Research Article

iMedPub Journals
http://www.imedpub.com

Journal of Clinical Nutrition & Dietetics
ISSN 2472-1921

2016
Vol. 2 No. 1: 5

DOI: 10.4172/2472-1921.100012

Community-Dwelling Older People's Dietary Habits, Calorie Intake and Calorie Expenditure and their Relationship with Frailty

Mateu Serra-Prat[1,2], Mònica Papiol[3], Judit Vico[1], Isabel Lorenzo[1] and Mireia Arús[4]

1 Research Unit. Consorci Sanitari del Maresme. Mataró, Barcelona, Spain
2 CIBEREHD. Instituto de Salud Carlos III, Spain
3 Argenona Primary Care Centre. Argentona, Barcelona, Spain
4 Dietetics and Nutrition Unit. Consorci Sanitari del Maresme. Mataró, Barcelona, Spain

Corresponding author: Mateu Serra-Prat

mserra@csdm.cat

Research Unit, Hospital de Mataró, arretera de Cirera s/n 08304, Mataró, Barcelona, Spain.

Tel: 93 741 77 30
Fax: 93 757 33 21

Citation: Serra-Prat M, Papiol M, Vico J, et al. Community-Dwelling Older People's Dietary Habits, Calorie Intake and Calorie Expenditure and their Relationship with Frailty. J Clin Nutr Diet. 2016, 2:1.

Abstract

Aim: to describe dietary habits and calorie expenditure in a community-dwelling older population, as well as to assess the relationship between these habits and frailty and pre-frailty status.

Methods: An observational, population-based, cross-sectional study was performed among community-dwelling people aged 75 years and older. Frailty was established according to Fried criteria, dietary habits were assessed by a validated food frequency consumption questionnaire, physical activity and calorie expenditure were estimated through the International Physical Activity Questionnaire.

Results: A total of 324 people were recruited (170 men and 154 women), with a mean age of 80.1 (3.5) years, and 94.6% considered as well nourished. In women, BMI was higher in frail and pre-frail than in robust (30, 30, and 26, respectively; $p < 0.001$). Study sample tended to have a diet rich in nuts, fruits and vegetables. No differences in protein intake between frail and non-frail persons were observed, but frail persons had a lower intake of salads, nuts, fruits and fibre, as well as alcohol. Frail persons had a lower calorie intake and much lower calorie expenditure than non-frail persons, resulting in a greater positive energy balance.

Conclusion: In an older population with sufficient calorie and protein intake, lower micronutrient intake of nuts, fruits and vegetables is a risk factor for frailty. Low physical activity is also related to frailty and predisposes to positive energy balance and obesity. Health professionals must encourage older people to exercise regularly and maintain good dietary habits including both good calorie and protein intake and good micronutrient intake of fruits and vegetables.

Keywords: Frailty; Dietary intake; Physical activity; Nutritional status

Received: February 18, 2016; **Accepted:** March 18, 2016; **Published:** March 25, 2016

Introduction

Frailty is a geriatric syndrome characterized by a diminished capacity of the organism to respond to external stressors and an increased vulnerability to suffer falls, functional decline, incapacity, dependency, institutionalization and even death [1]. Its prevalence increases with age and can reach 50% in adults 80 years or older [2], representing a serious public health problem that needs to be urgently addressed [3]. The pathophysiology of frailty is not well established. Rockwood et al. [4] considered that frailty results from the accumulation of unrelated diseases, dysfunctions and disabilities, but Fried et al. [5] considered frailty to be a unique pathophysiological process involving the breakdown of homeostatic mechanisms. Fried proposed a definition of the frailty phenotype in which muscle wasting was the major component. Different factors have been related to loss of muscle mass and function such as inflammatory processes, anabolic hormone declines, physical inactivity or under nutrition [6]. There is evidence suggesting that exercise and caloric and protein support may have a positive effect on frailty [7-9]. However, few studies on community-dwelling older people have directly related dietary habits, energy and protein intake and energy expenditure with frailty and pre-frailty status. The aim of this study was to describe dietary habits in a community-dwelling

older population and to assess whether dietary energy intake and energy expenditure by physical activity was related to frailty and pre-frailty status.

Methodology

Study design and population

An observational, population-based, cross-sectional study was performed on community-dwelling adults aged 75 years and older. A sample was randomly selected from the database of 3 primary care centres in the municipalities of Mataró and Argentona (Barcelona, Spain) on the western Mediterranean coast. Individuals were excluded if they had active malignancy, dementia or serious mental illness, had a life expectancy of less than 6 months, were in a palliative care programme or were institutionalized. Swallowing disorders were not exclusion criteria. Person who fulfilled all selection criteria and who signed the informed consent form were recruited from January to July 2014. A total of 324 persons were recruited, 170 men and 154 women, with a mean age of 80.1 years (min. 75, max.93).

