Macronutrient intake and food sources in the very old: analysis of the Newcastle 85+ Study

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Abstract

Food and nutrient intake data are scarce in very old adults (85 years and older) – one of the fastest growing age segments of Western societies, including the UK. Our primary objective was to assess energy and macronutrient intakes and respective food sources in 793 85-year-olds (302 men and 491 women) living in North-East England and participating in the Newcastle 85+ cohort Study. Dietary information was collected using a repeated multiple-pass recall (2×24 h recalls). Energy, macronutrient and NSP intakes were estimated, and the contribution (%) of food groups to nutrient intake was calculated. The median energy intake was 6·65 (interquartile ranges (IQR) 5·49–8·16) MJ/d – 46·8 % was from carbohydrates, 36·8 % from fats and 15·7 % from proteins. NSP intake was 10·2 g/d (IQR 7·3–13·7). NSP intake was higher in non-institutionalised, more educated, from higher social class and more physically active 85-year-olds. Cereals and cereal products were the top contributors to intakes of energy and most macronutrients (carbohydrates, non-milk extrinsic sugars, NSP and fat), followed by meat and meat products. The median intakes of energy and NSP were much lower than the estimated average requirement for energy (9·6 MJ/d for men and 7·7 MJ/d for women) and the dietary reference value (DRV) for NSP (≥ 18 g/d). The median SFA intake was higher than the DRV (≤ 11 % of dietary energy). This study highlights the paucity of data on dietary intake and the uncertainties about DRV for this age group.

Key words: Dietary intakes: Aged 80 years and over: Very old adults: Newcastle 85+ Study

The steady rise in life expectancy and decrease in later-life mortality make very old people (those aged 85 years and over) the fastest growing age segment of Western societies[1,2]. In the UK, there are now more than 1·5 million very old people (2·5 % of total population), and the number is projected to rise to 3·3 million or 5 % over the next 20 years[3]. Reduced mobility and independence, financial constraints, polypharmacy, hospitalisation, high incidence of disability and chronic diseases, and changes in body composition, digestion, absorption and taste perception place very old adults at increased risk of nutritional deficiencies, which are important predictors of morbidity and mortality[4]. In the UK, over 10 % of older adults (aged 65 years and over) and 18 % of those aged 85 years and over are at medium or high risk of malnutrition[5]. Public expenditure on disease-related malnutrition is estimated to exceed £13 billion per year and over half is expended on older adults[6]. However, very little is known about the dietary habits of the very old.

Many studies arbitrarily exclude very old people for no reason other than age[7], while others only include a small number, resulting in a lack of statistical power. For example, a Europe-wide, multi-centre study on food intake in older adults (Survey Europe on Nutrition in the Elderly: A Concerted Action) had an upper age limit of 79 years[8]. Out of the current (years 1–4) 4156 participants (sample size was weighted for unequal selection and non-response) in the UK's National Diet and Nutrition Survey (NDNS) rolling programme, only fifteen men and twenty-three women were aged 85 years and over[9]; 20 years ago, the 1994/1995 NDNS of people aged ≥65 years was the first representative dietary survey in the UK to include significant numbers of adults aged 85 years and over (172 men and 287 women), but this survey has not been repeated[10]. This survey reported that dietary intakes for most nutrients in the very old did not meet the dietary reference values (DRV)[10]. The UK's DRV for 'older people' add further to the evidence of how frequently very old

people are overlooked. Apart from the estimated average requirement (EAR) for energy intake (EI) and the reference nutrient intake (RNI) for protein, which sets a DRV for individuals aged 75 years and over and 50 years and over, respectively, all other DRV include everyone aged ≥18 years in the same category[11,12]. In summary, there is a need for more reports of dietary intake data for those aged ≥85 years.

The present study aimed to describe the intakes of energy, macronutrients and NSP by participants in the Newcastle 85+ Study, and to determine their principal food sources. Further, intakes were compared against the current UK DRV, and socio-economic and lifestyle influences on dietary intake were explored.

Methods

Newcastle 85+ Study

Details of the Newcastle 85+ Study have been reported elsewhere[7,13,14] (for study questionnaires, visit http://research.ncl. ac.uk/85plus). In brief, this longitudinal population-based study of health trajectories and outcomes in the very old approached all people turning 85 years in 2006 (born in 1921) who were registered with participating general practices (GP) within Newcastle upon Tyne or North Tyneside primary-care trusts (North-East England). The recruited cohort was socio-demographically representative of the general UK population and included institutionalised very old adults[13]. At baseline (2006/2007), multidimensional health assessment and complete GP medical records data were available for 845 participants[14], and complete dietary intake data (without protocol violation) were available for 793 participants.

Ethics approval

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Newcastle and North Tyneside local research ethics committee (06/Q0905/2). Written informed consent was obtained from all participants, and when we were unable to do so consent was obtained from a carer or a relative.

Dietary assessment, estimation of energy and macronutrient intakes and food group contributions

Dietary intake was assessed by a 24-h multiple-pass recall (24 h-MPR) on two non-consecutive occasions by trained research nurses, and portion sizes were estimated using the *Photographic Atlas of Food Portion Sizes*[15] (see Adamson *et al.*[16] for details). Energy and macronutrient (alcohol, total carbohydrate, non-milk extrinsic sugars (NMES), NSP, total fat, SFA, PUFA, MUFA and protein) intakes were estimated using *McCance and Widdowson's Sixth Edition Food Composition Tables*[17] and a purpose-designed Microsoft Office Access database. Individual foods were coded and allocated to food groups using a system that included fifteen first-level food groups (cereals and cereal products (CCP), milk and milk products, eggs and egg dishes, oils and fat spreads, meat and meat

products, fish and fish dishes, vegetables, potatoes, savoury snacks, nuts and seeds, fruits, sugars, preserves and confectionery, non-alcoholic beverages, alcoholic beverages and miscellaneous), forty-eight second-level and 132 third-level food groups with increasing specificity. Food group contribution to total energy and macronutrient intakes was calculated, and sources of at least 85 % of each nutrient intake are reported. In addition, consumed foods were also disaggregated into five groups (bread, rice, potatoes, pasta and other starchy foods; milk and dairy foods; food and drinks high in fat and/or sugar (FS); meat, fish, eggs, beans and other non-dairy sources of protein; and fruit and vegetables) and compared with the Eatwell Plate (Balance of Good Health)[18].

