British Journal of Nutrition (2007), **98**, 1046–1057
doi: 10.1017/S0007114507756520

Energy, macronutrient and fatty acid intake of French elderly community dwellers and association with socio-demographic characteristics: data from the Bordeaux sample of the Three-City Study

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(Received 10 November 2006 – Revised 4 April 2007 – Accepted 5 April 2007)

Few data are available regarding dietary habits of the elderly, in particular about fatty acid consumption, whereas these are major risk or protective factors of several age-related diseases. The aim of the present study was to characterise the dietary intake of a French elderly population in terms of energy, macronutrients and fatty acids based on their socio-demographic characteristics. The study population (age range 67·7–94·9 years) consisted of 1786 subjects from Bordeaux (France), included in the Three-City cohort. Dietary assessment was performed by a 24 h recall, allowing the estimation of energy, protein, carbohydrate, total fat, SFA, MUFA and PUFA intakes. Socio-demographic characteristics (age, sex, marital status, educational level and income), practice of sports and BMI were registered. Total energy intake (EI) was lower in women and in older participants (≥85 years) but higher in single subjects. Higher EI was associated with higher income, but not with educational level. Mean contribution of macronutrients to EI (protein 18 %, carbohydrate 46 % and total fat 31 %) was higher in women than men, except for alcohol. The oldest individuals consumed less protein and more mono- and disaccharides. Excess saturated fat intake (43 % of total fat), associated with a relative deficit in MUFA consumption (36 % of total fat), was observed. The mean 18 : 2*n*-6 : 18 : 3*n*-3 ratio was 9.9 and decreased with higher educational level. The present results suggest that being female, older age, being widowed and low income level could be considered as risk factors of inadequate dietary intake.

Cohort studies: Nutrition: Ageing: Fatty acids

The increasingly higher life expectancy observed in developed countries is in most part attributed to a decline of mortality at older ages. Besides considerable improvement in healthcare of older individuals, better living conditions and, in particular, healthy dietary practices, may explain this greater longevity[1]. In addition to the general recommendations for adults, the older population has specific nutritional requirements in order to avoid protein–energy malnutrition and also more subtle deficiencies due to imbalanced diets. In particular, there is a growing interest in the putative protective effects of *n*-3 PUFA against CVD[2], cancer[3] and neuro-psychiatric disorders[4], such as dementia[5] or depression[6], whose incidence sharply increases with age. The respective essential fatty acid precursors of the *n*-3 (18 : 3*n*-3; α-linolenic acid) and *n*-6 (18 : 2*n*-6; linoleic acid) families cannot be endogenously synthesised and must therefore be provided by diet. The dietary ratio of essential fatty acids (*n*-6 : *n*-3) must also be considered. This has led to the recommendation of about 2 % of total energy for adults provided by 18 : 2*n*-6, 1 % by 18 : 3*n*-3 and 0·3 % by EPA and DHA taken together (with at least 0·05 % each)[7,8]. Knowing that the biosynthesis of long-chain PUFA occurs only at a very low rate in young adults as in the elderly[9], and that experimental evidence indicates that the activity of the desaturase enzyme, which converts essential precursors in longer-chain PUFA, might be decreased in ageing[10,11], the needs for EPA and DHA must be mostly covered by way of diet. Therefore, the evaluation of the adequacy of fatty acid intake in the older population requires an estimation of the dietary intake of both precursors and long-chain PUFA. However, few data have been published regarding dietary fat intake of free-living elderly individuals and insufficient data are available on the actual intake of individual PUFA in human populations. Moreover, a good knowledge of dietary patterns is necessary to improve dietary counselling provided to high-risk individual groups whose characteristics have yet to be identified.

In France, where life expectancy is among the highest in the world[12], very few epidemiological studies have focused on nutrient intake of representative samples of elderly community dwellers. Surveys of the food habits of the French population

Abbreviations: EI, energy intake.

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were conducted in 1998–9 and in 2002 in representative samples but they did not include individuals over age 75 years[13]. The SU.VI.MAX study reported very detailed data on dietary fat intake of French adults but did not include subjects over age 60 years[14]. Therefore, we lack data on fatty acid intake of the elderly, whereas this might contribute to the particularly high life expectancy[15] and low CHD mortality rate observed in France (the so-called 'French paradox')[16].

The aim of the present study was to describe patterns of energy and macronutrient intakes and their link to socio-demographic characteristics in a population-based sample of elderly community dwellers in south-western France, with a special focus on dietary fat intake.

Subjects and methods

The data come from the Three-City Study, a prospective cohort study of vascular risk factors of dementia whose methodology is described in detail elsewhere[17,18]. The protocol of the Three-City Study was approved by the Consultative Committee for the Protection of Persons participating in Biomedical Research of the Kremlin-Bicêtre University Hospital (Paris, France). To be eligible for recruitment into the Three-City Study, individuals had to be (a) living in Bordeaux, Dijon or Montpellier (three French cities), (b) aged 65 years and over and (c) not institutionalised. A personal letter was sent to each potential subject inviting them to participate and including a brief description of the study protocol and an acceptance and refusal form. Subjects from the Bordeaux sample were randomly chosen from the electoral rolls of ten districts of the urban area of Bordeaux in order to ensure a representative socio-economical variability. Hence, a sample of 9294 community dwellers was selected in 1999–2000 from the electoral rolls of Bordeaux (*n* 2104), Dijon (*n* 4931) and Montpellier (*n* 2259). All participants signed a written consent. The baseline (wave 1) data collection included socio-demographic information, lifestyle, symptoms and complaints, main chronic conditions, neuropsychological testing, a physical examination and a blood sampling. The present study is based on the second wave (wave 2) of data collection conducted in 2001–2 in Bordeaux, which placed a particular emphasis on nutritional data.

