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Adequacy of Energy Consumption and Macronutrients of the Elderly in Tabriz: Association with Cognitive Function

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A B S T R A C T

Background: We aimed to investigate whether the elderly living in Tabriz, Iran meet the requirements for energy and macronutrients intake, and to examine the relationship of their dietary intake to cognitive function.

Methods: In this cross-sectional study, 164 elderly subjects aged 65 years and older were enrolled. Anthropometric and dietary parameters were measured. The cognitive performance was assessed using Mini Mental State Examination (MMSE) and compered between males and females. The associations of energy, BMI, and macronutrients with cognitive function were also investigated.

Results: About half of the participants (n=83, 50.6%) had BMI in normal range, 22.6% (n=37) were underweight, while 26.8% (n=44) were overweight/obese. Average daily energy intake was 1235.21 (360.89) kcal/day; in 87 (53%) of the elderly, total energy intake was lower than the recommended intake. The subjects consumed 0.77g protein/kg body weight. Fat intake <20-35% (the recommended values) was observed in 93.3% (n=153) of the participants. Additionally, 123 cases (76.4%) suffered from cognitive impairment. A significant difference was also found between genders for cognitive status ($p<0.001$). A significant association of BMI and fat and protein intake was found with cognitive function.

Conclusion: This study revealed that a relatively high percentage of the elderly had inadequate and unbalanced nutritional intake. Additionally, the degree of cognitive decline was remarkable in the studied subjects. There was a relationship between dietary intake and cognitive performance. Due to the higher vulnerability to nutritional deficiencies and cognitive impairments of the elderly, more attention of health professional to nutritional and cognitive status is warranted.

Introduction

Population aging is accelerating rapidly worldwide; a 56% growth is estimated in the number of people older than 60 years by 2030. In the Islamic Republic of Iran in 2015, around 10% of the population is aged 60 years and over [1]. Dietary intake is an essential factor in the promotion and maintenance of health throughout life; however, according to the literature, the elderly are vulnerable to nutritional deficiencies [2]. It is estimated that about 21% of older adults show symptoms of aging-associated anorexia [3] and aging increases the risk of malnutrition [4]. Malnutrition is a frequently reported problem in elderly individuals [5] and the intake of energy, nutrients, and water has been reported to decrease with age [6-8].

Poor nutritional status is associated with functional decline and high mortality [9] and increases the cost of National Health Service. Additionally, malnutrition aggravates deterioration in the quality of life, physical and cognitive decline, and sarcopenia [10]. The adequacy of nutrients is one of the most important nutritional concerns around the world. It has been demonstrated that optimal nutritional adequacy is necessary for higher mental and physical health status of people at all ages including the older adults [11].

A recent study [12] assessed the individuals' energy intake and approximately 60% of the participants had the energy intake below the

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recommended levels. On the other hand, the role of energy intake in preventing frailty is proven in the literature [13]. Regarding the macronutrients consumption, the sufficient intake of proteins is related to better physical and mental function [14].

The effect of dietary energy and macronutrient on cognitive performance, however, has barely been studied. A few observational studies reported an association between protein intake and cognitive performance. Roberts et al. [15] showed that higher protein intake decreases the risk of mild cognitive impairment or dementia later in life. We hypothesized that elderly are susceptible to a possible adverse effect of nutrient inadequacy which can influence on cognitive performance.

Regarding the growing population of older adults in Iran, and lack of studies on the association between nutritional status and cognitive function of elderly individuals, assessing their nutritional status and cognitive function is of great importance.

The primary aim of the present study was to investigate whether elderly living in Tabriz, Iran meet the requirements for energy and nutrient intakes. The secondary aim was to examine the relationship of their dietary intake to cognitive function.

Subjects and methods

In The present study was conducted between April 2015 and June 2015. A total of 164 elderly subjects met the inclusion criteria and participated in the study. Criteria for inclusion were individuals at 65 years or older, with willingness and sufficient capability to participate in the study. Exclusion criteria were severe physical or mental illnesses, end-stage liver or kidney diseases, edema, chronic inflammatory diseases, smoking, and consuming alcoholic drinks.

The study protocol was reviewed by the regional ethics committee of Tabriz University of Medical Sciences and approval was obtained (Ethics code: TBZMED.REC.1394.24). All study participants gave informed consent.

