

Daily protein intakes and eating patterns in young and elderly French

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An adequate level of protein intake is required to limit the gradual body protein loss observed during ageing. Different factors (cohort age, sex, life conditions) may modify protein intake and distribution. However the precise amounts, as well as their daily distribution which affects protein utilisation and N retention, are unknown in both young and elderly individuals. The hypothesis was tested that protein intake and its distribution over daily meals could be different between the young and elderly. The consumption of six different protein-rich food groups by 292 healthy individuals aged 20–30 and 65–75 years was determined throughout each day for 1 week. The data of the total protein intake and protein intakes at each meal were analysed by ANOVA for each sex separately, using age group as the independent factor. The average protein intake of men was lower in the older age group whilst the opposite trend was seen in women. The distribution of protein intake was different between the two age groups: 56.5% of the daily protein was eaten at lunch by the elderly but only 47% ($P < 0.0001$) by the younger subjects. In the elderly subjects, those eating larger amounts consumed a greater proportion of protein-rich foods at dinner than those eating small amounts (30.4 v. 26.2%, $P = 0.05$). A high level of protein intake was related to a higher meat-product consumption in both the elderly and young individuals. In conclusion, the pattern of protein intake differs significantly between age groups and sexes.

Protein: Eating patterns: Elderly: Young individuals

The loss in lean body mass is a common feature of ageing and is progressive in men from 30 years while it occurs more rapidly in post-menopausal women reaching about 20% in both sexes at 70 years of age (Cohn *et al.* 1980). Moreover, ageing is associated with a decline in homeostatic capabilities (Rolls *et al.* 1995). In the elderly, feeling hungry before eating is reduced (Clarkston *et al.* 1997), smell and taste are reduced (Schiffman, 1994) and satiety just after meals increases more slowly (Rolls *et al.* 1995). These changes may be partly explained by the fact that the adjustment of energy intake, following undernutrition or overnutrition, is less efficient (Roberts *et al.* 1994). Gastric emptying is also slower which may also affect the intake of the subsequent meals (Evans *et al.* 1981; Horowitz *et al.* 1984). These modifications in eating behaviour may have an impact in elderly subjects. Social factors could also play a part in eating behaviour. For example, 79% of French individuals believe that elderly individuals need to eat less food than younger individuals, and 20% of older individuals are convinced that

meat has to be cut out from their diet (IPSOS, 1996). Thus, the French elderly aged over 65 years consume less meat and less of other foods than younger individuals (Institut National de la Statistique et des Études Économiques, 1991). Such beliefs and behaviours might lead certain elderly individuals to become exposed to a risk of protein deficiency. One way to improve the assimilation of proteins without increasing the protein intake is to modify the pattern of protein digestion or protein intake during the day (Boirie *et al.* 1997). Arnal *et al.* (1999) have shown for elderly women that the daily eating pattern can influence protein metabolism. A protein pulse pattern, i.e. when 80% of the daily protein intake is given at midday, generated a positive and significantly higher N balance than the same quantity of protein intake spread over four meals. This suggests that a pulse intake could compensate for the low protein intake in elderly individuals by improving the anabolic response to protein intake. However, the optimum protein intake and the best daily pattern of protein intake in healthy elderly individuals

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are unknown. Previous studies, such as the 'Survey in Europe on Nutrition and the Elderly, a Concerted Action' (SENECA Investigators, 1991; 1996a), reported the overall protein intake of elderly individuals and the differences between men and women from different countries. Schlettwein-Gsell *et al.* (1999) reported that the most important characteristic of the southern European meal pattern was the large proportion of energy consumed at the midday meal by the elderly. There is no available information on the proportion of protein consumed at lunch, any differences in protein eating pattern, or the sources of dietary protein for different age groups. The present study aimed to answer three questions: (1) Does the protein eating pattern depend on sex and age group? (2) Does the distribution of protein intake at the main meals differ among young and elderly men and women? (3) Do the patterns of protein intake differ between consumers of small or large amounts of protein? To do this, a typical French population including young and elderly individuals was investigated for 1 week and their protein intakes as well as their protein eating patterns were determined.