Evaluation of misreporting

Dietary misreporting is an acknowledged limitation of all dietary assessment methods. Goldberg *et al.*[19] tried to address this problem by introducing cut-off values to identify misreporters. The cut-off values are derived from estimations of EI divided by the estimated BMR (BMR_{est}) ($EI:BMR_{est}$)[20]. Fredrix equations have been shown to be the most accurate in older subjects[21] and were used to calculate each participant's BMR_{est}. Under-reporters and over-reporters were defined as having an EI: BMR_{est} below 1·05 and over 2·0, respectively. A 17 % within-subject variation for EI, 15 % between-subject variation for physical activity level (PAL)[20] and 3·5 % within-subject variation for BMR measurements[22] were assumed. The individual limits were calculated assuming a PAL value of 1·55, the WHO value for 'light activity' and a 95 % CI[20]. As a sensitivity analysis, nutrient intakes with the cut-off values applied were calculated and compared with the nutrient intakes of all participants (without the cut-off values).

Socio-economic, health and lifestyle factors

Participants were classified according to housing: standard, sheltered (self-contained housing with communal areas such as a lounge, laundry or garden and on-call support) or institutional housing. Further, participants were characterised as living alone, with spouse or with others (participants living in institutions were excluded from the living arrangement categories (*n* 34)). As socio-economic status (SES) influences dietary intake[23], the following SES variables were included in the analysis: years of full-time education (categorised as 9 years or less, 10–11 years and 12 or more years) and social class according to the National Statistics Socio-Economic Classification (NS-SEC) three-class scheme (higher managerial, administrative and professional occupations (Class 1); intermediate occupations (Class 2); and routine and manual occupations (Class 3)[24]) based on past main occupation[13]. Participants were categorised as those with low (scores 0–1), medium (scores 2–6) or high (scores 7–18) physical activity based on a validated and purpose-designed physical activity questionnaire[25].

Statistical analysis

Statistical analyses were conducted using the IBM statistical tool SPSS version 22.0. Normality was tested using the Shapiro–Wilk

test and confirmed with Q-Q plots. Normally distributed continuous data are presented as mean values and standard deviations, and non-Gaussian distributed variables are presented as medians and interquartile ranges (IQR). Categorical data are presented as percentages (with corresponding sample size). Case selection and simple descriptive analysis were used to identify the baseline characteristics, dietary intake and the whole group's percentile below or above the DRV. Sex differences were assessed with the two-sample t test or the χ^2 test for normally distributed continuous variables and categorical variables, respectively, and the Mann–Whitney U test was used for non-parametric continuous data. Energy and nutrient intakes were compared across housing, living arrangements (with whom participants live), years of full-time education, past occupation (NS-SEC) and physical activity groups by multinomial logistic regression. All models were adjusted for sex, except for NSP, which was adjusted for sex and EI. $P < 0.05$ was considered to be statistically significant.

Results

Characteristics of the Newcastle 85+ Study population

Dietary intake data were available for 793 participants of the Newcastle 85+ Study (302 men and 491 women, female: male ratio of 1·6), who were all born in 1921 (aged 85·5 (SD 0·4) years at the time of data collection). Health and socio-demographic characteristics of these 793 participants by sex are included in Table 1. The majority of participants lived in standard housing (78 %), alone (61 %) and had 9 years or less of full-time education (64 %). Approximately half (51 %) had had a routine or manual occupation (NS-SEC class 3) and 44 % had a medium PAL. Using WHO adult BMI cut-off values[26], 7 % of the participants were underweight, whereas 10 % were obese, suggesting the existence of a double burden of malnutrition. Participants with 2×24 h-MPR data and those without (n 40) or only with 1×24 h-MPR (n 12) did not differ with respect to sex, living arrangements (who participants live with), education, social class and BMI. However, people without complete dietary data were more likely to live in institutional housing, to be physically inactive, to be unable to cook a hot meal and unable to do grocery shopping independently compared with those with complete dietary data (data not shown).

Dietary intake

Intakes of energy, EI:BMR$_{est}$, macronutrients and NSP are reported in Table 2. The median EI was 6·65 (IQR 5·49–8·16) MJ/d of which 46·8 % was derived from carbohydrate, 36·8 % from total fat and 15·7 % from protein. EI:BMR$_{est}$ was 1·33 (IQR 1·08–1·60) for both men and women. As expected, men had significantly higher intakes of energy, macronutrients and NSP than women. However, when expressed as relative contribution to energy or per 1 MJ for NSP, only percentage of energy from protein was significantly higher for men ($P = 0.010$). Conversely, the percentage of energy from

SFA was lower in men ($P = 0.012$), whereas the PUFA:SFA ratio was higher in men than in women ($P = 0.017$).

