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ORIGINAL CONTRIBUTION

Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: scope for improvement

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Abstract

Purpose Adequate dietary protein intake is required to postpone and treat sarcopenia in elderly people. Insight into dietary protein intake in this heterogeneous population segment is needed to locate dietary inadequacies and to identify target populations and feeding strategies for dietary interventions. Therefore, we assessed dietary protein intake, distribution of protein intake throughout the day, and the use of protein-containing food sources in community-dwelling, frail, and institutionalized elderly people in the Netherlands.

Methods Secondary analyses were carried out using dietary data collected from studies among community-dwelling, frail, and institutionalized elderly people to evaluate protein intake characteristics.

Results Dietary protein intake averaged 1.1 ± 0.3 g/kg-bw/day in community-dwelling, 1.0 ± 0.3 g/kg-bw/day in frail, and 0.8 ± 0.3 g/kg-bw/day in institutionalized elderly men. Similar protein intakes were found in women. Ten percent of the community-dwelling and frail elderly and 35% of the institutionalized elderly people showed a protein intake below the estimated average requirement (0.7 g/kg-bw/day). Protein intake was particularly low at breakfast in community-dwelling (10 ± 10 g), frail (8 ± 5 g), and institutionalized elderly people (12 ± 6 g) with bread and dairy products as predominant protein sources.

Conclusions Whereas daily protein intake is generally well above the recommended dietary allowance in community-dwelling and frail elderly people, a significant proportion of institutionalized elderly showed an intake below the current protein requirement, making them an important target population for dietary interventions. Particularly at breakfast, there is scope for improving protein intake.

Keywords Skeletal muscle mass · Sarcopenia · Frail · Institutionalized · Nutrition · Aging

Introduction

Sarcopenia, the age-related loss of skeletal muscle mass and strength, is accompanied by a decline in functional ability that affects many aspects of life [3]. Sarcopenia is a process caused by a combination of factors, which include a sedentary lifestyle and an inadequate dietary protein intake [22, 37]. In both young and elderly people, dietary protein intake stimulates skeletal muscle protein synthesis and inhibits protein breakdown, resulting in a positive protein balance [23, 32, 33] and net muscle protein accretion [5, 41]. Although results of acute studies show anabolic properties of dietary protein, so far, most dietary intervention studies that supplemented dietary protein for several months have failed to observe

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measurable gains in skeletal muscle mass in elderly people [13, 16, 39, 42, 43]. The absence of any apparent benefits of long-term protein supplementation might be attributed to a less than optimal feeding regimen. Various dietary protein intake strategies have been proposed. It has been suggested that the total amount of protein ingested is of importance to maintain skeletal muscle mass in elderly people. It has been reported that elderly people lose substantially less lean and appendicular lean body mass over time when consuming 1.2 g dietary protein per kg bodyweight per day (g/kg-bw/day) when compared with a dietary protein intake of 0.8 g/kg-bw/day, i.e., the current recommended dietary allowance (RDA) [17]. Besides the importance of total daily protein intake, the amount of protein ingested at each meal is of relevance [31]. Previous studies show similar postprandial skeletal muscle protein synthetic responses between young and older individuals after ingesting a large bolus of dietary protein [24]. Smaller amounts of dietary protein, however, have revealed an attenuated postprandial skeletal muscle protein synthetic response in elderly people when compared with young individuals [19, 34]. In addition, it has been suggested that protein intake distribution throughout the day might be of importance for daily net protein balance. For example, Arnal and coworkers suggested that feeding dietary protein in pulses improves nitrogen balance more than feeding dietary protein spread over a variety of small meals throughout the day does [2]. Finally, evidence has emerged to suggest that the type, i.e., source, of protein consumed, may modulate the skeletal muscle anabolic response to food intake [4, 21, 35]. Besides the fact that daily amount, distribution and/or source of dietary protein in nutritional intervention trials might not have been optimal to observe measurable gains in skeletal muscle mass in healthy elderly people, it has been suggested that the proposed positive effects of prolonged dietary protein supplementation are confined to specific elderly subpopulations, e.g. frail or institutionalized elderly people [42]. Unfortunately, detailed dietary protein intake characteristics among various elderly subpopulations are still lacking. Insight into these dietary protein characteristics is important to locate dietary protein inadequacies in this heterogeneous population segment and, as such, to define more effective countermeasures.