Dietary assessment

In Bordeaux, 1811 individuals already visited at wave 1 participated in the nutritional survey included in wave 2 of the Three-City Study. We did not intend to be representative of the whole Three-City cohort but of the Bordeaux sample. All these participants were visited at home by one of the four specifically trained dietitians who administered a FFQ and a 24 h dietary recall during a face-to-face interview. These dietitians received a collective training and monitoring to optimise the standardisation of the nutritional interviews. The 24 h recall was used to estimate nutrient intake. During the 24 h recall the dietitian registered all the meals and beverages consumed in a period of exactly 24 h before the subject awoke on the day of the interview. No weekend day was recorded. Quantities were assessed according to a book of photographs[19] edited for the SU.VI.MAX study[20]. The book showed three portion sizes for each food and proposed two intermediate categories plus one below the smallest one and one above the largest one; i.e. seven portion sizes were available for each of the 236 foods or beverages. A table gave the correspondence between the portion size and the weight of the food item. Photographs of dishes and glasses with the corresponding volume were also available. The same dietitian then entered the data of the 24 h recall in the BILNUT® software (SCDA Nutrisoft, Cerelles, France) to obtain an estimation of the daily nutrient intake of each participant. Food composition tables for France[21] are included in the BILNUT® software. Detailed data for fatty acids from the food composition and nutrition tables edited by Souci *et al.*[22] were added. As the 24 h recall was open-ended, additional data were found by consulting a French table developed by the Institut National de la Santé et de la Recherche Médicale (INSERM) and the University of Montreal[23], the United States Department of Agriculture National Nutrient Database, on food packaging, and by contact with food manufacturers. Some specific data for fatty acids were directly provided by the Institut des Corps Gras – Centre Technique Industriel (ITERG) in Bordeaux.

The results are expressed in quantities and in proportion of total energy intake (EI) with or without alcohol. For fatty acids, results are also expressed in percentage of total fat.

As suggested by Willett *et al.*[24] the validity of dietary questionnaires was assessed by the evaluation of the association between total fat intake estimated from the 24 h recall and ln(TAG) assessed at wave 1[24].

Other variables

Age was recorded at the time of the dietary survey. Three age groups were defined as follows: less than 75 years, between 75 and 84 years and 85 years and over. Socio-demographic information recorded at wave 1 included sex and education (in four classes: no education or primary school only, secondary (middle) school, high school, vocational school or university). Socio-demographic characteristics also included marital status (married, divorced or separated, widowed, single), and income in five categories (less than €750, €750 to €1500, €1500 to €2250, more than €2250 per month and refuse to answer). Individuals who did not know their monthly income were added to the group of subjects who refused to answer this question.

Practice of physical exercise was assessed between waves 1 and 2 on a self-administered questionnaire by two questions: 'Do you practise sports?' (yes or no) and 'Do you perspire when you practise sports?' (never, sometimes, most of the time, always). A three-level variable was computed to describe intensity of physical exercise: no physical exercise (answer no to the first question); moderate intensity (answer yes to the first question and never or sometimes to the second one); high intensity (answer yes to the first question and most of the time or always to the second one). Subjects who did not answer the first question were represented in another group ('no answer').

Height (m) was measured at wave 1. Weight (kg) was measured by the dietitian at the time of the dietary survey. BMI was computed as the weight/height^2 ratio and then grouped in five categories (less than 21, 21–23, 23–27, 27–30 and more than 30 kg/m^2) according to Guigoz *et al.*[25] and Heiat *et al.*[26] as previously established by Deschamps *et al.*[27].

The calculation of the BMR (MJ/d) was predicted using Henry's equations based on age, sex and body weight[28]. For men aged 60–69·9 years, the equation used is BMR = 0·0543 weight + 2·37; for men aged 70 years and over, BMR = 0·0573 weight + 2·01. For women aged 60–69·9 years, the equation used is BMR = 0·0429 weight + 2·39; for women aged 70 years and over, BMR = 0·0417 weight + 2·41.

The macronutrient and fatty acid intakes were compared with the French RDA[8] and, for 20 : 5*n*-3, with the recommended levels of EPA intake of Simopoulos *et al.*[7].

Statistical methods

Intakes of energy and macronutrients were described by their mean, standard deviation, median and quartiles. The cross-sectional associations of total EI and nutrient intake with socio-demographic characteristics of the participants were assessed by Student's *t* test (when comparing two categories) or by ANOVA (when comparing more than two categories) followed by Dunnett's *post hoc* tests to compare means of categories with one of them taken as the reference group. Dunnett's statistical significance was accepted at $P < 0.05$. Stepwise backward linear regression was used to identify the socio-demographic variables associated with total EI. The normal distribution of EI was verified since the mean and the median were similar and the mean ± 2 SD included about 95 % of the total EI of the subjects.

The SAS statistical package (version 9.1; SAS Institute Inc., Cary, NC, USA) was used for these analyses.

Results

After exclusion of twenty-two participants who gave incomplete information on the 24 h recall and three with extremely low reported EI (less than 2000 kJ/d), the sample included 1786 participants aged 67 (range 67·7–94·9) years and over (62·7 % women, mean age 76·8 years and 37·3 % men, mean age 76·1 years). Their total EI based on their socio-demographic characteristics is given in Table 1. Men had a significantly higher EI mean than women (8389 *v.* 6335 kJ; $P < 0.0001$). Mean EI was significantly lower after age 85 years, for widowed individuals and for individuals with incomes below €750. Mean EI was significantly higher in participants with a higher educational level (significant Dunnett's tests).

The total EI was described based on BMI and the practice of physical exercise (Table 2). Weight and height data were absent in 152 subjects. In the remaining 1634 participants, total EI was not significantly different between the five predefined categories of BMI of the whole population, as was the case in men, although the EI was lower in the group of subjects whose BMI was the highest. However, the reported EI was significantly higher in women with BMI higher than 23 kg/m^2 (significant Dunnett's test). As expected, the mean EI significantly increased with the intensity of the practice of physical exercise.