Sensitivity analysis

In all, sixty-two participants (thirteen men and forty-nine women) did not have records of weight and/or height, and therefore were excluded from the analysis of effects of misreporting, which was conducted for the remaining 731 participants. Using 1·05:2·0 EI:BMR$_{est}$ as a cut-off, 26·3 % (n 192) of the participants were identified as potential misreporters (30·4 % men and 23·5 % women). Of the 731 very old, 21·6 % (n 158) were defined as under-reporters (25·6 % men and 19·0 % women) and 4·7 % (n 34) as over-reporters (4·8 % men and 4·5 % women). Dietary intake of non-misreporters (n 607) and the differences between total reporters (n 731) are presented in the online Supplementary Table S2. As there were more under-reporters than over-reporters, daily EI increased by 0·36 MJ or 86 kcal when cut-offs were applied, marginally increasing intakes of all macronutrients and NSP. Data from all participants (n 793) were used in our primary analyses because of the uncertainty regarding the identification of misreporters.

Contribution of food groups to dietary intake

CCP and non-alcoholic beverages were the only food groups consumed by all participants (Tables 3). As CCP includes macronutrient-rich foods such as bread, buns and breakfast cereals, CCP were frequent top contributors of macronutrients (Fig. 1). One-third of the 34·2 % of EI that came from CCP came from bread (32·7 %). Similarly, more than a third of CCP contribution to carbohydrate intake (48·3 %) was from bread (38·7 %). Non-alcoholic beverages contributed to 18·4 % of NMES intake of which 60 % was from fruit juice and the remaining 40 % from soft drinks. Added sugar was coded separately from tea/coffee if it was added. Therefore, tea and coffee contributed to 0 % of NMES intake, even though they were ubiquitously consumed in this population. More than half of the 42·3 % of NSP intake attributable to CCP came from bread (50·8 %). Nearly half of the contribution of vegetables to NSP intake (22 %) came from peas and cruciferous vegetables (49·7 %). The biggest contributors to fat intake were CCP with 23·1 % (38·5 % of which was provided by buns, cakes, pastries and fruit pies), followed by meat and meat products (20·8 %) and oils and fat spreads (19·9 %). Meat and meat products were greater contributors to fat intake in men than in women (23·8 v. 18·5 %), whereas the opposite was true for oils and fat spreads (18·0 v. 21·4 %). There were similar sex differences in contributions to SFA intake. The large majority of SFA intake attributable to oils and fat spreads consumption (21·6 %) came from butter (81·9 %). Similarly, most of PUFA that came from oils and fat spreads (31·9 %) came from fat spreads (87·4 %). Meat and meat products were the main sources of protein (34·6 %), followed by CCP (24·2 %) and milk and milk products (11·5 %). Most sex differences occurred when meat and meat products were a top contributor to

Table 1. Health and socio-demographic characteristics of the Newcastle 85+ Study participants with complete dietary data by sex
(Percentages and numbers; mean values and standard deviations)

	All		Men		Women		
	%	n	%	n	%	n	P*
Sex	–	793	38	302	62	491	–
Age (years)							0·472†
Mean	85·5		85·5		85·5		
SD	0·44		0·46		0·43		
Housing							0·001
Standard	78	620	85	256	74	364	
Sheltered	17	137	12	37	21	100	
Institutional	4	34	3	8	5	26	
Living arrangements‡							<0·001
Alone	61	437	42	119	74	318	
With spouse only	28	204	51	145	14	59	
With others	11	79	8	23	13	56	
Years of full-time education							0·608
≤9 years	64	501	61	184	66	317	
10–11 years	23	183	25	75	23	108	
12–20 years	12	97	13	39	12	58	
Past occupation (NS-SEC)							<0·001
Higher managerial/administrative/professional (Class 1)	34	259	40	118	31	141	
Intermediate (Class 2)	15	109	8	23	19	86	
Routine and manual (Class 3)	51	385	52	155	50	230	
BMI (kg/m²)							0·125
Underweight (<18·5)	7	48	5	13	8	35	
Eutrophic (18·5–24·9)	51	374	51	146	51	228	
Overweight (25·0–29·9)	32	236	36	105	30	131	
Obese (≥30·0)	10	72	9	25	11	45	
Physical activity§							<0·001
Low	22	176	20	60	24	116	
Medium	44	343	33	99	50	244	
High	34	270	47	142	26	128	
Diet change in past year							0·082
Yes	7	53	5	15	8	38	
No	93	718	95	279	92	439	
Food provision (social services+ private+ voluntary)							0·610
No visit	94	671	94	268	93	403	
At least once in 4 weeks	6	47	6	17	7	30	
Luncheon club							0·010
Attended	7	55	4	12	9	43	
Not attended	93	734	96	289	91	445	
Cook a hot meal independently							0·051
No difficulty	79	624	83	251	76	373	
Some difficulty	7	48	5	16	7	32	
Unable	15	118	11	34	17	84	
Shopping for groceries independently							<0·001
No difficulty	48	378	64	191	38	187	
Some difficulty	13	100	12	37	13	63	
Unable	40	313	24	73	49	240	

NS-SEC, National Statistics Socio-Economic Classification.
* χ^2 Test for no sex difference.
† Independent t test for no sex difference.
‡ Excludes participants in institutional care.
§ Purpose-designed physical activity questionnaire[25].

macronutrient intake but the male:female ratio did not exceed 1·3 (data not shown).

Comparison of food intake with the Eatwell Plate

As a public health tool, the Eatwell Plate (not the recently updated version) is intended to illustrate the recommended intake of five food groups (%). Foods and drinks high in FS accounted for 18% of the 'Newcastle 85+ plate', much higher than the 8% recommended by the Eatwell Plate, leading to lower than recommended proportions of fruit and vegetables, bread, rice, potatoes, pasta and other starchy foods and, although to a less extent, of meat, fish, eggs, beans and other non-dairy sources of protein in the Newcastle 85+ Study (online Supplementary Fig. S1).