The present study was performed to assess daily protein intake, protein intake distribution, and the specific protein sources that are consumed in community-dwelling, frail, and institutionalized elderly people in the Netherlands. This study aims to locate dietary protein inadequacies and to identify target populations and feeding strategies needed to define more effective dietary interventions to postpone and treat sarcopenia in elderly people.

Methods

Data collection

We used data from four previously performed studies among community-dwelling, frail, and institutionalized elderly people. Data of apparently healthy community-dwelling elderly people were derived from the most recent Dutch National Food Consumption Survey (DNFCS) conducted in 1998 [18]. A total of 707 elderly men and women, who lived independently, were stratified into two age-groups: 65–74 years and 75–97 years. Dietary intake data were randomly collected during the week using 2-day food records. Data of frail independently living elderly people ($n = 194$) came from baseline data of a randomized placebo controlled trial, conducted in 1997, aiming to improve physical and mental health [9, 11]. Criteria for frailty in this study were age $\geq$70 year, requiring healthcare, physical inactivity and self-reported body mass index (BMI) of $\leq$25 kg/m^2 or recent involuntary weight loss. Dietary intake data were obtained by trained dieticians using 3-day food records collected on two nonconsecutive weekdays and one weekend day. Data of the institutionalized elderly people were derived from baseline dietary assessments of two intervention studies. The first study, INST-1 ($n = 60$), investigated the effect of supplementation on nutritional status and physical performance [27]. The second study, INST-2 ($n = 216$), was designed to investigate the effect of ambiance during mealtimes in Dutch nursing homes [30]. The latter study selected elderly people who were housed in somatic wards. Dietary intake data were collected using 2-day food records in the INST-1 study and 3-day food records in the INST-2 study. In addition, subject characteristics including age, sex, physical activity, ADL performance, cognitive function, body weight, and BMI were used if available. Physical activity in the frail elderly population was measured using the validated Physical Activity Scale for Elderly (PASE) [44]. The PASE, with a score ranging from 0 to 400, is designed to assess activities commonly engaged by elderly people. In the elderly people of the INST-1 study, the activities of daily living (ADL) were analyzed according to the Barthel index [26]. The Barthel index is developed to measure the performance of ADL and uses a scale from 0 to 100. A higher score indicates better functional capacity. In addition, cognitive function was measured in the INST-1 study using the Dutch revision of the Alzheimer's Disease Assessment Scale (ADAS). ADAS consists of a noncognitive part and a cognitive part. The latter part is used in this study and referred to as ADAS-cog, consisting of 12 items with a total score ranging from 0 (no impairment) to 75 (severe impairment) [28, 38]. Furthermore, Mini-Mental State Examination (MMSE) scores (0-30) were reanalyzed in INST-1 study [14].

Calculation of dietary protein intake

Dietary intake data were coded (food intake, amount, and mealtime) and cross-checked by dieticians. Portion sizes were documented in household measures, whereby frequently used household measures were checked in all the studies. Energy and protein intakes were calculated with a computerized Dutch food consumption table. The DNFCS and the INST-1 study used the Dutch food composition table of 1996 and the FRAIL and INST-2 study used the Dutch food composition tables of 1997 and 2001. Dietary protein intake was calculated as follows: (1) total protein intake (g/day), (2) protein intake per kilogram body weight (g/kg-bw/day), and (3) percentage of energy from protein (en%). Furthermore, protein intakes (g) per mealtime moment, i.e., breakfast, lunch, dinner, and between meals (snacks), were calculated, and protein intake from specific food sources was assessed. Percentage of inadequate dietary protein intake in the community-dwelling, frail, and institutionalized elderly people was estimated using the cut-point method [12] based on the protein estimated average requirement (EAR) of 0.7 g/kg-bw/day.