Since all these socio-demographic characteristics are closely linked, they were entered as dummy explanatory variables in a multilinear regression model on total EI (Table 3). In the whole population, female sex and age 85 years and over were significantly related to a lower EI whereas being

Table 1. Total energy intake based on socio-demographic characteristics of elderly community dwellers from Bordeaux (France), 2001–2002

		Energy intake (kJ)						
Socio-demographic characteristic	*n*	Mean	SD	1st quartile	Median	3rd quartile	Range	*P*†
Total	1786	7100	2272	5427	6933	8556	2176, 16 900	
Sex	1786							< 0·0001
Men	666	8389	2243	6983	8242	9774	3046, 16 900	
Women	1120	6335	1912	5004	6130	7422	2176, 14 519	
Age (years)	1786							0·006
< 75 (reference group)	769	7259	2368	5494	7037	8719	2200, 16 900	
75–84	904	7025	2180	5418	6912	8460	2176, 15 322	
≥ 85	113	6594	2230	5050	6381	7858	2498, 13 146	*
Marital status	1782							< 0·0001
Married (reference group)	946	7506	2218	5895	7268	8941	2351, 15 322	
Divorced or separated	141	7054	2335	5197	7029	8510	2335, 13 644	
Widowed	577	6448	2155	4954	6121	7719	2176, 14 343	*
Single	118	7125	2410	5335	6979	8519	2402, 16 900	
Education	1777							< 0·0001
No or primary (reference group)	619	6791	2159	5243	6699	8021	2200, 14 975	
Secondary	479	7058	2163	5468	6933	8481	2276, 15 192	
High school	366	7234	2397	5456	7000	8749	2176, 16 900	*
University	313	7594	2389	5824	7385	9100	2347, 14 494	*
Monthly income (€)	1786							< 0·0001
< 750 (reference group)	139	6167	2008	4720	5996	7372	2200, 13 506	
750–1500	545	6736	2180	5188	6468	8000	2402, 14 518	*
1500–2250	434	7226	2234	5427	7058	8569	2176, 16 900	*
≥ 2250	519	7623	2322	5837	7456	9100	2598, 15 192	*
Refused to answer	149	7113	2297	5619	7004	8514	2276, 15 322	*

* Mean value was significantly different from that of the reference group ($P < 0.05$; Dunnett's test).
† By ANOVA comparing mean energy intake.

Table 2. Total energy intake based on body mass index and physical exercise of elderly community dwellers from Bordeaux (France), 2001–2002

		Energy intake (kJ)						
Variable	*n*	Mean	SD	1st quartile	Median	3rd quartile	Range	*P*†
BMI (kg/m²)	1634							0·10
All subjects								
< 21	181	7259	2293	5519	7063	8648	2874, 15 322	
21–23	249	7155	2167	5594	6945	8468	2176, 13 510	
23–27	669	7293	2222	5627	7138	8757	2347, 15 192	
27–30	322	7088	2406	5259	6837	8807	2276, 14 974	
≥ 30	213	6824	2289	5259	6586	8180	2335, 16 900	
Men	635							0·16
< 21	33	8502	2464	6895	8594	9464	3824, 15 322	
21–23	63	9067	2130	7372	8899	10 636	4912, 13 510	
23–27	294	8318	2113	7071	8167	9531	3046, 15 192	
27–30	164	8326	2310	6586	8230	9924	3339, 14 974	
≥ 30	81	8284	2351	6786	8138	9447	3230, 16 900	
Women	999							< 0·0001
< 21 (reference group)	148	6983	2167	5364	6908	8217	2874, 13 297	
21–23	186	6506	1766	5322	6280	7460	2176, 11 594	
23–27	375	6489	1958	5146	6381	7519	2347, 14 518	*
27–30	158	5803	1475	4481	5489	6971	2276, 11 184	*
≥ 30	132	5925	1724	4699	5636	6966	2335, 11 104	*
Physical exercise	1786							< 0·0001
No (reference group)	923	7004	2226	5343	6858	8297	2402, 16 900	
Moderate	288	7468	2435	5640	7205	8874	2176, 15 322	*
Intensive	122	7971	2469	6075	7598	9916	3230, 14 343	*
No answer	453	6824	2121	5268	6707	8196	2200, 14 974	

* Mean value was significantly different from that of the reference group ($P<0{\cdot}05$; Dunnett's test).
† By ANOVA comparing mean energy intake.

single, having a monthly income greater than €2250 or unknown were associated with a higher EI. There was no significant association of EI with educational level. The model explained 20 % of total variance of EI (adjusted R^2). Given that dietary intakes of men are significantly higher than those of women, we performed the analyses of the association between EI and socio-demographic characteristics stratified by sex. As in the whole population, education was not associated with EI in men or in women. However, a significant interaction between sex and education ($P=0{\cdot}015$) was found. Although no significant association was observed for each educational level, the coefficients were in the opposite direction in men and women. Mean EI tended to decrease drastically with age in men whereas a lowest decrease was observed only in the oldest women. EI was significantly related to marital status in women, with a noticeable decreased intake in widowed women. The association between income and EI showed similar trends in men and women.

In comparison with the recommendation concerning EI (125 kJ/kg per d), 73·1 % of the subjects on average, and mainly women, had an insufficient daily EI (70·4 % of men *v.* 74·8 % of women; $P=0{\cdot}046$). This proportion did not vary significantly between the three age groups defined previously (ANOVA; $P=0{\cdot}57$). The total reported EI was lower than the estimated BMR for 20·2 % of men and 27·2 % of women.

Intake of macronutrients based on sex is given in Table 4. The macronutrient intakes expressed in g/d were all significantly different between men and women. Men had a higher intake of every macronutrient in terms of quantities but, when expressed in proportion of EI, they had a lower intake of protein ($P<0{\cdot}0001$), carbohydrate ($P<0{\cdot}0001$), with significant differences between the mono- and disaccharide and polysaccharide intakes, and total fat ($P=0{\cdot}017$), mainly saturated fat ($P=0{\cdot}006$). Concerning alcohol, men had a higher alcohol intake ($P<0{\cdot}0001$) than women as expressed in g/d or in proportion of EI. Alcohol was an important component of total EI since the mean daily intake of alcohol was 21·6 (range 0·0–115·2) g in men and 6·9 (range 0·0–76·8) g in women. In men, 70·5 % of proteins were of animal origin *v.* 72·1 % for women ($P=0{\cdot}007$).