Subjects and methods

Subjects

In January 2000, subjects were recruited locally using advertising in the press, displays in stores, direct recruitment at a technology show, and from a private database of postal addresses. The advertisements invited individuals between 20–30 and 65–75 years of age to participate in a survey dealing with eating habits. Those interested replied by telephone; suitable subjects were selected from these individuals. The percentage of subjects who actually accepted to complete the dietary survey was 71%. A total of 292 subjects took part in the present survey: sixty-three men of mean age 68.5 (SD 4.7) years; seventy-four women of mean age 68.3 (SD 4.5) years; sixty-nine men of mean age 25.6 (SD 3.7) years and eighty-six women of average age 24 (SD 2.9) years. They were not receiving medical treatment for any progressive illness. Anthropometric data (weight and height) were self-reported by the participants.

Experimental design

The consumption of protein-rich foods at each meal was assessed by questionnaire during seven consecutive days in spring 2000. The questionnaire, which was accompanied by instructions for completing it, comprised six headings, subdivided into several sub-headings. These were:

- dairy products (milk, hard cheese, soft cheese, yoghurt);
- meats (beef, pork, veal, lamb, horse, poultry, turkey, duck, rabbit, sausage, ham, dry-sausage, pâté, 'rillette', liver, kidney, black pudding, tongue, tripe);
- fish (cooked, breaded, smoked or canned) and shellfish (crabs, oysters, prawns, shrimps, mussels, squid);
- eggs;
- ready-made meals (pizza, quiche, couscous, paella, 'pot-au-feu', 'blanquette');
- starchy foods (bread, rusks, breakfast cereals, biscuits,

Viennese pastries, pasta, rice, peas, sweetcorn, potato, semolina, lentils, haricot beans, dried beans, soya).

The quantities of each food were assessed by the subjects themselves from photographic standards, designed specifically, validated and used in a large French epidemiological study (Guinot *et al.* 2001). All participants were contacted after having received the questionnaire and before beginning the study to make sure that they did not encounter any difficulty in completing it. This procedure was initially tested on ten elderly subjects in order to check that the questionnaire could be easily and correctly filled in. The subjects indicated their daily consumption for the three principal meals: breakfast, lunch and dinner and for any other snack meals. Protein intake was determined by using the Favier *et al.* (1995) table of food composition.

For each participant, other characteristics, such as living alone, income group and whether or not they were dieting, were recorded in order to compare both age groups and sexes.

Statistical analyses

The responses to questions about loneliness, income group and dietary practice were analysed by χ^2 tests to determine any effect of age group or sex.

For each sex separately, consumption was analysed for the effect of age group by a one-way analysis of covariance (SAS Institute, 1991) with the weight of the subject as a covariate. Subject weight was included as a covariate because of its variation within and between groups. This model examined type III sums of squares for age group, which give the sums of squares adjusted for the covariate. When consumption among groups differed significantly, the adjusted means were compared by LSMEANS test (SAS Institute, 1991).

The protein intakes at breakfast, lunch, dinner and as snacks, as percentages of total daily protein intake, were analysed by ANOVA (GLM procedure of SAS Institute, 1991) for each sex separately, using age group as the independent factor. Finally the protein eating patterns of subjects belonging to the lower and higher quartiles of their total daily protein intakes were compared in order to analyse the relationships between protein intakes and daily protein eating patterns.

Results

Social characteristics and diet practice

About 20% of participants lived alone. In elderly individuals, loneliness was more prevalent in women than in men (25 v. 6%, χ^2 9.8, $P < 0.01$) while it affected equally both young women and young men (19 and 22%, respectively). These percentages are slightly lower than in the SENECA Investigators (1991) study which showed that 9% of 70–75-year-old men and 38% of 70–75-year-old women lived alone in Europe. This difference could be explained by the age differences between these two studies.

The elderly participants had a higher income than the younger individuals (χ^2 31.1, $P < 0.0001$; Table 1).

