Low protein intake is associated with mortality in Brazilian older adults

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Abstract

Objective: To estimate the association between low protein intake and mortality in older adults. *Methods:* Prospective study carried out with 621 older adults in a medium-sized city (Viçosa, Minas Gerais) in Brazil. Protein intake was assessed at baseline (2009) by the usual intake recall and the protein intake classification was used as proposed by the Brazilian Society of Parenteral and Enteral Nutrition. Mortality data were collected in the follow-up period (2009 to 2018) from the Mortality Information System. Cox regression models were applied to estimate the independent association between total protein intake and mortality, and Hazard Ratio estimates and their respective 95% confidence intervals were calculated. *Results***:** Among the 621 participants in the study, 52.7% were female, and the prevalence of low protein intake was 60.9%. Over the 9 years of follow-up, there were 154 deaths (23,3%). In the adjust models, older adults with low protein intake showed increased risk of death [HR: 1.72; 95% CI: 1.05 - 2.82]. *Conclusion:* Low protein intake may increase the risk of death in the older adults.

Keywords: Proteins. Aged. Aging. Mortality.

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INTRODUCTION

Population aging is evident throughout the world. This scenario reflects achievements, but also involves numerous challenges regarding health because several physiological changes associated with the individual aging process, as well as socioeconomic determinants, can favor worse outcomes such as functional disability, frailty and mortality[1].

In this context, nutrition plays a central role in preventing and controlling health problems[2]. Among nutrients, protein plays an important role in the healthy aging process[3] as older adults are more leaning to malnutrition and anabolic resistance in muscle tissue, both related to insufficient levels of this nutrient[4].

There is evidence that low protein intake is associated with reduced lean mass and the risk of sarcopenia[5,6]. Sarcopenia is a growing global health problem, affecting 5 to 17% of individuals aged between 60 and 70 years and up to 50% of individuals over 80 years of age[7]. Furthermore, it is related to the occurrence of falls, favoring a reduction in functional capacity and quality of life, as well as higher mortality in older adults[5]. Despite this, few Brazilian studies have focused on the relationship between protein intake and health in the aged population.

Regarding the relationship between protein intake and mortality, international literature shows inconsistencies between study results. One study showed that older adults with higher protein intake had a lower risk of mortality[8], while another study showed that higher total protein intake was associated with higher all-cause mortality, with vegetable protein intake being inversely associated[9]. As far as it was possible to verify, there are no Brazilian studies on this topic.

Therefore, given the scarce number of studies carried out to date and their inconsistent results, it is important and timely to examine the relationship between low protein intake and mortality in older adults.

METHODS

The present study, with a prospective design, is part of a larger research on health conditions, nutrition and use of medicines by older adults in the municipality of Viçosa, a medium-sized Brazilian city located in the state of Minas Gerais. The eligibility criteria were older adults 60 or over, non-institutionalized and living in the urban and rural areas of the municipality in 2008.

The source population was identified based on a census of the population of older adults aged 60 years and over during the 2008 National Vaccination Campaign, whose vaccination coverage was 80%. From then on, the generated database was complemented with information from the municipality's occupational and health service registry bases, totaling 7980 individuals, who were organized in alphabetical order in the database.

The sample size was calculated considering a 95% confidence level, an estimated prevalence of 50% for different outcomes of interest to the larger project, a tolerated error of 4% and 20% for loss coverage. Based on these parameters, the expected final sample was 670 individuals. Participants were selected by simple random sampling from the previously mentioned database. Other details are described in Nascimento et al. (2012)[10].

Baseline data collection was carried out at the participant's home between June and December 2009. Data were collected through interviews and anthropometric assessments. Seven pairs of previously trained interviewers applied a semi-structured and pre-tested questionnaire covering sociodemographic information, health conditions, lifestyle and nutritional assessment.

In 2018, only death records of older adults participating in the baseline were collected through telephone calls, home visits and by consulting the municipality's Mortality Information System (SIM) databases.

Once the deaths were identified and compared with individual data from the questionnaire, the underlying cause of death was extracted from the SIM database. In cases of older adults not identified in the SIM, participants were contacted via telephone in order to update their survival status. In cases of finding information about death, a visit was scheduled with the family member/guardian of the deceased older adults to obtain information about the date, place of death and basic cause of death by consulting the Death Certificate. Data loss was considered when no information was obtained about the older adult or in the case of moving to Viçosa. The causes of death were classified according to the Tenth Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10)[11].