Nutrient adequacy

Compliance of the Newcastle 85+ Study cohort with the UK DRV is shown in the online Supplementary Table S1, whereas Fig. 2 shows the distribution of energy, NMES, NSP and SFA

Table 2. Daily energy, EI:BMR$_{est}$, macronutrient and NSP intakes in the Newcastle 85+ Study by sex

Macronutrients	All Median	% en	IQR	Men Median	% en	IQR	Women Median	% en	IQR	P*	% en
Energy (MJ)†	6·65		5·49–8·16	7·73		6·36–9·20	6·15		5·09–7·25	<0·001	
Energy (kcal)	1588		1018–1949	1848		1519–2201	1471		1217–1733	0·001	
EI:BMR$_{est}$	1·33		1·08–1·60	1·33		1·04–1·57	1·33		1·11–1·61	0·287	
Alcohol (g)‡	13·2		6·8–23·2	17·3		9·6–30·7	8·7		4·8–14·3	<0·001	
Carbohydrate (g)	193·9	46·8	156·9–238·1	228·3	46·8	180·9–271·9	177·3	46·8	147·2–218·6	<0·001	0·760§
NMES (g)	42·7	10·1	25·4–63·8	50·2	10·5	32·5–78·2	38·0	9·8	23·2–56·7	<0·001	0·055
NSP (g)	10·2		7·3–13·7	11·3		8·8–15·5	9·3		6·8–12·2	<0·001	
NSP (g) (1 MJ)	1·51		1·17–2·01	1·52		1·16–1·95	1·50		1·18–2·04	0·485	
Total fat (g)	65·8	36·8	50·1–84·2	74·7	36·4	57·7–95·0	60·4	37·2	47·1–77·1	<0·001	0·093‡
SFA (g)	24·3	13·6	17·3–32·4	27·0	12·9	18·8–35·5	22·8	13·7	16·4–30·9	<0·001	0·012
MUFA (g)	15·5	8·8	11·1–21·3	18·2	8·6	12·6–23·9	14·2	8·9	10·6–19·7	<0·001	0·761
PUFA (g)	6·3	3·4	3·9–9·9	7·3	3·6	4·7–11·4	5·7	3·4	3·5–8·5	<0·001	0·237
P:S ratio	0·25		0·15–0·42	0·28		0·17–0·43	0·23		0·14–0·41	0·017	
Protein (g)	61·3	15·7	48·9–75·7	73·0	15·9	57·9–90·1	54·5	15·5	45·1–67·2	<0·001	0·010
Protein (g/kg)	0·99		0·77–1·24	1·04		0·81–1·32	0·96		0·75–1·17	<0·001	

EI:BMR$_{est}$, energy intake as a multiple for estimated BMR[21]; % en, percentage of energy; NMES, non-milk extrinsic sugars; P:S ratio, PUFA:SFA ratio.
* Mann–Whitney U test for no sex difference unless stated otherwise.
† Does not include alcohol.
‡ Alcohol consumers only.
§ Independent t test for no sex difference.

Table 3. Percentage of consumers and consumption (g/d) of major food groups in the Newcastle 85+ Study participants by sex (Percentages, medians and interquartile ranges (IQR))

Food groups	All %	Median (g/d)	IQR	Men %	Median (g/d)	IQR	Women %	Median (g/d)	IQR	P*
Cereals and cereal products	100	105·5	70·8–153·5	100	132·8	95–191·4	100	93·3	62·8–131·8	<0·001
Non-alcoholic beverages	100	605·0	459·0–764·0	100	605·0	449·4–774·4	100	605·0	475·0–758·8	0·876
Meat and meat products	94	56·3	32·9–83·9	97	67·5	44·3–98·8	92	49·0	28·8–74·0	<0·001
Oils and fat spreads	93	8·0	5·0–14·0	92	9·0	5·0–14·9	93	8·0	5·0–13·0	0·213
Vegetables	91	51·9	30·3–79·8	91	57·3	35·0–84·5	91	48·3	27·0–73·8	0·006
Milk and milk products	90	70·8	30·3–112·5	89	69·3	27·1–112·5	90	71·8	37·5–112·5	0·412
Potatoes	82	49·5	33·0–76·8	83	65·5	39·3–89·1	81	45·3	24·9–70·0	<0·001
Sugar, preserves and confectionery	80	10·0	5·4–18·0	83	12·5	6·5–21·7	78	8·8	5·0–16·0	<0·001
Fruit	74	71·5	39·8–115·7	74	75·5	43·0–121·8	75	65·4	37·9–110·9	0·221
Miscellaneous	73	27·9	11·4–71·0	75	27·5	11·0–72·7	73	28·8	12·5–70·4	0·962
Eggs and egg dishes	39	15·0	12·5–30·0	40	25·0	12·5–30·0	38	15·0	12·5–30·0	0·102
Fish and fish dishes	36	28·0	16·0–42·8	33	30·0	18·8–38·8	38	26·1	14·0–45·0	0·259
Alcoholic beverages	34	62·8	25·0–150·5	50	125·0	50·0–284·0	24	37·5	20·0–71·0	<0·001
Savoury snacks	11	7·0	3·5–7·3	11	7·0	3·5–10·1	10	7·0	3·5–7·0	0·730
Nuts and seeds	7	7·5	3·2–10·4	9	10·0	6·6–11·9	7	4·5	2·5–9·7	0·015

%, Percentage of consumers throughout the 2 × 24 h multiple-pass recall.
* Mann–Whitney U test for no sex differences between consumption (g/d) of each food group (only consumers).