Table 4. Distribution of protein intake throughout the day among young and elderly men and women*
(Mean values, standard deviations and ranges)

	Men						Women						Statistical significance: P
	Elderly (n 63)			Young (n 70)			Elderly (n 74)			Young (n 85)			
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	
Breakfast (%)	13.8	7.2	1.9-37.4	10.8	6.1	0.0-25.8	13.6	7.3	1.2-37.8	12.7	8.0	0.0-42.0	0.4300
Lunch (%)	56.3	8.2	31.9-84.0	44.7	7.9	18.4-63.3	56.7	9.6	31.4-86.4	49.4	10.9	3.7-76.9	< 0.0001
Dinner (%)	28.5	7.8	8.8-43.4	40.5	7.8	23.1-63.6	27.3	8.5	6.8-48.4	35.2	11.8	10.3-86.9	< 0.0001
Snack (%)	1.4	2.4	0.0-11.9	4.1	5.8	0.0-27.0	2.3	3.6	0.0-20.6	2.8	3.2	0.0-17.3	0.4100

* For details of subjects and procedures, see Tables 1 and 2 and p. 1108.

Differences in protein from dairy-product intake between age groups, which were smaller than those for meat or starchy products, occurred at dinner for the women and outside meal times (snacks) for the men. The elderly individuals favoured large protein intakes for lunch, being higher in percentage and also in quantity than those of the younger individuals. However eggs were an exception; the elderly individuals obtained only half as much protein from them at lunch as at dinner while the younger individuals obtained similar amounts at lunch and at dinner.

Having shown differences in protein eating pattern occurring between age and sex groups, the eating pattern intake in relation to the quantity of protein consumed was examined.

Protein eating pattern of the small and big eaters of proteins

In each age group, eating patterns were compared of the small eaters belonging to the lower quartile and the big eaters belonging to the higher quartile. (Small eaters had protein consumptions lower than 77.7, 62.7, 82.3 and 53.3 g/d for the older men and women, the younger men and women, respectively; big eaters had consumptions higher than 107.3, 85.2, 108.2 and 75.6 g/d for the older men and women, and the younger men and women, respectively.) The intake of protein varied by as much 100% between the small and big eaters (Table 5). Only for the elderly individuals was the daily eating pattern related to the level of protein intake. The elderly small eaters consumed a protein-lighter dinner (26.2 v. 30.4%, $P=0.05$; Table 5) and obtained less protein from meat products compared with the big eaters (31.3 v. 37.2%, $P=0.03$; Table 6). A difference in food choice between the small and big protein eaters was also observed in the younger subjects. The young big eaters consumed more of their protein from meat products (41.4 v. 32.7%, $P=0.007$; Table 6), and lower proportions from starchy foods, fish and eggs. However, their distributions between meals were the same.

Discussion

The present study showed that, first, protein intake, even when adjusted for a subject's weight, depended both on sex and age group with a lower intake in elderly men than in young men but a higher intake in elderly women than in young women. Second, a change in food eating pattern, shown by a larger lunch followed by a lighter dinner, occurred in old age. Third, the smaller proportions of protein eaten at dinner by the elderly small eaters distinguished them from the big eaters. These main results are discussed by comparing the present results concerning age effects with other human and longitudinal studies on rats, then by proposing hypotheses linked to physiology, beliefs, social characteristics, diet practices and to eating habits to explain the differences in food eating patterns between young and elderly individuals, and between elderly small and big eaters.

Considering age and sex in both human subjects (Garry *et al.* 1989; Hercberg *et al.* 1991; SENECA Investigators,