Daily protein intake was assessed only at baseline, through the application of a habitual intake record, using the multiple passage method[12] and with the aid of a photographic album of food portions. A single interviewer from each pair was previously trained and was responsible for applying the recall in order to promote precision in obtaining information.

The food consumption data described in household measurements were converted into grams (g) or milliliters (mL) after checking the information by the interviewer and a data collection supervisor. The estimation of food consumption and the macronutrient value of the foods consumed was carried out using the DietPro version 5i software. Daily protein intake was analyzed in grams per kilogram of weight (g/kg/day), using the adapted classification of protein intake proposed by the Brazilian Society of Parenteral and Enteral Nutrition (BRASPEN) (2019)[13]: inadequate intake (<1 g/kg/day) and adequate/high (≥1 g/kg/day).

Covariates were selected according to the literature. Sociodemographic variables included sex (male, female), age (60 to 69; 70 to 79 and 80 years or more), education (0; <4 years and >4 years of study). Behavioral variables were also collected, such as smoking (never smoked, ex-smoker and smoker) and health conditions such as number of hospitalizations in the last year (none; ≥1), number of diseases (<5; ≥5). Additionally, the total caloric value/day was considered. It was calculated from the sum of the macronutrient values; namely, for each 1 g of carbohydrate, proteins and lipids, 4kcal, 4kcal, 9kcal were considered, respectively.

Weight, height, waist circumference and leg circumference were measured for anthropometric assessment[14,15]. The Body Mass Index (BMI) was calculated as the ratio between weight and height squared and when above 28 kg/m^2 it was classified as overweight[16]. Abdominal obesity was classified by cutoff points for waist circumference values: normal (men <94 cm; women <80 cm) and increased (men ≥94 cm; women ≥80 cm)[15]. Cardiovascular risk was considered when the waist-to-height ratio (WHR) ≥0.5 for both sexes[17]. Muscle reserve was classified by leg circumference (LC) and considered low for values below 33 cm (women) and 34 cm (men)[18].

The data were presented through descriptive analysis based on measures of absolute and relative frequencies for qualitative variables and measures of central tendency (median) and dispersion (interquartile range, IIQ) for quantitative variables. The normality of quantitative variables was assessed using the Shapiro-Wilk test. Mortality was compared according to covariates using Pearson's chi-square test and linear trend chi-square test. Furthermore, a survival curve was generated to evaluate protein intake (inadequate/adequate) according to survival status.

Cox regression models were used to estimate the independent association between total protein intake and mortality, calculating hazard ratio estimates and their respective 95% confidence intervals. The proportionality of risk over time was assessed based on Schoenfeld residuals. Based on the literature and epidemiological and statistical criteria, confounding factors were considered in the models adjusted for variables (sex, age group, education, number of diseases, BMI, LC, smoking and total caloric value).

The analyzes were carried out considering a significance level of 5% to reject the null hypotheses.

The study was conducted in accordance with the principles established in the Declaration of Helsinki and approved by the Research Ethics Committee of the Federal University of Viçosa

(CAAE:69998517.0.0000.5153). All participants signed the free and informed consent form.

DATA AVAILABILITY

The entire dataset supporting the results of this study is available upon request from the corresponding author.

RESULTS

Of the 670 individuals initially planned for inclusion in the study, 621 individuals actually participated, as there were losses due to refusal (n=24, 3.6%), death (n=9, 1.3%), address not located (n=8, 1.2) and moving to another city (n=8, 1.2%). Losses did not differ according to sex and age.

Among the 621 baseline participants in the study, the majority of them (52.7%) were female, 50.7% of them were aged between 60 and 69 years old, and more than 64.0% of them presented less than four years of education. The prevalence of inadequate protein intake was 60.9%.

For 45 individuals it was not possible to obtain information on survival status, so longitudinal analyzes were performed for 576 participants. Over the 9 years of follow-up (2009-2018), there were 154 deaths (26.7%). Compared to older adults who survived, the majority of non-survivors were aged between 70 and 79 years (39.0%), had less than four years of schooling (70.6%), had a history of one or more hospitalizations (23 .4%), self-reported five or more diseases (40.3%) and were classified as having low muscle reserve (39.4%) (Table 1). Furthermore, the frequency of survivors was statistically lower among those with inadequate protein intake (<1.0 g/kg/day) (Figure 1).