Statistical analysis

Data analyses were performed using the SPSS statistical software package (version 15.0). Descriptives were used to derive the mean and standard deviations of baseline characteristics. One-way ANOVA was used to compare differences in energy and protein intake between community-dwelling, frail, and institutionalized elderly people. In case of a significant difference ($p < 0.05$) in energy and protein intake, Bonferroni's post hoc test was applied to locate these differences.

Results

Characteristics of the participants

Descriptive characteristics of the study populations are presented in Table 1. In the community-dwelling, frail, and institutionalized elderly groups, the majority were women (58–75%). According to the PASE, low average physical activity levels were found in frail men (65 ± 39) and women (63 ± 30). The Barthel index score was 71 ± 26 for both men and women in the institutionalized elderly people (INST-1), reflecting a reasonable level of independency in activities of daily living. Average ADAS-cog score was 18 ± 12 and average MMSE score was 21 ± 6 in institutionalized elderly people (INST-1).

Dietary intake

Lowest energy intakes were reported in institutionalized elderly people (5.8 ± 1.5–8.2 ± 1.6 MJ/day in men; 5.9 ± 1.6–6.2 ± 1.5 MJ/day in women), whereas community-dwelling elderly people showed the highest energy intakes (9.4 ± 2.4–9.5 ± 2.5 MJ/day in men; 7.5 ± 1.9 MJ/day in women).

Lowest dietary protein intakes were observed in institutionalized elderly people showing a mean intake of 56 ± 17 g/day for men and 55 ± 15 g/day for women in the INST-2 study. The highest protein intakes, which averaged 85.9 ± 23.9 g/day, were reported in community-dwelling elderly men (Table 2). Dietary protein intake, expressed as g/kg-bw/day, was 0.8 ± 0.3 g/kg-bw/day in institutionalized elderly people, 1.0 ± 0.3 g/kg-bw/day in frail elderly people, and 1.1 ± 0.3 g/kg-bw/day in community-dwelling elderly people. Dietary protein intake of the institutionalized elderly people was significantly lower than the protein

Table 1 Baseline characteristics of community-dwelling, frail, and institutionalized elderly people

	Community-dwelling		Frail	Institutional	
	DNFCS (n = 400) 65–74 years	DNFCS (n = 307) 75–97 years	FRAIL (n = 194)	INST-1 (n = 60)	INST-2 (n = 216)
Age (year)					
Men	69.1 ± 2.8	78.3 ± 3.1	79.3 ± 5.9	80.3 ± 7.6	78.7 ± 7.1
Women	69.4 ± 2.9	78.5 ± 3.9	77.8 ± 5.3	80.2 ± 6.5	81.1 ± 7.8
Weight (kg)					
Men	78.5 ± 10.4	77.5 ± 10.6	73.2 ± 8.3	78.1 ± 7.6	75.9 ± 13.4
Women	72.4 ± 13.3	70.1 ± 11.7	63.7 ± 8.7	64.4 ± 10.5	71.6 ± 17.4
BMI (kg/m^2)					
Men	25.4 ± 3.0	25.5 ± 3.1	24.3 ± 2.1	27.1 ± 3.9	22.7 ± 9.7
Women	26.8 ± 4.6	25.8 ± 3.9	24.5 ± 2.9	25.6 ± 3.8	27.2 ± 9.2

DNFCS Dutch national food consumption survey, *INST-1* intervention 1 among institutionalized elderly people, *INST-2* intervention 2 among institutionalized elderly people. Values are means ± SD

Table 2 Energy and protein intake in community-dwelling, frail, and institutionalized elderly people