All subjects were interviewed by face to face interviews. The questionnaire was designed to obtain data on demographic characteristics. Anthropometric measurements were performed in light clothing and without shoes. Body height was measured using a tape. In elderly unable to stand straight, knee height was measured to the nearest 0.1 cm using a sliding broad-blade caliper (Ross Laboratories, OH, USA), according to techniques previously described [16]. Body weight was measured in the morning after urinating, using calibrated scale (Seca, Germany) to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight (kg)/height2 (m2). Waist circumference (WC) was measured at the midpoint between the lower border of the rib cage and the iliac crest and HC was measured at the widest part of the hip region. Using a metric tape with a precision of 0.1 cm, mid-arm circumference (MAC) was measured at the mid-point between acromion process of scapula and olecranon process. Calf circumference (CC) measurement was performed at the level of the largest circumference of the right calf, using a metric tape with a precision of 0.1 cm while subject sitting on a chair. If the elderly subject was not able to sit, CC was measured in the supine position with the leg bent at 90°. A cut-point of less than 31 cm was considered as descriptive of nutritional risk [17].

Dietary intake including energy and macronutrients were assessed by a three-day food record (two weekdays and one weekend) and were analyzed using Nutritionist IV (Axxya Systems, Stafford, TX) software.

Estimated energy requirements were calculated using basal metabolic rate (BMR) according to Harris-Benedict (H-B) formula for each participant [18]. Then, the calorie intake of the participants was compared with BMR in order to estimate whether they receive adequate energy. Percentage of energy derived from fat, protein, and carbohydrate was calculated. Intake of protein was also expressed per kg of body weight. Prevalence of inadequate intakes was calculated, comparing the mean intake with recommended intakes. The subjects were categorized as below the dietary recommended intake (DRI) (defined as less than 1 g protein/kg) or at or above the DRI (equal to or higher than 1 g protein/kg) for protein [19]. The subjects were categorized as below the recommended intake or at or above the DRI (20%-35% of total calories) for fat.

Cognitive function was assessed using Mini Mental State Examination (MMSE), already validated among the Iranian elderly [20]. Scores range from 0-30, and the higher value indicates a higher level of cognitive capacity. Any scores lower than 24 are indicative of cognitive impairment while scores equal to 24 or above was considered normal cognition.

Statistical analyses

Data were analyzed using SPSS software version 23.0 [SPSS, Inc., Chicago, Ill]) and P<0.05 was considered statistically significant. Kolmogorov-Smirnov test was done to check the normality of data distribution. The quantitative data are presented as the mean and standard deviation (SD) for normally distributed data and median and 25th and 75th percentiles for abnormally distributed variables. Chi-square or Fisher's exact test was used for categorical variables, and frequency and percentage are presented for categorical data. To compare differences between the two groups, Independent Samples t-test and Mann Whitney U test was used, where appropriate.

Results

General characteristics and anthropometric data are summarized in (Table 1). Participants (n=164) had 73.99 (8.30) years old and 104 (63.41%) were women. Mean BMI was within the normal weight range for the elderly, with 22.6% (n=37) being underweight and 26.8% (n=44) overweight–obese, while about half of participants (n=83, 50.6%) had BMI in normal range. Of the participants, 29.9% (n=49) had a calf circumference of <31 cm.

Table 1. Demographic and anthropometric characteristics of the subjects

	Males (n=60)	Female (n=104)
Age (years)	71.07 ± 5.66	75.68 ± 9.11
Weight (Kg)	69.41 ± 14.43	62.71 ± 15.58
Height (cm)	166.51 ± 7.99	150.25 ± 6.78
BMI (Kg/m^2) **	25.19 ± 4.86	27.62 ± 6.05
WC (cm)	92.62 ± 12.83	96.52 ± 14.01
BMI classification **		
<22	18 (30.0%)	19 (18.3%)
22-30	34 (56.7%)	49 (47.1%)
>30	8 (13.3%)	36 (34.6%)
MAC (cm)	28.52 ± 3.4	28.75 ± 4.34
CC classification **		
<31	12 (20.7%)	37 (35.6%)
≥31	46 (79.3%)	67 (64.4%)

*Values are as Mean ± SD unless specified; **statistically different between two groups.

BMI: body mass index; MAC: Mid-arm circumference; CC: Calf circumference.

Energy and macronutrients intake values are presented in (Table 2). Average daily energy intake was 1235.21 (360.89) kcal/day; in 87 (53%) of the elderly, total energy intake was lower than the recommended intake, while 45.7% (n=75) of the subjects consumed at least that much BMR (according to Harris-benedict formula).

Table2. Dietary intake of the study elderly

	Total (n=164) Mean ± SD	Males (n=60) Mean ± SD	Females (n=104) Mean ± SD	P
Energy (Kcal)	1235.21 ± 360.89	1279.52 ± 389.96	1210.08 ± 342.71	0.24
Carbohydrates (g)	201.64 ± 71.19	217.01 ± 84.66	192.58 ± 60.55	0.04
% carbohydrate of total energy	64.57 ± 9.25	66.56 ± 11.94	63.38 ± 6.97	0.04
Protein (g)	48.41 ± 16.42	48.06 ± 16.13	48.61 ± 16.65	0.84
% protein of total energy	21.18 ± 6.85	20.24 ± 6.87	21.71 ± 6.81	0.19
Fat (g)	28.87 ± 11.17	28.02 ± 10.06	29.37 ± 11.78	0.46
% fat of total energy	15.63 ± 15.632	15.11 ± 3.25	15.93 ± 3.64	0.15

p<0.05 is considered statistically significant.