Table 5 reports the intake of macronutrients based on age in three groups. Mean consumption of alcohol was not different between the three age groups ($P=0{\cdot}19$). The intake of macronutrients expressed in proportion of EI based on age in three groups showed that protein intake decreased with age (ANOVA; $P=0{\cdot}007$) notably after 85 years (significant Dunnett's test). This is particularly true for proteins of animal origins (ANOVA; $P=0{\cdot}013$) but less marked for the proteins of vegetable origins (ANOVA; $P=0{\cdot}044$). Furthermore, there was no difference in total carbohydrate intake between the three age groups (ANOVA; $P=0{\cdot}12$). Nevertheless, the consumption of mono- and disaccharides significantly increased with age (ANOVA; $P=0{\cdot}001$), notably after 75 years (significant Dunnett's test). The consumption of carbohydrates (46 % of EI on average) was below recommended levels (about 50 to 55 % of daily total EI provided by carbohydrates) for almost 63 % of the subjects. Concerning fat intake, there were no significant differences between the three age groups in terms of total fat, saturated fat, MUFA or PUFA intake. As expected, the total fat intake reported at wave 2 was inversely linked to ln(TAG) levels (r −0·05; $P=0{\cdot}038$).

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Table 3. Influence of socio-demographic characteristics on total energy intake in a multilinear regression model in the whole study population of elderly community dwellers from Bordeaux (France) and stratified by sex (*n* 1773)

	Whole population			Men			Women		
Socio-demographic characteristic	β Coefficient	95 % CI	*P*	β Coefficient	95 % CI	*P*	B Coefficient	95 % CI	*P*
Sex									
Men (reference group)			< 0·0001						
Women	−1970	−2184, −1754	< 0·0001						
Age (years)									
≤ 75 (reference group)			0·08			0·11			0·10
75–84	−50	−250, 150	0·62	−309	−663, 45	0·09	142	−99, 383	0·25
≥ 85	−470	−882, −58	0·025	−617	−1389, 154	0·12	−330	−809, 148	0·18
Marital status									
Married (reference group)			0·002			0·64			0·001
Divorced or separated	391	3, 779	0·048	453	−419, 1325	0·31	262	−172, 696	0·24
Widowed	−123	−376, 131	0·34	147	−357, 652	0·57	−289	−585, 6	0·055
Single	572	154, 991	0·007	441	−634, 1517	0·42	448	−3, 899	0·051
Education									
No or primary (reference group)			0·86			0·10			0·37
Secondary	−2	−256, 251	0·98	−166	−658, 324	0·50	96	−193, 384	0·52
High school	107	−176, 391	0·46	363	−173, 899	0·18	−59	−388, 270	0·72
University	7	−316, 329	0·97	−232	−788, 324	0·41	291	−122, 704	0·17
Monthly income (€)									
< 750 (reference group)			0·064			0·66			0·21
750–1500	195	−195, 584	0·33	31	−1463, 1526	0·97	196	−189, 583	0·32
1500–2250	290	−142, 723	0·19	229	−1282, 1739	0·77	184	−273, 640	0·43
≥ 2250	521	58, 984	0·027	390	−1133, 1913	0·61	481	−24, 987	0·06
Refused to answer	587	91, 1082	0·020	560	−1072, 2192	0·50	483	−29, 995	0·06

Table 4. Macronutrient intake based on sex of elderly community dwellers from Bordeaux (France), 2001–2002 (n 1786)

	Intake (g/d)					Proportion of total EI (%)			Proportion of EI without alcohol (%)		
Nutrient	Mean	SD	1st quartile	Median	3rd quartile	Mean	SD	P*	Mean	SD	P*
Alcohol	12·4	16·2	0·0	7·2	19·2	4·7	5·8	< 0·0001			
Men	21·6	20·1	5·8	17·6	32·0	7·5	6·6		–		
Women	6·9	10·0	0·0	1·9	11·3	3·1	4·4		–		
Proteins	74·9	26·9	55·4	71·4	90·6	18·0	4·7	< 0·0001	18·9	4·9	0·067
Men	85·0	27·2	66·3	82·8	101·2	17·2	4·3		18·7	4·7	
Women	68·9	24·8	51·7	65·5	83·0	18·5	4·9		19·1	5·1	
Animal proteins	53·5	24·0	36·4	49·8	66·4	12·9	5·0	< 0·0001	13·6	5·3	0·009
Men	59·9	25·0	43·2	55·9	74·6	12·2	4·5		13·2	5·0	
Women	49·7	22·6	34·1	46·5	62·0	13·4	5·3		13·8	5·5	
Vegetable proteins	21·4	9·1	15·1	20·3	26·3	5·1	1·6	0·63	5·3	1·6	0·006
Men	25·1	9·2	19·2	23·9	30·1	5·0	1·4		5·5	1·5	
Women	19·2	8·2	13·6	17·7	23·4	5·1	1·7		5·2	1·7	
Carbohydrates	194·0	70·0	144·8	187·3	233·9	46·1	9·8	< 0·0001	48·4	9·5	0·96
Men	223·3	73·1	172·7	216·8	263·9	44·8	9·7		48·4	9·4	
Women	176·5	61·8	133·5	171·3	213·2	46·9	9·7		48·4	9·6	
Mono- and disaccharides	89·1	39·9	61·2	83·7	111·5	21·7	8·7	< 0·0001	22·7	8·8	< 0·0001
Men	96·1	44·3	64·0	89·9	121·0	19·5	8·2		21·0	8·5	
Women	85·0	36·4	59·0	80·3	106·3	23·0	8·7		23·7	8·9	
Polysaccharides	104·8	49·6	70·2	98·9	134·4	24·5	8·2	0·0003	25·7	8·4	< 0·0001
Men	127·2	51·1	92·9	122·3	155·0	25·4	7·6		27·4	7·7	
Women	91·5	43·5	60·9	87·3	114·8	24·0	8·4		24·7	8·6	
Total fat	59·4	27·5	40·5	54·1	74·4	31·1	8·7	0·017	32·7	9·0	0·30
Men	69·0	29·7	47·7	64·3	85·4	30·5	8·5		33·0	9·0	
Women	53·7	24·3	36·8	49·6	67·4	31·5	8·9		32·5	9·1	
Saturated fat	25·5	12·9	16·1	23·2	32·6	13·3	4·6	0·006	14·0	4·8	0·88
Men	29·5	13·8	19·7	27·4	37·6	13·0	4·2		14·0	4·5	
Women	23·2	11·8	14·9	21·1	29·6	13·6	4·8		14·0	4·9	
MUFA	21·2	10·9	13·4	19·0	27·6	11·1	3·9	0·30	11·6	4·2	0·10
Men	24·8	12·1	16·1	22·1	30·7	10·9	4·0		11·8	4·3	
Women	19·0	9·5	12·4	17·2	24·1	11·1	3·9		11·5	4·1	
PUFA	8·4	6·0	4·8	6·9	10·1	4·4	2·6	0·37	4·7	2·7	0·45
Men	9·8	6·6	5·8	8·3	11·9	4·4	2·4		4·7	2·6	
Women	7·6	5·5	4·4	6·3	9·0	4·5	2·7		4·6	2·8	

EI, energy intake.
* By Student's t test comparing alcohol and macronutrient intakes as proportions of energy intake with or without alcohol consumption between men and women.