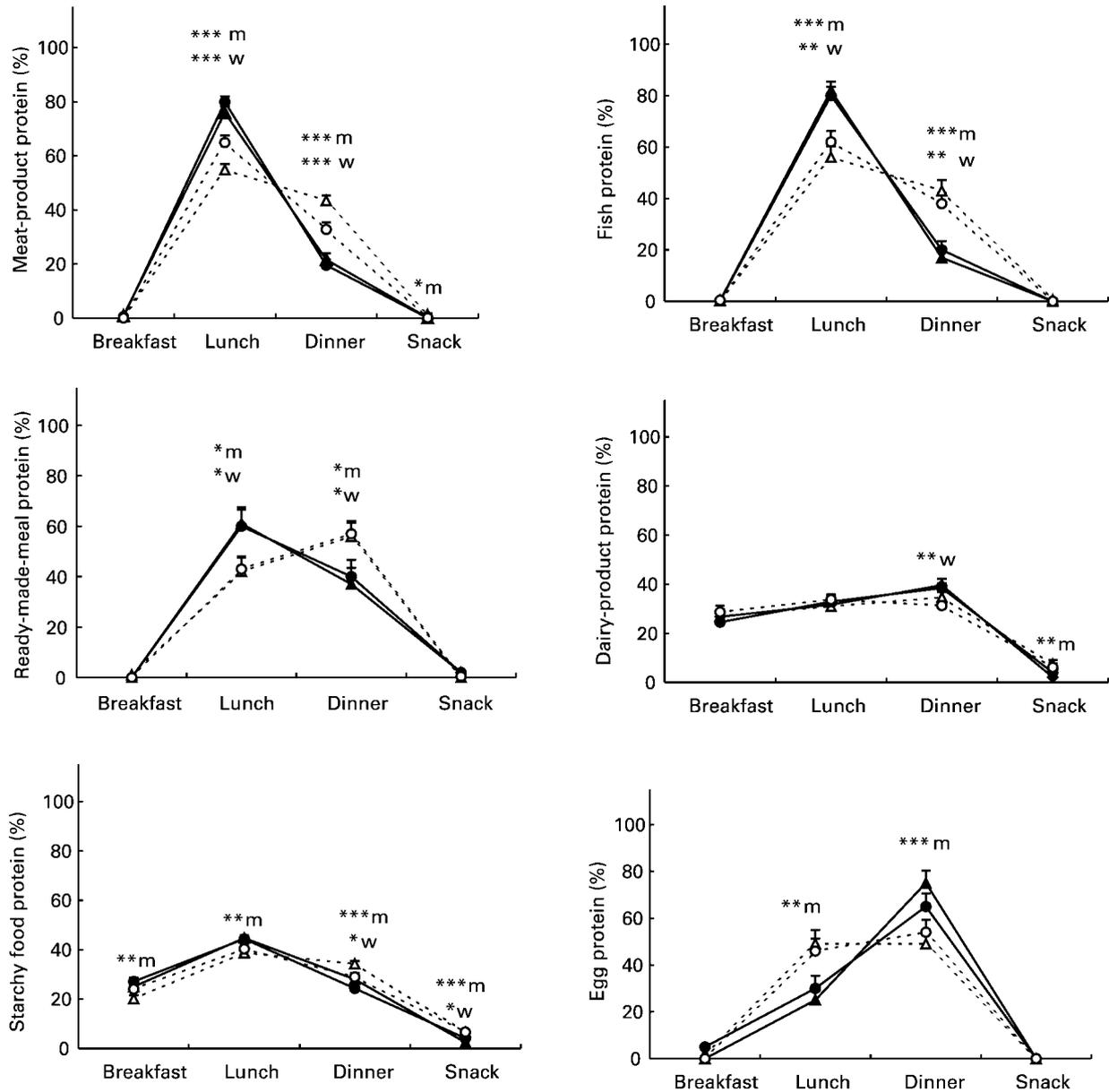


Fig. 1. Distribution of daily protein intake across meals for six types of food in older men (▲), young men (△), older women (●), and young women (○). Values are the mean percentages of protein intake in each meal, with standard errors of the mean represented by vertical bars. There were significant differences in consumption between young and elderly men (m), or between young and elderly women (w): * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

1996b; Veyrat-Durebex *et al.* 1998) and the Lou rat (Veyrat-Durebex & Alliot, 1997), protein intake has been found to be higher in males than in females and to decrease with age. Protein intake was maximum in male teenagers and young men then decreased with increasing age, while the decreased intake occurred later in women (Hercberg *et al.* 1991). Similarly Garry *et al.* (1989) also showed that ageing had less effect on energy and protein intake in women than in men when two age groups (60–72 and more than 73 years old) were compared in a cross-sectional study. When rats were used as animal models, Veyrat-Durebex & Alliot (1997) observed that the protein intake of male Lou rats decreased at 16–20 months in males but only at 28–32 months in females. Both animal and

human studies suggested this conclusion: males reduced their protein intake sooner than females.