On average, the subjects consumed 48.41 (16.42) gr protein/day, representing 0.77 g protein/kg body. The minimum and maximum reported protein intake was 0.3 g/kg/day and 1.85 g/kg/day weight/day, respectively. A protein intake <1 g/kg body weight was found in 72.6% (n=119) of the participants (77.3% in females and 77.2% in males).

The statistically significant differences in carbohydrate intake were observed with respect to gender. The percentage of total energy from carbohydrate was 64.57±9.25, and in 44.5% of the participants (n=73), the carbohydrates intake was higher than the recommended intake (45%-65% total calories).

The mean of energy intake from fat was 15.63% in the participants, lower than the recommended values. In the other word, a fat intake <20%-35% was observed in 93.3% (n=153) of the participants.

According to the results, 123 cases (76.4%) suffered from cognitive impairment to varying degrees. Further analysis showed a significant difference between genders for cognitive status (p<0.001; Figure 1); 89.1% of the females and 55% of the males had varying levels of cognitive impairment. (Table 3) presents the associations of BMI, energy and macronutrients intake with

MMSE score, adjusted for gender. An association was found for BMI, fat and protein intakes with cognitive function.

Table 3. Partial correlations between BMI, dietary intake, and MMSE score

Variables	Energy		Carbohydrate		Protein		Fat		BMI	
	r	p	r	p	r	p	r	p	r	p
MMSE score	0.129	0.11	0.082	0.312	0.201	0.010	0.237	0.003	0.423	<0.001

BMI: body mass index; MMSE: Mini Mental State Examination; p<0.05 is considered statistically significant.

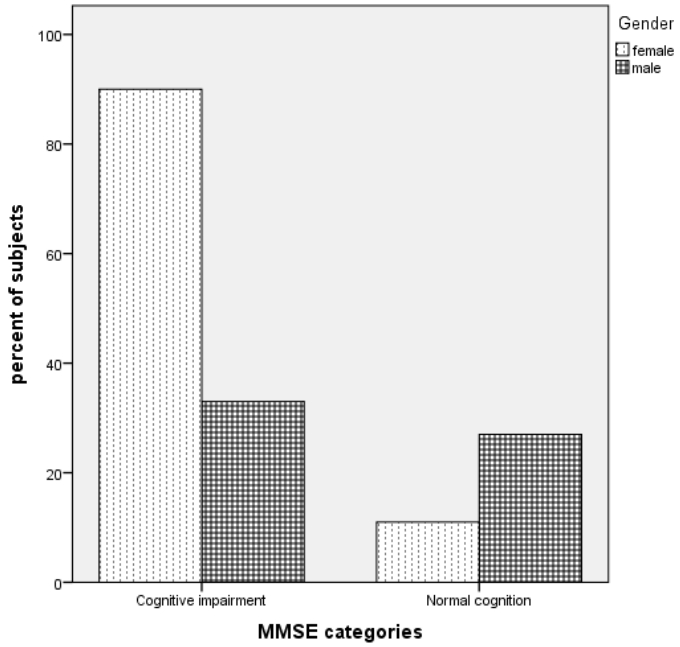

Figure 1. Percentage of the subjects based on MMSE categories in males and females (p<0.001)
MMSE: Mini-mental state examination

Discussion

In the present study on 164 older individuals, we investigated the dietary intakes of macronutrients and their relationship with cognitive function.

In our study, a high prevalence (76.4%) of cognitive decline was found. Similarly, Rashedi et al. [21], in a study including 212 elderly subjects, 45.3% of participants suffered from mild, 110 cases (51.9%) from moderate and 6 cases (2.8%) from severe cognitive decline. The process of aging usually accompanies with cognitive decline, which is in turn associated with dependency and autonomy and eventually affects daily function [22]. Thus, maintaining or improving cognitive performance is of great importance which nutritional status, as a modifiable factor, might play a crucial role.

The mean BMI of the study participants was within the normal range for the elderly; however, 22.6% (n=37) were below the normal range. This value was higher than that reported in the cross-sectional study by Pohlhausen et al. [12] performed in German, in which only 14% of seniors had a BMI below the normal ranges (i.e. lower than< 22 kg/m²). It should also be highlighted that in our study, the values of BMI were of lower magnitude in men compared with women.