According to the Cox regression, older adults with low protein intake had an increased risk of death in both the crude version [HR: 1.44, 95% CI: 1.02 - 2.02] and the adjusted version [HR: 1.72; 95% CI: 1.05-2.82] of the models (Table 2).

Table 1. Survival of older adults according to socioeconomic, behavioral, health and anthropometric characteristics. Viçosa, MG, Brazil - 2009 to 2018.

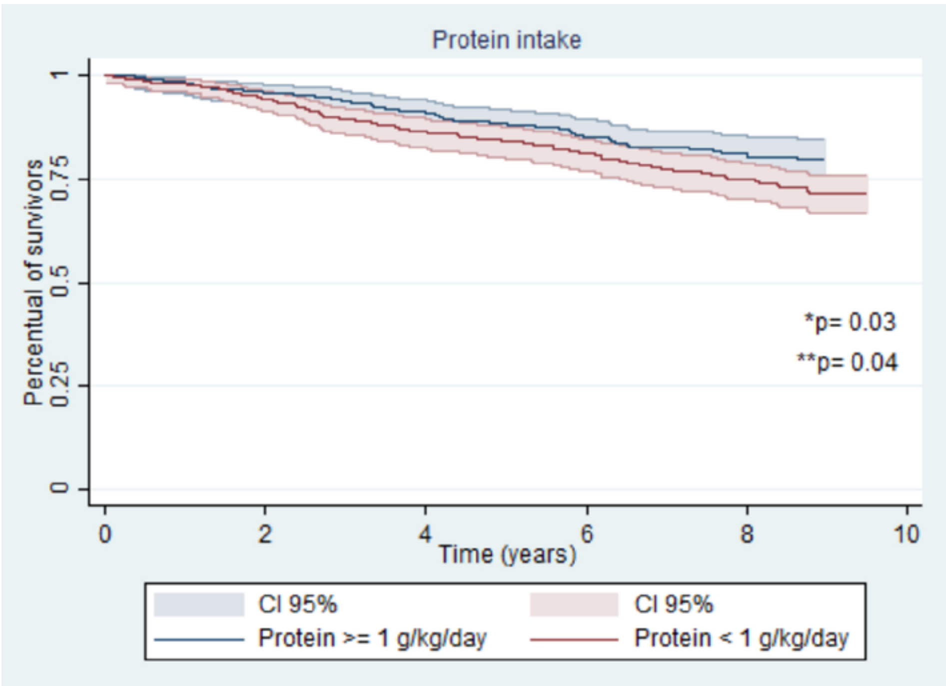
Characteristics	Total	Survivors	Non-Survivors	*p value*
	n (%)	n (%)	n (%)	
Sex (576)				
Female	272(47.2)	191(45.3)	81(52.6)	0.119*
Male	304(52.8)	231(54.7)	73(47.4)	
Age group (years)				
60 – 69	293(50.9)	252 (59.7)	41(26,6)	
70 – 79	197(34.2)	137 (32.5)	60(39.0)	<0.001**
≥ 80	86(14.9)	33 (7.8)	53(34.4)	
Education (complete years of study)				
0	89(15.5)	63 (14.9)	26(17.0)	0.030**
< 4	372(64.8)	264(62.6)	108(70.6)	
≥ 4	114(19.7)	95(22.5)	19(12.4)	
Cohabitation				0.273*
Only	58(10.1)	46(10.9)	12(7.8)	
Accompanied	518(89.9)	376(89,1)	142(92.2)	
Smoking				
Never smoked	333(58.0)	250(59.2)	83(54.6)	0.630*
Ex smoker	181(31.5)	129(30.6)	52(34.2)	
Smoker	60(10.5)	43(10.2)	17(11.2)	