The proportion of participants with a daily intake of proteins below the recommended value of 1 g/kg body weight per d was 44·1 % with a slight and insignificant difference between men (41·4 %) and women (45·7 %; $P=0·07$). There was no significant effect of age on this proportion (43·4 % of subjects under age 75 years; 43·9 % of subjects aged between 75 and 84 years and 50·5 % of those aged 85 years and over; $P=0·37$).

Fatty acid intake is described in Table 6. The main contributor to fat intake in proportion of EI was 18 : 1*n*-9 (oleic acid), followed by 16 : 0 (palmitic acid). The mean consumption of 18 : 2*n*-6 (3·35 % of EI) was just below recommended levels (4 % of EI) whereas the mean 18 : 3*n*-3 intake (0·40 % of EI) was half the recommendation (0·8 % of EI). The 18 : 2*n*-6 : 18 : 3*n*-3 ratio (9·90 on average) was twice as high as the recommended threshold of 5, which corresponded to approximately the first quartile. Concerning the long-chain *n*-3 PUFA, the intake of EPA (0·07 % of EI) was below recommended levels according to Simopoulos *et al.* (0·1 % of EI)[7]. Moreover, 61·6 % of the subjects consumed less than 50 % of the recommended DHA intake (about 0·05 % of EI); however, the mean consumption of DHA as a proportion of EI (0·15 %) was about three-fold above recommended levels. This intake of DHA highlights the great inter-individual variability observed, which is also shown for EPA but less obvious for 20 : 4*n*-6 (arachidonic acid).

The consumption of 18 : 2*n*-6 and 18 : 3*n*-3 PUFA and the 18 : 2*n*-6 : 18 : 3*n*-3 ratio based on socio-demographic characteristics are described in Table 7. There was no significant difference in the proportion of each *n*-6 and *n*-3 PUFA precursor as a proportion of EI according to sex, age group and education or income levels. Compared with married individuals, being widowed was significantly linked to a lower 18 : 2*n*-6 intake, but not to 18 : 3*n*-3 intake, as expressed as a percentage of EI (significant Dunnett's test). The 18 : 2*n*-6 : 18 : 3*n*-3 ratio was significantly associated with educational level (ANOVA; $P=0·011$), with a significant difference between the least educated participants who had the highest ratio and the subjects with secondary or high school, but not university, levels (significant Dunnett's test). The 18 : 2*n*-6 : 18 : 3*n*-3 ratio did not change according to sex, age, marital status and income. Concerning long-chain *n*-6 PUFA, the intake of 20 : 4*n*-6 (g/d) was lower in women than in men ($P<0·0001$) and significantly decreased as age increased (ANOVA; $P=0·011$). The intake of 20 : 5*n*-3 (g/d) significantly increased with higher income levels (ANOVA; $P=0·044$). When the long-chain *n*-6 or *n*-3 PUFA intakes were expressed as proportions of EI, there was no significant

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Table 5. Macronutrient intake based on age of elderly community dwellers from Bordeaux (France), 2001–2002 (*n* 1786)

	Intake (g/d)					Proportion of total EI (%)			Proportion of EI without alcohol (%)		
Variable	Mean	SD	1st quartile	Median	3rd quartile	Mean	SD	*P*†	Mean	SD	*P*†
Alcohol								0·19			
< 75 years	13·3	17·7	0·0	7·7	19·2	4·9	6·0		–		
75–84 years	12·0	15·3	0·0	7·4	19·2	4·7	5·6		–		
≥ 85 years	9·5	12·2	0·0	4·8	16·0	3·9	4·9		–		
Proteins								0·007			0·002
< 75 years	77·8	27·7	57·9	74·9	93·4	18·3	4·8		19·3	5·0	
75–84years	73·6	25·9	55·4	70·0	88·8	17·9	4·7		18·8	4·9	*
≥ 85 years	66·1	26·1	48·2	60·8	79·4	17·0	4·3	*	17·7	4·5	*
Animal sources								0·013			0·006
< 75 years	55·7	25·0	38·4	51·9	69·5	13·2	5·2		13·9	5·4	
75–84 years	52·7	23·1	35·6	49·6	65·1	12·9	5·0		13·5	5·2	
≥ 85 years	45·7	22·6	28·4	41·4	58·6	11·7	4·2	*	12·2	4·5	*
Vegetable sources								0·044			0·043
< 75 years	22·1	9·4	15·5	20·8	27·3	5·1	1·6		5·4	1·7	
75–84 years	20·9	8·8	14·8	20·0	25·5	5·0	1·5		5·2	1·6	*
≥ 85 years	20·5	8·4	14·2	19·6	26·2	5·3	1·6		5·5	1·7	
Carbohydrates								0·12			0·23
< 75 years	197·3	73·4	145·2	190·0	238·5	45·8	9·8		48·1	9·5	
75–84 years	192·0	67·5	145·0	184·3	231·4	46·2	9·9		48·4	9·8	
≥ 85 years	186·3	63·7	144·0	183·4	225·5	47·8	8·2		49·8	7·9	
Mono- and disaccharides								0·001			0·003
< 75 years	88·3	40·4	59·1	84·6	112·6	20·9	8·4		21·9	8·6	
75–84 years	90·0	39·7	62·3	83·0	111·6	22·1	8·9	*	23·1	9·0	*
≥ 85 years	88·3	37·5	63·7	82·0	103·4	23·4	8·8	*	24·2	8·7	*
Polysaccharides								0·08			0·06
< 75 years	109·0	51·7	72·7	101·8	138·8	25·0	8·1		26·2	8·3	
75–84 years	102·1	47·8	69·2	98·0	129·8	24·1	8·2		25·3	8·5	*
≥ 85 years	98·0	46·3	64·1	95·1	131·0	24·5	7·8		25·5	8·1	
Total fat								0·70			0·83
< 75 years	60·2	25·6	40·1	54·4	75·5	30·9	8·6		32·6	9·0	
75–84 years	59·3	27·5	40·8	54·2	74·4	31·3	8·9		32·8	9·3	
≥ 85 years	55·6	27·1	37·5	52·5	64·9	31·3	7·8		32·5	7·9	
Saturated fat								0·13			0·25
< 75 years	25·7	12·8	16·1	23·3	33·4	13·1	4·5		13·8	4·6	
75–84 years	25·5	13·0	16·2	23·3	32·5	13·4	4·7		14·1	4·9	
≥ 85 years	25·0	13·8	15·2	21·8	30·3	13·9	4·4		14·5	4·4	
MUFA								0·50			0·33
< 75 years	21·8	11·1	13·8	19·6	27·6	11·2	4·0		11·8	4·2	
75–84 years	20·9	11·8	13·3	18·7	26·2	11·0	3·9		11·6	4·1	
≥ 85 years	19·1	9·9	12·8	17·1	24·0	10·8	3·8		11·3	3·9	
PUFA								0·42			0·45
< 75 years	8·4	5·8	5·1	7·0	10·0	4·4	2·4		4·6	2·5	
75–84 years	8·6	6·3	4·6	6·9	10·2	4·5	2·8		4·7	2·9	
≥ 85 years	7·5	4·8	4·4	6·6	9·3	4·3	2·1		4·4	2·3	