	Community-dwelling		Frail	Institutional	
	DNFCS (n = 400) 65–74 years	DNFCS (n = 307) 75–97 years	FRAIL (n = 194)	INST-1 (n = 60)	INST-2 (n = 216)
Energy intake (MJ/day)					
Men	9.4 ± 2.4[a]	9.2 ± 2.5[a]	8.7 ± 2.0[a]	8.2 ± 1.6[a]	5.8 ± 1.5[b]
Women	7.5 ± 1.9[a]	7.5 ± 1.8[ab]	7.0 ± 1.5[bc]	6.2 ± 1.5[cd]	5.9 ± 1.6[d]
Protein intake (g/day)					
Men	85.9 ± 23.9[a]	81.9 ± 25.2[ab]	75.4 ± 21.3[b]	66.9 ± 18.8[bc]	56.3 ± 17.1[c]
Women	72.9 ± 18.2[a]	71.6 ± 18.8[a]	62.4 ± 14.9[b]	54.0 ± 12.9[c]	55.5 ± 15.4[c]
Protein intake (g/kg-bw/day)					
Men	1.11 ± 0.31[a]	1.07 ± 0.35[ab]	1.04 ± 0.29[ab]	0.86 ± 0.22[bc]	0.78 ± 0.28[c]
Women	1.03 ± 0.35[a]	1.05 ± 0.32[a]	1.00 ± 0.27[a]	0.85 ± 0.20[b]	0.81 ± 0.29[b]
Protein intake (en%)					
Men	15.8 ± 3.5[ab]	15.3 ± 3.2[ab]	14.8 ± 2.9[a]	13.9 ± 2.8[a]	16.4 ± 2.6[b]
Women	16.9 ± 3.9[a]	16.5 ± 3.5[ab]	15.3 ± 2.7[c]	15.0 ± 3.0[bc]	16.3 ± 2.5[ac]

DNFCS Dutch national food consumption survey, *INST-1* intervention 1 among institutionalized elderly people, *INST-2* intervention 2 among institutionalized elderly people, Values are means ± SD. Values with different superscript letters indicate significant differences in energy and protein intake of the elderly populations according to Bonferroni post hoc test ($p < 0.05$)

intake of community-dwelling elderly people ($p < 0.001$) (Table 2). Furthermore, 21% of elderly people in the INST-1 study and 35% of the elderly people in the INST-2 study had a protein intake below the estimated average requirement (EAR), whereas 10% of the community-dwelling and frail elderly people had an intake below this reference.

The distribution of protein intake across breakfast, lunch, dinner, and snacks times (i.e., in between meals) is presented in Fig. 1. Dietary protein intake at breakfast was 10 ± 10 g in community-dwelling, 8 ± 5 g frail, and 12 ± 6 g in institutionalized elderly people. During lunch, the community-dwelling elderly people consumed on average 27 ± 15 g protein per meal. Seventy percent of the community-dwelling elderly people consumed a bread containing meal, which contained 19 ± 9 g protein per meal during lunchtime (data not shown). When a hot meal was used during lunch, the average protein intake was 39 ± 16 g and 35 ± 9 g in elderly from the DNFC 65- to 74-year and DNFC 75- to 97-year studies, respectively. Frail elderly people consumed on average 18 ± 7 g of protein during lunchtime. In the institutionalized elderly people, the hot meal was consumed during lunchtime, resulting in 24 ± 8 g and 25 ± 8 g protein for the elderly people in, respectively, the INST-2 and INST-1 study. During dinnertime, the lowest protein intakes were found in the institutionalized elderly people because of the consumption of a bread meal.