intake compared with the corresponding DRV. The median EI were below the recently established EAR for dietary energy in the UK[12] and only 20 % of the cohort met the 9·6 and 7·7 MJ for men and women, respectively. In all, 50 % of men and 24 % of women reported drinking alcohol and most of those were below the 32 and 24 g advisable maximum limits of alcohol intake per day for men (77·5 %) and women (90·8 %), respectively[27]. As alcohol consumption was relatively low, the percentage of energy inadequacy decreased by only 5 % in men (from 80·1 to 75·1 %) and 3 % in women (from 80·2 to 77·2 %) when alcohol was included in EI estimations (data not shown). The median carbohydrate intake was also below the DRV for men and women, and carbohydrates contributed ≥50 % of food EI in one-third (33 %) of the population. The median NMES

intake did not reach 11 % energy from NMES per day, but more than 40 % of the group derived more energy from NMES than the dietary guidelines. In contrast, neither men nor women met the NSP intake DRV of 18 g/d, and only 9 % of the cohort had higher intakes. Moreover, median NSP intake was also <12 g/d (66 % of the population had lower intakes), the estimated lower end of the reference range[11]. Median total fat and SFA contributions to EI were higher than 35 and 11 %, respectively. Nearly 60 % of the group exceeded the recommended contribution of fat to EI, whereas this percentage rose to 72·1 % for SFA. However, median protein intake was higher than the RNI of 0·75 g/kg[11], reflecting that 78·1 and 67·4 % of men and women, respectively, had higher protein intakes than the RNI.
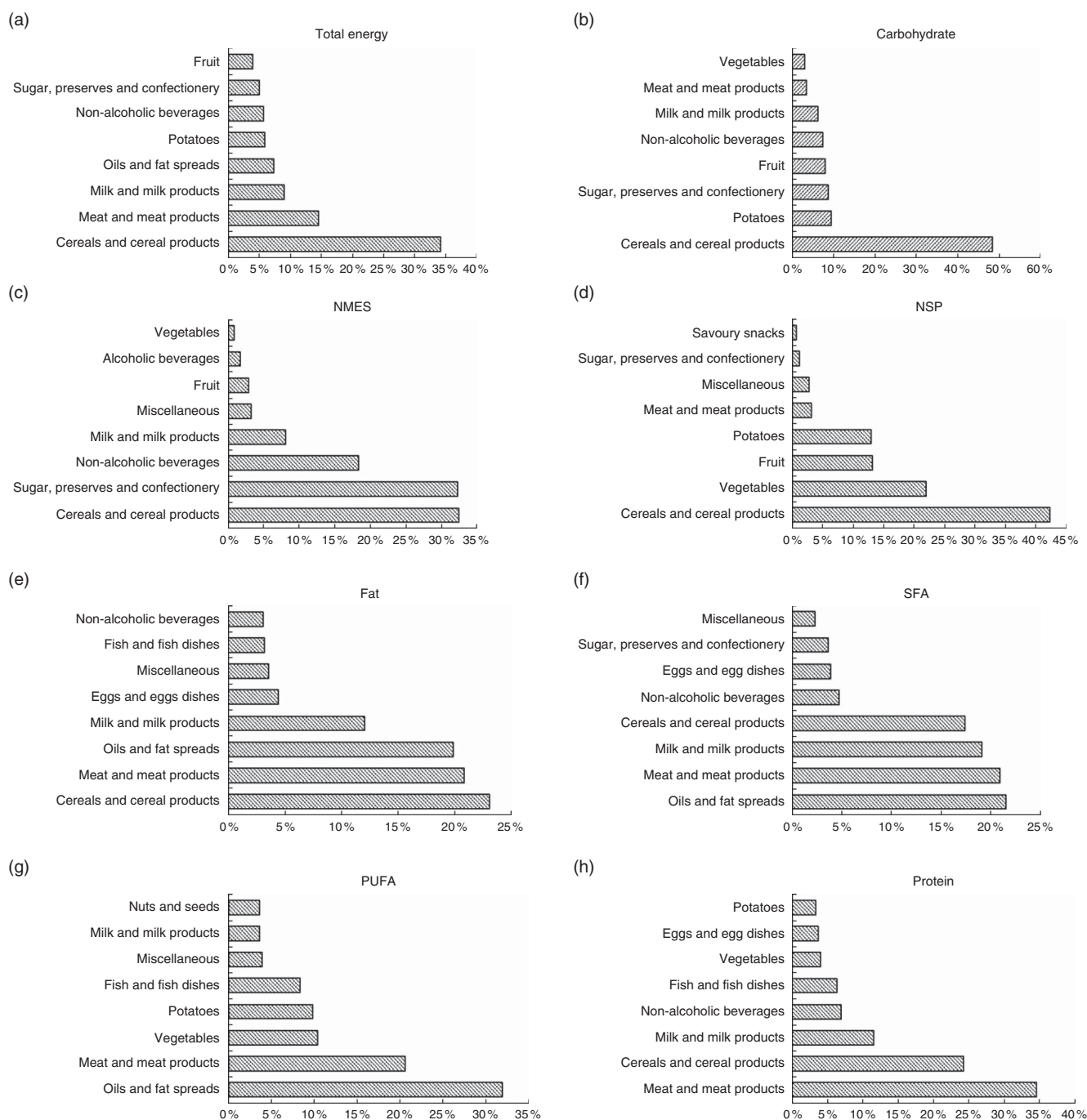
Fig. 1. Contribution (%) of fifteen food groups to average (a) energy (b) carbohydrate (c) non-milk extrinsic sugars (NMES) (d) NSP (e) fat (f) SFA (g) PUFA and (h) protein intakes in 793 Newcastle 85+ Study participants.