EI, energy intake.
* Mean value was significantly different from that of the reference group (subjects aged less than 75 years) ($P < 0·05$; Dunnett's test).
† By ANOVA comparing alcohol and macronutrient intakes as proportions of EI with or without alcohol consumption among the three age groups.

association with the socio-demographic characteristics studied (data not shown).

Discussion

In the present cross-sectional study, we observed a significant association between total EI and several socio-demographic characteristics such as age, sex, marital status, levels of income, but not educational level, in a multivariate analysis. Despite an adequate intake of total fat, our findings indicate an excessive intake of saturated fat concomitant to a relative deficit of MUFA intake according to the current French recommendations. Being widowed was significantly associated with lower 18 : 2*n*-6 PUFA intakes as expressed as a percentage of EI. The 18 : 2*n*-6 : 18 : 3*n*-3 ratio was linked to education.

The accuracy of food-intake assessment is crucial in dietary studies[29,30]. In the present study, a single 24 h recall was used to assess the dietary EI as a surrogate measure of the total quantity of food intake even if this method presents limitations. Indeed, it cannot capture long-term dietary intake patterns for each subject because of high intra-individual variation. Thus, a reported single day of intake is unlikely to be representative of usual individual intake. However, if sample sizes are sufficiently large, it may be used to determine average intake in defined subgroups of a population[31]. Moreover, it is usually recognised that the mean total EI was generally underestimated with such methodology[32]. Indeed, we

Table 6. Fatty acid intake of elderly community dwellers from Bordeaux (France), 2001–2002 (*n* 1786)

	Intake (g/d)		Proportion of total fat intake (%)		Proportion of total energy intake (%)				
Fatty acid	Mean	SD	Mean	SD	Mean	SD	1st quartile	Median	3rd quartile
14 : 0	2·85	1·82	4·80	2·12	1·49	0·77	0·92	1·41	1·93
16 : 0	12·71	6·69	21·22	4·33	6·63	2·41	4·96	6·35	7·93
18 : 0	5·43	3·21	9·11	3·07	2·85	1·29	1·97	2·65	3·48
16 : 1*n*-7	1·53	1·60	2·49	1·79	0·78	0·67	0·48	0·65	0·89
18 : 1*n*-9	18·22	9·85	30·32	6·78	9·55	3·77	6·86	8·96	11·75
Total *n*-6 PUFA	6·55	5·27	11·15	6·51	3·44	2·36	2·00	2·79	4·07
18 : 2*n*-6	6·38	5·23	10·86	6·48	3·35	2·35	1·91	2·70	3·97
20 : 4*n*-6	0·16	0·17	0·29	0·34	0·09	0·09	0·02	0·06	0·13
Total *n*-3 PUFA	1·23	1·40	2·17	2·34	0·65	0·69	0·30	0·43	0·63
18 : 3*n*-3	0·78	0·80	1·30	0·84	0·40	0·32	0·25	0·33	0·44
EPA	0·14	0·34	0·26	0·66	0·07	0·18	0·00	0·00	0·05
DHA	0·28	0·69	0·54	1·35	0·15	0·38	0·00	0·02	0·10
18 : 2*n*-6 : 18 : 3*n*-3 ratio	9·90	7·05	–	–	–	–	–	–	–

observed a relatively high proportion of subjects who declared to consume less than 125 kJ/kg body weight per d. However, in only 4 % of men and 6 % of women, the reported EI was under 80 % of the estimated BMR. In other studies, the intakes recorded in reports were more than 20 % below the estimated BMR[33]. Nevertheless, the validity of the BMR estimation seems to be questionable in the sample studied of the very elderly[34,35].

Even so, mean total EI observed in this sample of French elderly community dwellers is very close to the figures reported in elderly participants (mean age 77 years) in the New Mexico Aging Process Study (8698 kJ (2079 kcal) for men and 6251 kJ (1494 kcal) for women), although the methodology of the dietary survey differed[36]. Furthermore, in the EPIC-Elderly study, Bamia *et al.* reported that among almost 100 000 individuals aged 60 years and over living in nine European countries, the mean EI estimated by FFQ ranged from 8135 to 10 820 kJ for men and from 5945 to 9439 kJ for women[37]. The mean EI estimated in the present study was also close to that observed by Drewnowski *et al.* in French community dwellers aged 65 years and over[38]. In addition, the food photographs, as used here, generally have a positive influence on the relative validity for absolute food group intake[39]. In the present study, the mean EI was positively associated with the intensity of the practice of physical exercise. Altogether, these observations allowed us to validate the methodology employed in the present study to estimate the mean EI and macronutrient intake for this group of elderly subjects.