to be continued

Continuation of Chart 2

Characteristics	Total	Survivors	Non-Survivors	*p value*
	n (%)	n (%)	n (%)	
Number of hospitalization in the last year				
0	487(84.7)	369(87.6)	118(76.6)	<0. 001*
≥ 1	88(15.3)	52(12.3)	36(23.4)	
Number of disease				
<5	415 (72.0)	323(76.5)	92(59.7)	<0.001*
≥5	161(28.0)	99(23.5)	62(40.3)	
Muscular reserve (LC)				
Low	146(25.4)	85(20.1)	61(39.4)	<0.001*
Ideal	430(74.6)	337(79.9)	93(60.4)	
Overweight (BMI)				
Yes	325(65.4)	247(62.4)	78(67.2)	0.338*
No	187(34.6)	149(37.6)	38(32.8)	
Abdominal obesity (WC)				
Increased	415(74.9)	320(76.6)	95(69.1)	
Normal	139(25.1)	98(23.4)	41(30.1)	0.117*
Cardiovascular risk (WHtR)				
Increased	464(91.9)	366(93.1)	98(87.5)	
Normal	41(9.1)	27(6.9)	14(12.5)	0.054*

p-value:* Pearson's chi-square test: ** Chi-square test for linear trend. BMI, body mass index; WC, waist circumference; LC, leg circumference; WHtR, waist-to-height ratio. Missing data for the following variables: education and hospitalizations (1), smoking (2), overweight (64), abdominal obesity (22) and cardiovascular risk (71).



*p=0.03 Log-rank test; **p=0.04 Peto-Peto Test.

Figure 1. Survival curves (Kaplan Meier) according to protein intake. Viçosa, MG, Brazil - 2009 to 2018.

Table 2. Hazard ratios and 95% confidence intervals for the association between total protein intake and mortality in older adults. Viçosa, MG, Brazil - 2009 to 2018.

Variables	Model 1	Model 2
	Hazard ratio (95%IC)	Hazard ratio (95%IC)
Protein intake (g/kg/day)		
Adequate/high	1.00	1.00
Inadequate	1.44 (1.02 – 2.02)*	1.72 (1.05 – 2.82)*

Model 1: crude model; Model 2: adjusted by age group, sex, education, number of diseases, body mass index, leg circumference, smoking status and total caloric value; *p<0.05. g - grass; Kg - kilogram; CI - confidence interval.

DISCUSSION

The findings of this study suggest that low protein intake among older adults was independently associated with a higher risk of death. This is the first Brazilian study with non-institutionalized older adults to identify this relationship.

Protein intake below the Dietary Reference Intakes (DRI)(<0.8g/Kg/day) can lead to malnutrition, reduce protein synthesis in older adults and cause physical limitations in mobility and coordination[19]. Older men with protein intakes below the DRI presented a higher risk of death from cancer compared to those with intakes greater than 1.0 g/kg/day. The authors concluded that, regardless of the protein source (vegetable or animal), low intake is associated with a higher risk of death, especially from cancer in older men[20].

A prospective study of 1,998 older adults aged 70 to 79 years over six years found that those with protein intake <1g/kg/day, categorized into protein intake <0.70 g/kg/day (HR: 1.86; 95% CI: 1.41-2.44) and <1g/kg/day (HR: 1.49; 95% CI: 1.20-1.84), presented an increased risk of limitation in physical mobility compared to those with intake ≥1g/kg/day[21]. Another study identified benefits of greater protein intake (>1g/kg/day), with individuals in this group having greater mobility and physical functionality of the lower limbs compared to those with low protein intake (<0.80 g/kg/day)[22]. In general, these results suggest that a higher protein intake can benefit older adults, contributing to improved muscle function and disease prevention, thus improving quality of life[23].

Several factors contribute to lower protein intake in older adults, such as changes in swallowing and appetite, presence of multimorbidities, tooth loss and compromised functional capacity[24]. Furthermore, polypharmacy is common among older adults[25], and some medicines can cause chemosensory disorders[25], including hypogeusia (decreased taste) and dysgeusia (distorted sense of taste)[26]. Consequently, they favor inadequate food consumption.

Additionally, it is known that income and education influence the quality of food consumption, which may compromise adequate protein intake. Due to socioeconomic conditions, for example, there may be a lower consumption of animal proteins among the older adult population, who end up having to buy low-cost foods with lower quality and quantity of proteins[27].

