3	0.6	2.7	0.4	2.2	0.4	2.2	0.3	0.51	1373	2.2	0.2	2.5	0.4	2.0	0.3	2.1	0.3	2.4	0.3	0.9
Spain																								
Granada	214	2.0	0.5	—	—	1.7	1.1	2.3	0.7	1.5	1.2	0.33	300	2.5	0.3	2.7	0.9	2.1	0.6	2.5	0.5	3.7	1.1	0.4
Murcia	243	2.5	0.5	1.6	1.5	2.7	0.9	2.2	0.7	5.0	1.7	0.16	304	2.2	0.3	2.3	0.7	2.5	0.6	1.8	0.6	—	—	0.4
Navarra	444	2.3	0.4	0.4	1.6	1.7	0.6	2.8	0.5	3.2	1.1	0.02	271	2.2	0.4	2.7	1.0	2.5	0.6	2.1	0.6	—	—	0.1
San Sebastian	490	4.2	0.3	3.3	0.8	4.9	0.5	3.6	0.6	6.1	1.7	0.28	244	3.4	0.4	5.0	0.8	2.8	0.6	3.2	0.6	—	—	0.9
Asturias	386	4.7	0.4	6.9	1.4	4.9	0.6	4.0	0.6	6.0	1.0	0.64	324	4.7	0.3	4.4	0.8	4.2	0.5	5.2	0.5	5.4	1.2	0.1
Italy																								
Ragusa	168	7.5	0.6	—	—	8.0	0.9	7.6	0.9	—	—	0.27	138	5.6	0.5	4.8	0.9	6.2	1.0	6.8	0.9	—	—	0.6
Naples													403	3.9	0.3	4.8	1.0	4.2	0.5	3.9	0.5	2.2	1.0	0.1
Florence	271	5.9	0.5	6.4	1.4	6.3	0.8	5.5	0.7	—	—	0.80	784	5.0	0.2	4.9	0.7	5.1	0.4	4.9	0.3	4.7	0.8	0.4
Turin	676	6.0	0.3	6.9	0.9	6.3	0.5	5.8	0.4	5.3	1.1	0.00	392	5.1	0.3	6.2	1.0	5.9	0.5	4.5	0.4	—	—	0.0
Varese	327	5.4	0.4	—	—	6.5	0.9	5.3	0.5	2.4	1.4	0.20	794	5.6	0.2	8.9	0.7	5.9	0.4	5.0	0.3	4.6	0.6	0.1
France																								
South coast													620	3.0	0.2			2.7	0.4	2.6	0.4	4.0	0.5	0.3
South													1425	3.2	0.2			3.4	0.2	3.1	0.3	2.8	0.4	0.0
North-East													2059	3.8	0.1			4.5	0.2	3.5	0.2	3.0	0.3	0.1
North-West													631	3.2	0.2			3.1	0.4	3.1	0.4	3.2	0.6	0.7
Germany																								
Heidelberg	1034	5.1	0.2	7.1	0.6	4.7	0.4	5.0	0.3	—	—	0.08	1087	4.1	0.2	4.1	0.3	3.8	0.3	4.9	0.3	—	—	0.9
Potsdam	1233	4.9	0.2	4.9	0.6	4.4	0.4	5.0	0.3	5.2	0.8	0.50	1061	4.8	0.2	5.3	0.4	4.9	0.4	4.5	0.3	5.4	1.2	1.0
The Netherlands																								
Bilthoven	1024	7.8	0.2	8.1	0.5	7.7	0.4	8.0	0.4	—	—	0.26	1086	6.3	0.2	6.6	0.3	6.4	0.3	6.2	0.4	—	—	0.5
Utrecht													1870	7.0	0.1			6.7	0.2	7.1	0.2	6.9	0.3	0.7
United Kingdom																								
General population	402	8.2	0.4	7.2	1.2	10.4	0.7	6.7	0.7	7.6	0.7	0.81	570	6.3	0.3	5.5	0.8	6.7	0.4	6.5	0.5	5.5	0.5	0.9
Health-conscious	114	5.1	0.7	—	—	4.7	1.2	4.4	1.1	—	—	0.69	197	4.0	0.4	4.6	1.4	3.4	0.7	4.2	0.7	4.8	1.2	0.7
Denmark																								
Copenhagen	1356	4.9	0.2			5.1	0.3	4.6	0.3	6.4	1.0	0.49	1484	3.9	0.2			3.9	0.3	3.7	0.2	3.9	0.7	0.9
Aarhus	567	5.4	0.3			5.1	0.4	5.8	0.5	—	—	0.89	510	4.2	0.3			4.4	0.4	3.9	0.4	—	—	0.5
Sweden																								
Malmö	1421	6.5	0.2			5.3	0.6	6.0	0.3	6.9	0.3	0.05	1711	5.2	0.1			5.1	0.3	5.3	0.2	4.8	0.2	0.6
Umeå	1344	6.8	0.2	7.9	0.7	6.9	0.4	6.6	0.3	6.8	0.6	0.22	1574	5.0	0.2	6.2	0.4	5.0	0.3	4.5	0.2	4.9	0.5	0.2
Norway																								
South and East													1004	5.0	0.2	4.8	0.5	5.4	0.2	4.2	0.5			0.7
North and West													793	5.1	0.2	5.9	0.5	5.2	0.3	4.8	0.6			0.1

Abbreviations: M, mean; s.e., standard error; —, if a group comprised fewer than 20 persons, mean intake is not presented;.
[a]Adjusted for age (when not stratified for age), total energy intake, weight, and height and weighted by season and day of recall.