Dietary intake by housing, socio-economic status and physical activity

Table 4 reports daily energy, macronutrient and NSP intakes stratified by housing, living arrangements, years of full-time education, social class (NS-SEC) and physical activity. When adjusted for sex, participants in institutional housing were more likely to have higher intakes of energy, carbohydrate and higher percentage of energy from NMES than those who lived in standard housing. However, institutionalised participants were more likely to have lower intakes of NSP (also adjusted for EI) and percentages of energy from MUFA and PUFA. Participants living in sheltered housing were more likely to have lower NSP intakes than those living in standard housing. There were no statistically significant differences between those living with their spouse or with others compared with those living alone except for protein intake. Participants who lived with others were more likely to have a lower protein intake than those who
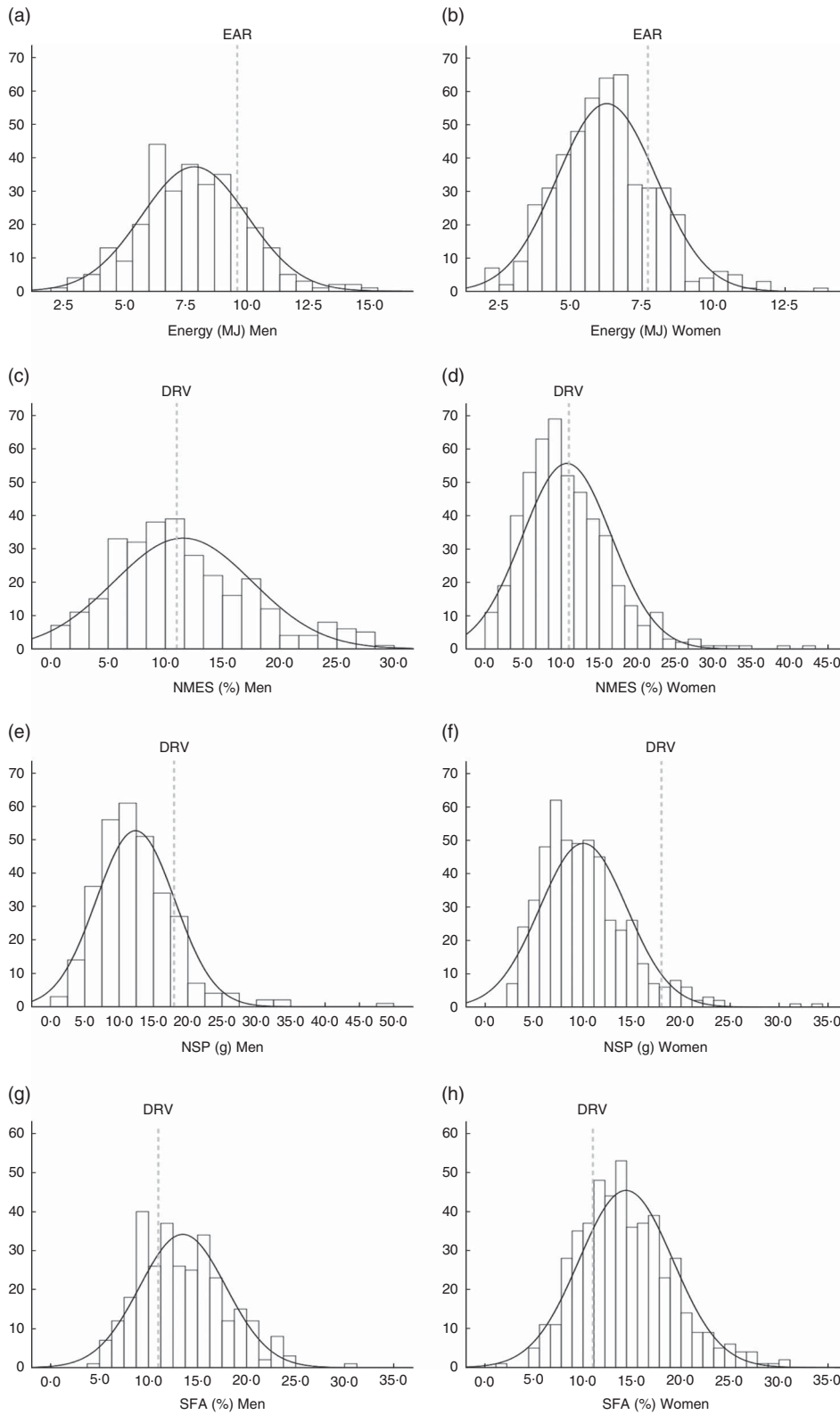
Fig. 2. Distribution and adequacy of food energy intake (MJ) in (a), men and (b), women; of non-milk extrinsic sugars (NMES) intake (%) in (c), men and (d), women; of NSP intake (g) in (e), men and (f), women; and of SFA intake (%) in (g), men and (h), women. Vertical dashed lines represent the DRV in the UK for adults[11] and for adults aged 75 years and over for energy[12]. EAR, estimated average intake; DRV, dietary reference value.

Table 4. Daily energy, macronutrient and NSP intakes of the Newcastle 85+ Study participants by demographic, socio-economic and lifestyle characteristics†