Besides the physiological-requirement hypothesis, beliefs should also be considered. Thus, health beliefs and social influences predict current red-meat consumption, self-reported changes in red-meat consumption and intentions to make such reductions (Shepherd & Stockley, 1987; Sapp & Harrod, 1989; Contento & Murphy, 1990; Sapp, 1991). Moreover, elderly individuals believe that they should eat less meat because they think they have lower nutritional requirements than younger individuals (Rousset *et al.* 2002). On the other hand, red-meat consumption is also associated with the masculine stereotype (Adams, 1990) and might explain the low intake of young

Table 5. Size and distribution of daily protein intake of elderly and young, small and big eaters*
(Mean values)

	Elderly						Young								
	Small eaters			Big eaters			Small eaters			Big eaters			Statistical significance: P		
	Men (n 18)	Women (n 22)	Men (n 17)	Women (n 20)	Eater	Sex	Eater x sex	Men (n 18)	Women (n 23)	Men (n 20)	Women (n 23)	Eater	Sex	Eater x sex	
Protein intake at breakfast (%)	12.3	16.5	12.7	11.1	0.1300	0.4100	0.0700	10.4	12.4	9.5	14.1	0.7800	0.0400	0.4200	
Protein intake at lunch (%)	57.6	57.1	56.6	54.6	0.4100	0.5300	0.7100	44.4	51.4	45.2	50.4	0.9600	0.0100	0.7100	
Protein intake at dinner (%)	28.5	24.3	29.4	31.2	0.0500	0.5500	0.1300	41.3	32.8	40.1	33.8	0.9700	0.0050	0.6700	
Protein intake at snack (%)	1.8	2.0	1.2	3.0	0.7900	0.2000	0.3600	3.9	3.4	5.2	1.7	0.7900	0.0500	0.1500	
Protein intake (g/d)	62.6	55.3	117.6	96.9	<0.0001	<0.0001	0.0090	72.9	41.7	130.9	83.8	<0.0001	<0.0001	0.0020	
Protein intake (g/kg per d)	0.88	0.92	1.49	1.62	<0.0001	0.1700	0.5300	1.03	0.80	1.72	1.41	<0.0001	<0.0001	0.3900	

* For details of subjects and procedures, see Tables 1 and 2 and p. 1108.

Table 6. Percentage of total daily protein intake from different foods of elderly and young, small and big eaters*
(Mean values and standard deviations)

	Elderly						Young															
	Small eaters			Big eaters			Small eaters			Big eaters			Statistical significance: P									
	Men (n 18)	Women (n 22)	Men (n 17)	Women (n 20)	Eater	Sex	Eater x sex	Men (n 18)	Women (n 23)	Men (n 20)	Women (n 23)	Eater	Sex	Eater x sex								
Starchy foods (% of total protein)	26.4	6.1	25.9	7.8	28.4	7.8	21.8	7.3	0.50	0.03	0.08	26.1	8.3	26.0	10.5	22.4	4.9	23.1	6.1	0.05	0.87	0.80
Eggs (% of total protein)	3.4	1.8	2.9	2.7	2.6	2.2	1.8	1.3	0.05	0.17	0.83	2.7	3.2	4.1	4.3	1.2	1.3	2.3	2.2	0.01	0.05	0.79
Ready-made meals (% of total protein)	4.6	7.1	1.9	3.9	2.1	2.1	4.1	5.1	0.84	0.78	0.04	5.4	6.2	6.7	7.9	4.8	5.5	4.5	4.8	0.32	0.71	0.53
Fish (% of total protein)	11.5	10.6	13.3	9.2	7.8	4.4	11.3	6.1	0.13	0.15	0.65	8.8	6.5	14.2	13.5	6.4	3.7	9.0	7.7	0.05	0.04	0.48
Meat products (% of total protein)	33.9	10.1	28.7	14.4	38.7	9.4	35.7	12.2	0.03	0.013	0.69	38.8	16.3	26.6	18.9	43.8	9.8	39.0	10	0.007	0.008	0.24
Dairy products (% of total protein)	20.2	7.6	27.3	10.9	20.4	8.1	25.3	7.5	0.70	0.004	0.55	18.2	10.6	22.4	13.1	21.4	7.7	22.1	8.7	0.53	0.30	0.44

* For details of subjects and procedures, see Tables 1 and 2 and p. 1108.