Definition of frail

People were classified as robust, pre-frail or frail according to the Fried criteria [5]. The following five criteria were assessed: a) Unintentional weight loss of ≥ 4.5 kg in the last 12 months, b) Exhaustion, defined by a response of 3 days or more to either or both of 2 questions: "How often in the last week did you feel you could not get going?" and "How often in the last week did you feel that everything you did was an effort? c) Low physical activity, defined as total weekly kcal of physical activity expenditure < 383 kcal in men or < 270 kcal in women, d) Slow walking speed, defined as < 0.65 m/s for a height of ≤ 173 cm in men / ≤ 159 cm in women or < 0.76 m/s for a height of > 173 cm in men / > 159 cm in women, e) Poor grip strength (using a handheld JAMAR dynamometer), defined as ≤ 29 kg for body mass index (BMI) ≤ 24, ≤ 30 kg for BMI 24.1 - 28 and ≤ 32 kg for BMI > 28 in men or ≤ 17 kg for BMI ≤ 23, ≤ 17.3 kg for BMI 23.1-26, ≤ 18 kg for BMI 26.1 - 29 and ≤ 21 kg for BMI > 29 in women. Persons were classified as robust if they fulfilled none of the above criteria; pre-frail if they fulfilled 1 or 2 criteria; and frail if they fulfilled 3 or more criteria.

Study factors and data collection

Dietary intake was assessed by a food frequency consumption questionnaire validated in Spain [10] which registers the frequency individuals eat 45 different foods over a week. Each serving of food was converted into grams of carbohydrates, lipids, proteins and fiber intake according to the BEDCA database of food composition (http://www.bedca.net/). Finally, grams of ingested carbohydrates, lipids and proteins were converted into Kcal intake. In addition, grams of ingested fiber and alcohol intake were also estimated from the same questionnaire. Nutritional status was assessed by anthropometric measurements (weight, height, BMI) and the short-form of the Mini Nutritional Assessment (MNA-sf) which classifies individuals as well nourished (12 - 14 points) or at risk of malnutrition (< 12 points) [11]. Physical activity was assessed by the International Physical Activity Questionnaire (IPAC) [12]. This questionnaire estimates total METs (metabolic equivalent of task) for severe, moderate or mild physical activity and for overall physical activity. To convert 1 MET into kcal/min the following equation applies: Kcal/min = 0.0175 × MET × weight (kg). Other study variables included socio-demographic characteristics, co-morbidities and chronic medication. Information on comorbidities and medication was obtained from the electronic medical records held by each centre. All other information was obtained directly from the patient by healthcare professionals.

Ethics

No person was recruited without signing the informed consent form. The research ethics committee from Consorci Sanitari del Maresme approved the study protocol and documentation (code 64 / 13).

Statistical analysis

Continuous variables were described using means and standard deviations and categorical ones using percentages. Comparisons across the 3 study groups (robust, pre-frail and frail) were made using ANOVA or the Kruskal-Wallis test for numerical variables and the X^2 test or the Fisher's exact test for categorical ones. To evaluate factors associated with frailty, the robust and pre-frail groups were pooled together in a non-frail group and frail versus non-frail persons were compared. Comparisons between 2 groups (non-frail and frail) were made using the t-test or Mann-Whitney U test for numerical variables and the X^2 test or the Fisher's exact test for categorical ones. The effect (OR) of the variables associated with frailty was estimated by logistic regression analysis. Statistical significance was established at $p < 0.05$.

Results

A sample of 324 persons was recruited (52.5% men and 47.5% women) with a mean age of 80 (3.5) years. Main co-morbidities were arterial hypertension (70.0%), osteoarthritis (52.4%), dyslipidaemia (50.9%), diabetes (24.2%), ischemic heart disease (21.5%) and depression (19.6%). Participants were taking a mean of 6 medications. Gender was related to frailty, as women represented 28.8% of the robust group, 51.1% of the pre-frail group and 76.1% of the frail group ($p < 0.001$).