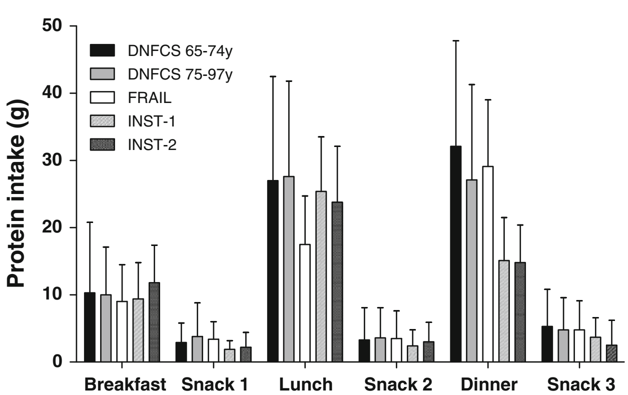

Fig. 1 Daily protein intake in grams distributed per mealtime in community-dwelling, frail, and institutionalized elderly people. *DNFCS* Dutch national food consumption survey, *INST-1* intervention 1 among institutionalized elderly people, *INST-2* intervention 2 among institutionalized elderly people. Values are means ± SD. Snack 1 represents protein intake between breakfast and lunch. Snack 2 represents protein intake between lunch and dinner. Snack 3 represents protein intake after dinner

During the day, mostly animal proteins (65%), especially from meat and dairy products, contributed to dietary protein intake (Table 3). During breakfast, 50% of the protein intake was derived from vegetable proteins in the community-dwelling elderly with bread as predominant source (41%). In the institutionalized elderly people, dietary protein was mostly derived from dairy products during breakfast (37% in the INST-1 study and 40% in the INST-2 study). During the hot meal, either served at lunchtime or at dinnertime, meat and dairy products prevailed. There were no gender differences in the distribution of protein intake and in the contribution of specific food sources to dietary protein intake.

Discussion

This study provides detailed information on dietary protein intake, the distribution of protein intake throughout the

Table 3 The 5 main food groups contributing to daily protein intake and protein intake during breakfast for community-dwelling, frail, and institutionalized elderly people

	Community-dwelling				Frail		Institutional			
	DNFCS 65–74 years		DNFCS 75–97 years		FRAIL		INST-1		INST-2	
	Food group	%	Food group	%	Food group	%	Food group	%	Food group	%
Daily protein intake	Meat	29	Meat	30	Meat	24	Dairy	24	Dairy	30
	Dairy	18	Dairy	19	Dairy	21	Meat	18	Meat	27
	Bread	14	Bread	15	Bread	15	Bread	13	Bread	12
	Cheese	9	Cheese	8	Cheese	10	Fish	8	Cheese	6
	Fish	5	Fish	5	Fish	4	Cheese	8	Vegetables	3
	Other	25	Other	23	Other	26	Other	29	Other	22
Protein intake during breakfast	Bread	41	Bread	42	Bread	43	Dairy	37	Dairy	40
	Cheese	21	Cheese	21	Cheese	23	Bread	30	Bread	26
	Dairy	15	Dairy	14	Dairy	18	Cheese	20	Cheese	15
	Meat	9	Meat	8	Cereals	3	Meat	6	Meat	9
	Eggs	4	Eggs	5	Eggs	3	Pastry	2	Eggs	5
	Other	10	Other	10	Other	10	Other	5	Other	5

DNFCS Dutch National Food Consumption Survey, *INST-1* intervention 1 among institutionalized elderly people, *INST-2* intervention 2 among institutionalized elderly people. Values expressed in % of daily protein intake and protein intake during breakfast

Meat represents meat, meat products, and poultry. Dairy represents milk and milk products with the exception of cheese. Other represents all other food groups contributing to protein combined

day, and intake of protein-containing food sources in community-dwelling, frail, and institutionalized elderly people. Dietary protein intakes are well above the RDA in community-dwelling and frail elderly people. In institutionalized elderly people, a significant proportion showed an intake below the average protein requirement, which makes them an important target population for dietary interventions. Dietary protein intake was particularly low at breakfast with bread and dairy as main protein sources.