Macronutrients	Housing			Living arrangements‡			Education (years)			Past occupation (NS-SEC)			Physical activity		
	Standard (n 620)	Sheltered (n 137)	Institutional (n 34)	Alone (n 437)	Spouse (n 204)	Others (n 79)	≤9 (n 501)	10–11 (n 183)	≥12 (n 97)	Class 1 (n 385)	Class 2 (n 109)	Class 3 (n 259)	Low (n 176)	Medium (n 343)	High (n 270)
Energy (MJ)	6·62	6·78	7·65*	6·36	7·28	6·64	6·57	6·69	6·89	6·76	6·63	6·64	6·77	6·37	6·92
Energy (kcal)	1581	1619	1828	1520	1739	1587	1571	1599	1646	1617	1586	1588	1617	1522	1653
Alcohol (g)§	13·3	10·1	—‖	11·5	16·1	9·7	10·6	15·0	13·6	12·8	10·2	13·4	12·6	10·2	15·0
Carbohydrate (g)	191·6	198·4	222·0**	184·2	220·4	186·2	192·4	190·1	211·4	200·9	195·8	192·7	197·2	185·8	203·1
% Energy	46·8	46·9	47·6	46·5	47·2	47·8	46·9	46·1	48·1	47·1	47·5	46·6	46·7	47·3	46·2
NMES (g)	42·3	41·5	63·6**	38·8	49·5	40·2	41·5	42·6	45·9	44·5	45·7	41·4	46·6	41·5	43·9
% Energy	10·0	10·2	12·9*	9·8	10·6	9·5	10·0	10·3	9·9	10·1	10·3	9·8	10·1	10·1	10·1
NSP (g)	10·4	9·4**	7·1***	9·9	11·0	10·1	9·9	10·1	11·7**	10·8**	10·4*	9·9	9·1	10·0**	11·3***
Total fat (g)	65·5	64·7	74·4	63·9	68·1	60·8	65·5	66·6	65·0	66·0	63·9	67·1	66·8	62·3	69·7
% Energy	36·8	37·3	37·7	36·9	36·4	37·3	36·9	37·6	35·6	35·7	36·6	37·2	37·3	36·7	36·7
SFA (g)	24·0	24·9	25·6	23·5	25·3	22·3	23·5	25·5	24·4	24·4	24·9	24·1	25·3	23·3	25·4
% Energy	13·6	13·7	12·9	13·6	13·2	13·5	13·5	14·4	13·1	13·4	13·4	13·7	14·1	13·5	13·4
MUFA (g)	15·8	14·9	14·5	15·3	16·3	15·4	15·5	15·7	16·1	15·2	16·5	16·0	14·7	14·8	16·7*
% Energy	9·0	8·2	7·8**	9·0	8·6	9·3	8·8	9·0	8·4	8·6	9·1	8·9	8·3	8·7	9·2*
PUFA (g)	6·5	5·9	4·1*	6·5	6·4	6·4	6·6	6·3	5·9	6·4	6·5	6·3	5·2	6·2*	6·9***
% Energy	3·6	3·3	2·3**	3·7	3·3	3·8	3·6	3·4	3·0	3·4	3·7	3·4	2·8	3·5*	3·8**
Protein (g)	61·2	61·1	61·9	58·3	67·5	55·0*	59·4	62·0	65·7	63·5	59·5	61·1	59·6	58·0	66·2*
% Energy	15·7	15·3	14·0	15·7	15·9	14·3	15·7	15·5	15·7	15·7	15·8	15·5	15·3	15·4	16·1*

NS-SEC, National Statistics Socio-Economic Classification; Class 1: higher managerial, administrative and professional occupations; Class 2: intermediate occupations; Class 3: routine or manual occupations; NMES, non-milk extrinsic sugars.

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

† All models were adjusted for sex except NSP, which was adjusted for sex and energy intake. Standard housing, Living alone, ≤9 years of full-time education, Class 3 of past occupation and low physical activity were the reference categories.

‡ Excludes people in institutional care.

§ Only alcohol drinkers.

‖ Not reported because of low participant number.

Macronutrient intake in the very old

lived alone ($P = 0.032$). After adjusting for sex and energy, participants who had 12 years or more of full-time education had higher NSP intakes than those with ≤9 years of full-time education ($P = 0.008$). Similarly, those with previous higher managerial, administrative or professional (Class 1) and intermediate (Class 2) occupations (NS-SEC) had higher NSP intakes than those with routine or manual occupations (Class 3) ($P = 0.001$ and 0.018, respectively). Participants with high physical activity had higher intakes of NSP and percentage of energy from MUFA, PUFA and protein than those with low physical activity. The same was true for NSP and percentage of energy from PUFA in those with medium physical activity.

Discussion

Participants of the Newcastle 85+ Study had a median EI of 6·65 MJ, of which 46·8, 36·8 and 15·7% were from carbohydrates, fats and proteins, respectively. CCP were the top contributors for most macronutrients, followed by meat and meat products. Only 20% of the cohort had higher EI than the EAR. This recommendation was established for those aged ≥75 years and its relevance for those aged 85 years is unclear. Most participants did not meet the DRV for NSP and SFA intakes (91 and 72%, respectively). NSP intake was higher in non-institutionalised, more educated, from higher social class and more physically active 85-years-olds.

Comparison with other studies

The Newcastle 85+ Study is the first to investigate the dietary intakes of such a large and socio-demographically representative sample of 85-years-olds in the UK. There have been two earlier studies with considerable numbers of 85-year-olds: the 1994/1995 NDNS of people aged 65 years and over (172 men and 287 women aged 85 years and over)[10] and the European Prospective Investigation into Cancer and Nutrition (EPIC)-Oxford study (411 men and 872 women aged 80 years and over at the third follow-up in 2010–2014)[28].

Non-institutionalised (standard and sheltered housing) very old adults (aged 85 years and over) in the 1994/1995 NDNS had lower median energy (6·99 and 5·60 MJ in men and women, respectively), carbohydrate, fat and protein intakes but higher NMES, SFA, MUFA and PUFA intakes compared with the Newcastle 85+ participants[10]. The food groups used in the Newcastle 85+ Study are comparable with those used in the NDNS, and our analysis showed that food sources of macronutrients for non-institutionalised very old adults were similar in both studies. However, the very old respondents in the NDNS derived more energy (15 *v.* 9%) and SFA (29 *v.* 19%) from milk and milk products, more carbohydrates (13 *v.* 9%) and NMES (44 *v.* 32%) from sugar, preserves and confectionery, and more NSP from CCP (50 *v.* 42%) compared with the Newcastle 85+ Study cohort[10]. Although the Newcastle 85+ Study included 85-year-olds only, the 1994/1995 NDNS included those aged 85 years and over. Further, dietary data collection diverged by more than a decade, which might reflect not only different dietary habits but also different prevalence of age-related diseases and disabilities[29].