women more influenced by that stereotype than their older counterparts. Thus, the lower protein intake in the young women compared with their older counterparts could be explained by their motivation to restrict their overall food intake and maintain a low body weight in order to project a feminine social identity (Chaiken & Pliner, 1987; Pliner & Chaiken, 1990). Moreover, in the present study dietary practices may be related to income and lifestyles. A low income, loneliness or dieting may be associated with lower protein consumption. However, as income was higher in the elderly individuals, it is unlikely to have been responsible for the lower protein consumption in the old men compared with the young men. Loneliness could not have had a significant influence on the eating pattern of the old men since fewer of them lived alone than the young men or old women. Low-cholesterol diets usually lead to a decrease in the consumption of fat and therefore processed meats, cheese or fatty foods and may be accompanied by a reduction of the protein intake. Three times as many old men were on such a diet than younger men. Furthermore, most of the dieting old men had not decided it for themselves but were under a doctor's instructions. McIntosh *et al.* (1995) showed that old men were more likely to reduce their red-meat consumption than old women because of mass-media and physician influences. This could partly explain the lower protein intake of the old men compared with the younger men in the present study.

Another interesting result concerns the daily protein distribution, as it was different in the elderly compared with the younger individuals. Lunch was the main protein meal for the elderly individuals while for the younger individuals protein intake was similar at lunch and dinner. The proportion of energy taken at lunch also tends to increase in French women over 60 years (Vincent *et al.* 1997). The small dinner of the elderly individuals could be explained by the delayed satiating effect of the protein intake at lunch as a pulse protein intake which affects energy intake of the subsequent meal in human subjects and in rats (Booth *et al.* 1970; Geliebter, 1979; Rolls *et al.* 1988). As gastric emptying, which is related to satiation (Bergman *et al.* 1992), is slower in elderly individuals, they may be less hungry at dinner. Such a pulse protein intake pattern was also shown to be more efficient in improving or restoring the N balance after a low protein intake than was spreading protein intake over four meals (Arnal *et al.* 1999). Thus a pulse meal would appear to increase circulating amino acids which reduce protein catabolism and increase protein synthesis. Furthermore, a dinner low in protein reduces post-absorptive protein losses. There is an advantage in elderly women to take a pulse protein eating pattern at lunch but no positive effect on N balance was demonstrated in young women (Arnal *et al.* 1999).

Other studies have shown that eating patterns depend on food habits, which differ between European countries (Schlettwein-Gsell *et al.* 1999). This 'Survey in Europe on Nutrition and the Elderly, a Concerted Action' study of elderly European individuals showed that, together, afternoon and evening energy intake was, on average, less than 40% of total daily intake and was as low

as 27% in Poland and 30% in France, where cooked midday meals predominate. This compared with 50% in The Netherlands where bread-based meals are usually eaten for lunch. Soup, a low-protein meal, is the main constituent of the evening meal in eight out of nine southern European towns. Eating habits are also influenced by the different lifestyles of young and elderly individuals. Young individuals are more constrained to eat outside for lunch than the elderly living at home. They are impelled to eat more at dinner because lunch is often taken quickly and outside home (Hoint, 1987).

The protein distribution between lunch and dinner was even more marked in the elderly small eaters. Thus, the elderly female small eaters ate proportionately less protein at dinner than the big eaters (24.3 v. 31.2%). In the elderly, the smaller the total intake of protein the higher was the imbalance between lunch and dinner intakes. A richer protein lunch followed by a poorer protein dinner might be an eating behaviour adaptation to the loss of appetite and to the alteration in protein anabolism in elderly compared with young adults (Arnal *et al.* 1999, 2000). Moreover, other macronutrients such as carbohydrates, found in fruits and in vegetable soup and consumed at dinner, would limit the protein loss in the post-absorptive period (Pacy *et al.* 1994).

In conclusion, the present study clearly indicates, for the first time in France, that protein eating patterns differ between young and elderly subjects, between young men and women, and with the amount of protein intake. One of the challenges in understanding the regulation of food intake is to determine if there are any advantages in taking a protein-rich lunch by comparing morbidity criteria measured on elderly individuals. Such fundamental information is essential to establish nutritional requirements and to optimise the chronobiology of food intake. This information is important when designing strategies to maintain health and to prevent lean body-mass loss in the ageing population.

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