A major strength of the present analysis is that dietary intake data were collected from well-characterized elderly population groups differing in health status. The community-dwelling elderly subpopulation represents apparently healthy, independently nationwide, living elderly people. This group was stratified into two different age-groups in order to allow comparisons with frail and institutionalized elderly people, similar in age but with a different health status. As compared to community-dwelling elderly people, frail elderly people had a worse health profile and a lower physical activity level (PASE score of 85 vs. 64) [40]. Considering and reflecting on the current widely used Fried criteria, we feel confident to have properly classified the population as being frail [1, 8, 15]. Institutionalized elderly people were described either as a borderline-demented or as a somatic disordered population [30].

For comparative purposes, the use of the same methodology is important. In our study, the same dietary assessment method, the dietary record, was used across studies. This method has been described as a suitable instrument for assessing energy and protein intake in elderly people [25, 36]. The latter has also been validated against urinary nitrogen studies in both community-dwelling and institutionalized elderly people [25]. Despite the similarity in dietary assessment method, a possible limitation might be the difference in number of days (2-day food records and 3-day food records). Additional analysis, however, showed no differences in the level of dietary protein intake between a 2- or 3-day assessment in both frail and institutionalized elderly (INST-2). Furthermore, variances of the protein intake in the different elderly subpopulations were equal, indicating a limited effect of the one day difference. Another limitation might be the use of different food composition tables across studies. As a result of updating food composition tables, composition of several products might have been changed. However, comparison between the food composition tables showed similar protein content of the various food products.

In our study, we observed the lowest average protein intake in the institutionalized elderly (0.8 ± 0.3 g/kg-bw/day). Thirty-five percent of this population reported a daily protein intake below the estimated average protein requirement of 0.7 g/kg-bw/day [10]. Yet on average, the protein intake equals the RDA of 0.8 g/kg-bw/day. It has been discussed that though the RDA for daily protein intake might be adequate to prevent deficiency in young adults, it may be insufficient to maintain health, including the preservation of skeletal muscle loss at a more advanced age [20, 31, 45]. Several experimental studies suggest greater needs for elderly people when compared with young individuals [6, 7]. Moreover, a prospective study among 2,066 community-dwelling elderly people suggests higher requirements, as a protein intake of 1.2 g/kg-bw/day was significantly associated with approximately 40% less loss of lean body mass and appendicular lean body mass when compared with a protein intake of 0.8 g kg-bw/day after a 3-year period [17]. In view of these considerations, institutionalized elderly people, with an average protein intake of 0.8 g/kg-bw/day, would be an important target population for dietary interventions aiming to slow down or counteract sarcopenia.

In addition to daily protein intake, dietary protein intake with each meal might be important to maintain skeletal muscle mass in elderly people. Paddon-Jones et al. suggested that 25–30 g of dietary protein per meal is required to maximally stimulate skeletal muscle protein synthesis [31]. Ingestion of smaller, meal-like amounts of dietary protein, i.e., less than 20 g, attenuated the skeletal muscle protein synthetic response in elderly people when compared with young individuals [19]. In our study, we observed average protein intakes less than 12 g at breakfast. The latter protein intake is substantially below the proposed minimum of 20 g. Therefore, increasing the amount of dietary protein at breakfast to at least 20 g might represent a promising dietary strategy to enhance the skeletal muscle protein synthetic response in elderly people.

Finally, the intake of specific protein-containing food sources might be of importance to modulate the muscle protein synthetic response [4, 21, 35]. In our study, 65% of daily protein intake was derived from animal products in all elderly subpopulations. Also, breakfast was relatively rich in animal protein sources, especially dairy (including cheese), egg, and meat sources. Though it is evident that the amount of protein during breakfast is too low to attain a maximal postprandial muscle protein synthetic response [29], more work is needed to define the preferred protein source(s) that should be used to optimize postprandial muscle protein synthetic response in elderly people.

In summary, institutionalized elderly people are an important target population for dietary interventions since a significant proportion of institutionalized elderly showed an intake below the average protein requirement. Improving dietary protein intake in the morning might represent an interesting strategy for dietary interventions aiming to postpone and treat sarcopenia in elderly people.

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