The decreased mean EI in the oldest group might be due in part to dental and digestive disturbances which increase with age[40,41]. A decrease of perceived attractiveness of food with increased age in terms of taste, appetite and palatability of food was also commonly admitted[42,43]. As already observed in the literature[30,44], there was a trend to lowest EI for the subjects who had the highest BMI. The low energy reporters with high BMI may be individuals who have difficulties estimating their actual food intake. They are also more likely to be dieters or they tend to have higher levels of energy restraint[44,45]. Since the present study is cross-sectional, we cannot assert that the socio-demographic characteristics identified as markers of unbalanced dietary patterns are responsible for this poor dietary pattern. Moreover, the differences in mean EI with marital status described in this sample of subjects already enrolled in the Three-City cohort were expected. Indeed, according to the FFQ administered to all participants of the Three-City Study at wave 1, subjects living alone had poorer dietary habits[18]. However, the association between mean EI and educational level already demonstrated in the Three-City cohort at wave 1 disappeared in the present study when adjusted on the other socio-demographic characteristics. This result could be in part due to the association of income with EI because of the collinearity between income and educational level. The association between income and dietary habits was not assessed at wave 1 in the Three-City Study[18]. An association between energy density and diet cost was also demonstrated in a population of 837 French adults[46]. Altogether, these results obtained at wave 1 in the Three-City cohort and wave 2 in this Bordeaux sample suggest that these particular socio-demographic characteristics are associated with a specific dietary pattern. According to these studies and others, these lifestyle characteristics, which are known to be associated with age-related disorders such as cognitive decline or dementia[47], should be considered as potential confounding factors in the relationship between nutritional and pathological status in older individuals. However, since the present study is cross-sectional and because of the methodology employed, some associations between EI and socio-demographic characteristics could be due to chance findings. This could partly explain why some of these associations disappeared in men or in women when they were analysed separately by sex. Moreover, another explanation is that stratifying on sex may also have generated insufficient statistical power to detect associations.

In comparison with the French RDA[8], the food patterns in this sample of the French elderly seem to be low in carbohydrates, rich in proteins and acceptable for total fatty acids, yet showing an excess in saturated fat and deficiency in MUFA intakes. The decreased consumption of polysaccharides with age might be due in part to changes in behaviour with advanced age, suggesting that the elderly have a greater taste for sweet foods. A previous study on dietary patterns prevailing among the elderly across Europe reported that the 'sweet- and fat-dominated' diet reflected the choice of older

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Table 7. *n*-6 and *n*-3 Polyunsaturated fatty acid intakes and 18 : 2*n*-6 : 18 : 3*n*-3 ratio based on socio-demographic characteristics (sex, age, marital status, education, income) of elderly community dwellers from Bordeaux (France), 2001–2002 (*n* 1786)

	18 : 2*n*-6						18 : 3*n*-3						18 : 2*n*-6 : 18 : 3*n*-3 ratio		
	Intake (g/d)			Proportion of total EI (%)			Intake (g/d)			Proportion of total EI (%)					
Socio-demographic characteristic	Mean	SD	*P*†	Mean	SD	*P*†	Mean	SD	*P*†	Mean	SD	*P*†	Mean	SD	*P*†
Sex			< 0·0001			0·75			< 0·0001			0·92			0·54
Men	7·50	5·70		3·33	2·17		0·92	0·92		0·40	0·33		9·78	6·03	
Women	5·72	4·82		3·36	2·45		0·69	0·70		0·40	0·32		9·97	7·59	
Age (years)			0·30			0·43			0·15			0·29			0·70
< 75	6·36	4·98		3·29	2·19		0·78	0·76		0·39	0·30		9·75	6·50	
75–84	6·49	5·54		3·42	2·52		0·79	0·86		0·41	0·35		10·00	7·44	
≥ 85	5·69	4·33		3·21	1·96		0·64	0·42		0·36	0·18		10·19	7·42	
Marital status			< 0·0001			0·034			0·002			0·42			0·57
Married (reference group)	7·02	5·71		3·50	2·51		0·84	0·89		0·41	0·36		10·07	6·67	
Divorced or separated	5·91	4·04		3·20	2·02		0·75	0·58		0·40	0·28		9·41	6·48	
Widowed	5·52	4·70	*	3·16	2·22	*	0·70	0·73	*	0·39	0·29		9·66	7·79	
Single	6·17	4·37		3·22	1·95		0·68	0·39		0·36	0·18		10·08	6·60	
Education			0·90			0·07			0·15			0·95			0·011
No or primary (reference group)	6·42	4·91		3·55	2·49		0·73	0·67		0·39	0·29		10·64	7·87	
Secondary	6·26	5·05		3·27	2·12		0·78	0·74		0·40	0·29		9·45	6·58	*
High school	6·38	5·69		3·26	2·43		0·81	0·90		0·41	0·35		9·35	6·15	*
University	6·54	5·66		3·21	2·33		0·84	0·96		0·40	0·38		9·83	6·95	
Monthly income (€)			0·006			0·77			0·021			0·74			0·44
< 750 (reference group)	5·30	3·63		3·24	2·09		0·63	0·44		0·38	0·22		10·16	7·84	
750–1500	5·99	4·60		3·35	2·34		0·72	0·68		0·40	0·29		9·94	7·53	
1500–2250	6·71	5·39	*	3·45	2·36		0·80	0·83		0·40	0·31		10·13	7·19	
≥ 2250	6·82	5·68	*	3·34	2·41		0·83	0·86	*	0·40	0·36		9·89	6·44	
Refused to answer	6·37	6·32		3·18	2·44		0·86	1·03	*	0·43	0·40		8·89	5·92	

EI, energy intake.
* Mean value was significantly different from that of the reference group ($P < 0·05$; Dunnett's test).
† By Student's *t* test or ANOVA comparing mean 18 : 2*n*-6 : 18 : 3*n*-3 ratio or 18 : 2*n*-6 and 18 : 3*n*-3 intakes in g/d or as a proportion of total EI.