The current study shows a positive association between BMI in old age and cognitive function. Other studies have linked both low BMI and high BMI to lower cognitive abilities in later life [23-24]. Besser et al. [25] reported that cognitive impairment was faster in elderly with weight loss; while those with higher baseline BMI experienced slower clinical progression; which is in agreement with the finding of the present study. The mechanisms behind low BMI and poor cognitive status are not clear; however it is suggested that decreased BMI may indicate pathologic processes that contribute to the subsequent decline in cognition or even development of Alzheimer disease [23]. A decline in BMI and in cognition may result from

decreased energy metabolism due to declines in adipose tissue and other organs [25]. To date the evidence on the association of BMI with cognition are mainly based on studies with a cross-sectional design or studies with short-term follow-up; thus, they should be interpreted with caution.

To our knowledge, this is the first study providing information on dietary intake of the elderly in the northwest, Iran. In general, in about half of the subjects (53%), energy intakes did not meet the requirements which raises concerns. This is similar to the study by pahayoo et al. [26] in which up to 50% of the subjects had poor nutritional status. Moreover, we observed the distribution of the macronutrients was imbalanced since the protein intake was insufficient to adequately meet the metabolic and physiological needs. In addition, the percentage of energy from fat was lower than the recommended levels; however, carbohydrate intake met the recommendations.

Energy from macronutrients was consistent with another study on the elderly [10], which reported inadequate and unbalanced nutrition in the elderly. However, healthy diets with balanced proportions of macronutrients have been associated with low levels of inflammatory markers and with better glycemic control, besides reducing the risk of dyslipidemia and the development of chronic diseases [27]. Thus, evaluation of the nutritional status of the elderly deserves more research.

The daily dietary protein intake was insufficient (<1gr/kg) in the majority of the participants (72.6%, n=119), indicating inadequate intake of dietary protein in elderly population. In our study, protein and fat intakes were in positive significant association with MMSE score only among female elderly. In males, weaker associations were observed. These findings are consistent with a study by Roberts et al. [15] which reported dietary patterns consisting of a relatively low intake of fat and protein may have adverse implications for the development of cognitive impairment. Overall, the role of dietary protein intake on cognitive function as well as cognitive decline has hardly been studied. However, protein intake is suggested to be essential to maintain the integrity and function of cells and neuronal membranes [15, 28]. In addition, protein supplementation has been shown to improve cognitive performance in term of reaction time [22]. An association between protein intake and cognitive function may specifically be due to certain amino acids that are common constituents of protein-rich foods. By affecting blood concentrations of single amino acids, protein intake causes variations in the uptake of amino acids into the brain and therewith influences the production of neurotransmitters [29].

There is evidence available [30], suggesting that the current recommendations of protein intake in the elderly are insufficient for good bone and muscle health and nitrogen balance and need to be revised due to the recommendations. More research in elderly populations, in particular, is needed to come to definitive conclusions and specific recommendations regarding protein intake or intake of specific amino acids for maintaining optimal cognitive function.

In the present study, fat intake as a proportion of energy tended to be lower compared with recommended values. However, carbohydrate intake tended to be higher than recommended levels; this explains the lower intakes of fat, suggesting unbalanced proportions of macronutrients intake. Data on the proportion of macronutrients intake are scarce. Evidence suggests that the higher intake of carbohydrates is compensated by the lower intake of lipids [27] [31]. Likewise, subjects with the highest percent of carbohydrate intake had the lowest percent of fat intake in another study [15]. In our research, percent of fat intake was directly associated with the score of MMSE. High percent of fat intake was associated with a reduced risk of mild cognitive impairment or dementia [15]. A possible explanation for the association of fat intake with cognitive function is that fats are required for the integrity of the myelin sheaths in the brain [15].

The present study had some limitations. First, we failed to assess different sources of macronutrients intake which might have different effects on energy balance and cognitive performance. Second, the observational nature of our study does not allow us to claim causal associations. On the other hand, this study had some strengths; it was the first to reveal inadequate dietary macronutrients intake as well as a high prevalence of cognitive decline in the elderly of Tabriz.

Conclusion

the present work revealed a relatively high percentage of the elderly had inadequate and unbalanced nutritional intake. Additionally, the

degree of cognitive decline was remarkable in the studied subjects. Therefore, it is appropriate to focus on the relationship between diet and cognitive performance in the elderly due to the higher vulnerability to both nutritional deficiencies and impairments in cognitive functions. Health professionals should pay more attention to evaluate and improve the mental status of elderly people.

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Author contributions

Maryam Saghafi-Asl: design and conduction of the study, acquisition of data; revision of the manuscript.

Azimeh Izadi: Analysis and interpretation of data; writing and revision of the manuscript.

Conflict of interest

Authors declare that there is no conflict of interest.

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