The consequences of low protein intake are harmful to the health of older adults. As their age advances, muscle mass is reduced, there is a reduction in postprandial amino acids and muscle uptake of ingested amino acids, which, among other factors, leads to increased protein needs[28,29]. When these needs are not met, protein-energy malnutrition can occur. This is a frequently identified condition in older adults that can lead to immunodeficiency and morbimortality[29,30].

This type of malnutrition causes an initial reduction in the metabolic rate, followed by the production of energy from adipose tissue and, subsequently, protein metabolism occurs, as well as the degradation of muscle tissue, resulting in weight loss[30], which favors the occurrence of countless unfavorable outcomes.

The set of these factors highlights the need for individual and collective interventions to guarantee the quality of nutrition for older adults and adequate protein intake for healthy aging.

Policies to promote food and nutritional security focusing on the particularities of population aging are essential. Moreover, nutritional care can focus on guidance on food sources of protein, considering substitute sources as lower-cost options. It is also important to highlight that adequate protein intake encompasses issues of quantity and quality of the protein to be offered, as well as the distribution of these protein sources between meals. This reinforces the importance of nutritional care in the health care in older adults. Finally, the combination of good protein intake with regular physical activity, including resistance exercise, can contribute to the maintenance of muscle mass and strength[31].

A strength of this study consists of the longitudinal analysis, with control for confounding factors in a representative sample of the older adult population. On the other hand, its main limitation is the fact that protein intake was measured at a single moment, not allowing to infer a causal relationship with mortality. Furthermore, the comparison of low protein intake between studies is compromised due to differences in classification criteria.

Another safeguard must be made regarding the fact that the habitual intake record was used as an instrument for assessing food consumption. Although it is not a validated instrument, it was observed that older adults found it easier to report their usual consumption than their consumption in the last 24 hours[32]. Furthermore, meals eaten by older adults tend to be monotonous due to issues of habit, as well as difficulties in acquiring, preparing and ingesting food[33]. These aspects contribute to minimizing possible biases arising from the application of habitual intake recalls, such as memory bias.

It is worth highlighting that all methods of measuring food consumption have limitations[34]. In this study, it is believed that the training of interviewers and the restriction to a smaller set of administrators contributed to the quality of the measurements and the reduction of bias.

Another limitation concerns the assessment of muscle reserve, which was carried out by indirect measurement (leg circumference), given the unavailability of more precise methods (such as computed tomography, magnetic resonance imaging, ultrasound and dual-energy x-ray absorptiometry (DEXA)). This may imply a greater likelihood of errors in measurement, especially considering changes typical of aging, such as reduced skin elasticity[18]. Furthermore, there may be an overestimation of LC in overweight and obese individuals and significantly lower LC values may be observed in underweight individuals[35].

However, anthropometric measurements are widely used in health care for older adults because they are easy to obtain and present good results in predicting different events. As an example, the consensus of the European Working Group on Sarcopenia in Older Adults[5] recommends the use of anthropometric measurements such as LC when no other methods are available. Finally, it was not possible to adopt the use of leg circumference corrected by BMI. Since the adjusted model includes both BMI and LC, the effect of a possible overestimation in the association between LC and the outcome may have been reduced.

The results of this study suggest that low protein intake may increase the risk of death in older adults. It is necessary to ensure a greater intake of proteins in aging, mainly to maintain lean body mass in order to reduce the risk of death. However, this increase in protein intake must consider the individuality of each older adult, including comorbidities (such as kidney problems) and socioeconomic aspects. Encouraging a healthy diet is a way to ensure an adequate supply of nutrients, including a higher protein intake.

AUTHORSHIP

- Ângela Maria Natal de Souza - study design, data collection, statistical analysis, data interpretation, writing and approving the final version for publication.
- Dalila Pinto de Souza Fernandes - data collection; data interpretation; critical review and approving the final version for publication.

- Isah Rabiu - data interpretation; writing the manuscript and its critical review and approving the final version for publication.
- Jérsica Martins Bittencourt - data interpretation; writing the manuscript and its critical review and approving the final version for publication.
- Juliana Farias de Novaes - data interpretation; writing of the manuscript and critical review and approving the final version for publication.
- Andréia Queiroz Ribeiro - conception and design of the study; data interpretation; writing and critical review and approving the final version for publication.

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