women with low educational achievement[37]. Indeed, a notably lower carbohydrate intake (38 to 40 % of EI) was observed in a population of younger French individuals[48]. The proportion of proteins was on average higher than the recommendation (about 10 to 15 % of total EI). In younger French adults, Czernichow *et al.* reported a similar protein intake (16 to 17 % of EI)[48]. However, the protein intake decreased with age and almost half of the population enrolled in the present study ate less than 1 g protein/kg body weight per d. Taking into account that lower weights were observed in the oldest group, these observations suggest that some protein–energy malnutrition occurs in the oldest individuals, putting them at risk of sarcopenia[49]. It is worth noting that foods from animal protein sources are generally high in fats, particularly in saturated fat and cholesterol. In the average French adult diet, 30 to 35 % of energy was estimated to come from total fat[8], which is the case in the population sample enrolled in the present study but notably lower than the values found in younger French adults where 36 to 40 % of EI comes from total fat in men and women aged no more than 65 years[14,48,50]. In the present study, as previously described by Willett *et al.*[24], an inverse association between the ln(TAG) and total fat intake was observed whereas the food questionnaire completion and blood collection were within 2 years of each other and not 1 year as Willett *et al.*[24] This result could be interpreted as a relative stability of dietary intake of the elderly during these 2 years. Concerning saturated fat, the consumption was almost twice higher than recommendations (8 % of EI) as already observed in the elderly[37] and also reported in the literature for French adult consumers[50]. According to these authors, the higher intake of saturated fat is largely the consequence of high intakes of butter, cheese, meat products and baked products. Indeed, 93 % of the population enrolled in the Three-City Study were regular consumers of dairy products[18]. Hence, the common opinion of the elderly French that 'there is no good meal without cheese' seems to be held in the population studied. Recent analysis on dietary habits among Americans reported that they consumed too much saturated fat, as was observed in the present study in French elderly individuals[51]. Moreover, we observed that the excess of saturated fat was associated with a relative deficit in MUFA consumption, compared with the dietary allowances (about 20 % of EI). Concerning PUFA, the intake of 18 : 3*n*-3, despite it being an essential fatty acid, was below the recommendations (about 0·8 % of EI) and quantitatively comparable with that observed by others in a younger French population[14]. As a consequence, the 18 : 2*n*-6 : 18 : 3*n*-3 ratio is fairly high (9·90 on average) and close to the ratio observed in younger populations[14]. The very large range of intake and the asymmetric quartiles of distribution for EPA and DHA have already been observed in various studies and countries[14]. Knowing that the main source of EPA and DHA is fish, a food not consumed daily in the Three-City cohort[52], this result might also be due in part to the single 24 h recall used which allows a good estimation of the mean but not of the variance of the consumption. The analysis of the FFQ assessed at wave 2 allowed us to ensure that in this sample the fish consumption frequency was linked to the estimated EPA and DHA intake (Spearman coefficient; r 0·16; $P<0·0001$). As well, the analysis of the FFQ allowed us to identify about 17·3 % of subjects who consumed only rarely (i.e. less than once per week) poultry or eggs which are rich in 20 : 4*n*-6. This pattern of food consumption could explain the large distribution of arachidonic acid intake observed in this sample of elderly and not mentioned by others in younger French populations[14]. Indeed, there was a significant correlation between the poultry or egg consumption estimated by FFQ and the 20 : 4 intake (Spearman coefficient; r 0·12; $P<0·0001$). Since essential *n*-6 and *n*-3 fatty acid intakes were below the recommendations and that the biosynthesis of long-chain PUFA occurs only at a very low rate and seems to decrease with age[10,11], the intake of long-chain PUFA seems to be insufficient for a non-negligible part of the sample compared with the recommendations. Moreover, the present findings indicate a statistical association between educational level and the 18 : 2*n*-6 : 18 : 3*n*-3 ratio in the elderly. A difference from 9·35 to 10·64 of this ratio between the lowest educated subjects and subjects with a higher educational level seems apparently too small to have any nutritional consequences. However, the effects of *n*-3 PUFA intake or educational level on age-related disorders such as dementia have already been demonstrated[2–6,53]. Likewise, marital status was associated with the intake of the precursor of *n*-6 PUFA. Knowing that the intake of long-chain *n*-3 fatty acids was correlated to indicators for healthy dietary habits[54], socio-demographic characteristics, such as marital status and education, associated with inadequate intake of fatty acids could be considered as markers of vulnerability in the elderly.

Thanks to the present cross-sectional study, it was possible to identify socio-demographic characteristics associated with quantitatively and qualitatively poor dietary patterns in a French elderly group. Older individuals at risk of malnutrition, mainly women, the very elderly, the widowed or single subjects, or individuals with low educational or income level, all of whom seem particularly vulnerable to age-related diseases, should be targeted for nutritional counselling. Our findings suggest that the elderly of southwestern France have an unbalanced fatty acid intake, characterised by, on average, an excessive intake of saturated fats related to a deficit of MUFA and PUFA, notably in *n*-3, intake.

Acknowledgements

The Three-City Study is conducted under a partnership agreement between the Institut National de la Santé et de la Recherche Médicale (INSERM), Victor Segalen – Bordeaux 2 University and the company Sanofi-Synthélabo. The Fondation pour la Recherche Médicale funded the preparation and beginning of the study. The Three-City Study is also sponsored by the Caisse Nationale Maladie des Travailleurs Salariés, Direction Générale de la Santé, Conseils Régionaux of Aquitaine and Bourgogne, Fondation de France, Ministry of Research-INSERM Programme 'Cohortes et collections de données biologiques'. The Conseil Régional d'Aquitaine also contributed to the funding of the dietary data.

C. F.'s research was sponsored by a grant from Conseil Régional d'Aquitaine. None of the authors had any financial or personal conflicts of interest. C. F. contributed to the analysis of data and the writing of the manuscript. M. A. J. contributed to the design of the experiment, collection of data and the providing of significant advice. S. L. contributed to

the design of the experiment and collection of data. L. L. contributed to the design of the experiment, collection of data and the providing of significant advice. C. D. contributed to the design of the experiment, and the providing of significant advice. N. C. contributed to the collection of specific data on fatty acids. P. B.-G. contributed to the design of the experiment, collection and analysis of data, and to the writing of the manuscript. All the authors made a critical revision of the draft.

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