At the third follow-up, EPIC-Oxford participants had higher mean EI (9·84 and 9·02 MJ in men and women, respectively), percentage of energy from carbohydrates, NSP intake and PUFA:SFA ratio than the Newcastle 85+ Study participants, but fat and SFA did not contribute to EI as much (T. Key & P. Appleby, personal communication). Some notable differences between the two studies include different age (80 years and over *v.* 85-year-olds), different dietary assessment methods (FFQ *v.* 24 h-MPR), different dietary habits (14% of the participants aged 80 years and over in the EPIC-Oxford were vegetarians or vegans) and use of different descriptive statistics to report the results (mean *v.* median).

It will take several years until the current NDNS rolling programme has similar numbers of very old adults to compare with the Newcastle 85+ Study. Until then, the contemporary dietary data from our study are likely to be the most reliable for this age group. However, their younger counterparts (191 men and 237 women aged 65 years and over-weighted) had similar macronutrient intakes to those of the Newcastle 85+ Study cohort, except for the percentage of energy from protein and NSP intakes, which were higher in the NDNS[9,30]. The top food group contributors did not greatly differ, but sugar, preserves and confectionery contributed less to NMES intake and CCP and oils and fat spreads contributed less to total fat intake in the NDNS current rolling programme's older adults compared with the Newcastle 85+ Study[9,30]. Differences between studies might reflect age-specific dietary habits.

Public health implications

A new European Society for Clinical Nutrition and Metabolism consensus statement defines unintentional weight loss as >5% over 3 months or >10% of habitual weight (irrespective of time) as one of the criteria for diagnosing malnutrition[31]. The majority of participants did not meet the current energy EAR at baseline, which might lead to unintended weight-loss and account for the increased malnutrition risk in this age group. Follow-up analysis of weight change can help confirm this finding.

Failure to meet the NSP intake DRV of 18 g/d might be a cause for concern in very old adults, as it may contribute to the high prevalence of constipation[32]. Non-compliance with the NSP DRV was significantly higher in women than in men, partly because the recommendations do not differ between sexes[11]. The Scientific Advisory Committee on Nutrition (SACN) recommended that the DRV of dietary fibre be increased to 30 g/d as measured by international methods (an increase from 18 to 23 g/d of NSP by the Englyst method)[33]. In comparison with the proposed new reference values, only sixteen participants (eleven men and five women) or 2% would meet the DRV for dietary fibre (data not shown). CCP (half from bread) and vegetables (half from cruciferous vegetables and peas) together account for 64·3% of the NSP intake. Efforts to reduce the burden of constipation and increase NSP intake should focus on these food sources. The use of laxatives (bulk forming, stimulant or osmotic) was collected by the Newcastle 85+ Study and will be explored in a future publication.

Median NMES intake in the Newcastle 85+ Study exceeded the DRV for NMES of less than 11 % of dietary energy[11] and would exceed the SACN DRV for free sugars (or NMES) of 5 % of total EI[33]. This is a reflection of 89 % of men and 86 % of women who would exceed the new DRV (data not shown). These findings may be a concern because high NMES intake is strongly associated with dental caries in older people[34].

A plethora of socio-economic, biological and lifestyle characteristics change with advancing age, which may place very old adults at increased risk of poor nutrition. However, the lack of robustly based dietary recommendations for very old people limits our ability to interpret the dietary intakes of the Newcastle 85+ Study participants by reference to age-appropriate DRV. Given the projected increase in the numbers of very old people in the UK[3], filling this evidence gap should have high priority[35].

Malnutrition is prevalent among institutionalised older adults in the UK[36]. In our study, institutionalised participants had higher intakes of energy and percentage of energy from NMES, whereas NSP intake and percentage of energy from MUFA and PUFA were lower, compared with those living in standard housing. Despite the numerous challenges of dietary assessment in an institutional setting, a higher prevalence of disabilities in institutionalised than in non-institutionalised very old adults may explain these differences.

SES is frequently associated with diet quality and this was also seen in the Newcastle 85+ Study[23]. Participants who were more educated and from a higher social class (NS-SEC) had higher NSP intakes than those who were less educated and from a lower social class. Healthy behavioural habits tend to cluster together (healthier diet, higher physical activity, non-smoking, moderate or low alcohol intake)[37]. In the Newcastle 85+ Study, physically active 85-year-olds had a higher intake of NSP, MUFA, PUFA and protein than those with low physical activity.

Strengths and weaknesses

The Newcastle 85+ Study cohort was socio-demographically representative and included institutionalised and cognitively impaired very old (two commonly excluded characteristics in study samples). The participants were all from Newcastle upon Tyne and North Tyneside (mainly urban areas) and of a predominantly white background. Generalisations to other geographical locations and to populations with different ethnic makeup should be undertaken with caution. Adamson et al.[16] have described in detail the challenges of dietary data collection in the very old of the Newcastle 85+ Study, such as impaired cognition. Cognitive impairment at baseline was associated with misreporting (OR 1·61; 95 % CI 1·11, 2·33, $P = 0·012$), and our efforts to mitigate these limitations have been reported elsewhere[16].

Conclusion

EI in the Newcastle 85+ Study were relatively low, and only 20 % of the cohort had higher EI than the EAR. Median NSP intakes were very low, and the percentage of energy derived from SFA was high compared with the DRV. Although the low NSP intake is likely to contribute to the high prevalence of constipation in very old people, the health significance of the relatively high SFA intake in this age group is unknown. In general, the lack of robustly based dietary recommendations for very old people limits our ability to interpret the dietary intakes of the Newcastle 85+ Study participants by reference to age-appropriate DRV. It is essential that the very old are included in future nutrition studies to inform the development of new, age-specific DRV.

Supplementary material

For supplementary material/s referred to in this article, please visit http://dx.doi.org/doi:10.1017/S0007114516001379

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