Table 1 shows the dietary intake of the whole sample and for robust, pre-frail and frail groups. It shows that participants ate more than 15 servings of fruit a week and more than 12 servings of vegetables a week. Frail older persons ate more soups and white fish but fewer non-citric fruits, dried fruits (like nuts), and salads, and drank less wine and beer than non-frail. When all fruit servings (citric fruits, non-citric fruits and nuts) were pooled together we observed that eating ≤ 2 fruit servings / day was a risk factor for frailty with an OR = 1.90 (95% CI: 1.01 - 3.56, p = 0.046). Similarly, when all vegetables servings were pooled we observed that eating ≤ 1 vegetable servings / day was a risk factor for frailty with an OR = 1.93 (95% CI: 1.03 - 3.62, p = 0.041). Moreover, a fibre intake ≤ 23 g/day was a risk factor for frailty with an OR=2.86 (95%CI: 1.49 - 5.50, p = 0.002). Frail men eat less shellfish and nuts and drink more low-calorie beverages, while frail women eat less bread, ham and non-citric fruits and eat more yogurts, soups,

Table 1 Dietary habits by frailty groups in community-dwelling older people.

Times per week Mean (SD)	Overall sample	Robust N = 104	Pre-Frail N = 174	Frail N = 46	P (3 groups)*	Non-frail N = 278	P (frail vs. non-frail) †
Milk	6.2 (4.5)	5.6 (3.5)	6.4 (4.9)	7.1 (4.7)	0.284	6.1 (4.5)	0.228
Yogurt	4.3 (4.0)	4.4 (3.6)	4.5 (4.3)	3.2 (3.6)	0.164	4.5 (4.1)	0.058
Chocolate	1.7 (2.4)	1.6 (2.4)	1.8 (2.6)	1.5 (2.1)	0.878	1.7 (2.5)	0.846
Breakfast cereals	0.60 (1.8)	0.67 (2.4)	0.61 (1.8)	0.40 (1.5)	0.817	0.6 (1.9)	0.571
Biscuits	2.1 (2.7)	2.36 (2.8)	2.0 (2.8)	2.0 (2.3)	0.633	2.1 (2.8)	0.880
Biscuits with chocolate	0.2 (0.9)	0.03 (0.1)	0.2 (1.0)	0.3 (1.2)	0.148	0.2 (0.8)	0.662
Muffins	1.0 (2.2)	1.2 (2.6)	0.79 (1.7)	1.6 (2.6)	0.114	0.9 (2.1)	0.044
Pastries	0.6 (1.3)	0.5 (1.2)	0.5 (1.2)	0.9 (1.8)	0.683	0.5 (1.2)	0.427
Salad	4.0 (2.6)	4.6 (2.9)	3.9 (2.4)	3.1 (2.5)	0.010	4.2 (2.6)	0.008
Green beans, beets, spinach	2.8 (1.5)	2.8 (1.3)	2.9 (1.6)	2.5 (1.5)	0.179	2.9 (1.5)	0.064
Eggplant, mushrooms, etc.	1.4 (1.2)	1.4 (1.2)	1.5 (1.2)	1.2 (1.3)	0.409	1.5 (1.2)	0.194
Potatoes	2.6 (1.3)	2.7 (1.0)	2.6 (1.3)	2.5 (1.5)	0.345	2.6 (1.2)	0.230
Lentils,chickpeas, beans, etc.	1.5 (0.9)	1.6 (1.0)	1.5 (0.8)	1.3 (0.9)	0.147	1.6 (0.9)	0.050
Rice, “paella”	1.3 (0.7)	1.3 (0.7)	1.3 (0.7)	1.4 (0.8)	0.528	1.3 (0.7)	0.555
Pasta: macaroni,spaghetti, etc.	1.4 (1.0)	1.5 (1.0)	1.3 (0.9)	1.5 (1.1)	0.704	1.4 (0.9)	0.740
Soups and creams	1.9 (1.8)	1.8 (2.0)	1.8 (1.7)	2.4 (1.5)	0.008	1.8 (1.8)	0.002
Eggs	1.3 (1.0)	1.3 (0.8)	1.3 (1.0)	1.3 (1.1)	0.383	1.3 (0.9)	0.961
Chicken,turkey	1.5 (1.0)	1.4 (1.0)	1.5 (0.9)	1.6 (1.1)	0.359	1.5 (0.9)	0.326
Beef, pork, lamb	1.3 (1.0)	1.4 (1.0)	1.2 (1.1)	1.0 (1.0)	0.137	1.3 (1.0)	0.097
Groundbeef,sausage, hamburger	0.5 (0.6)	0.6 (0.7)	0.5 (0.5)	0.5 (0.5)	0.167	0.5 (0.6)	0.491
White fish: hake, grouper	1.7 (1.0)	1.5 (0.9)	1.7 (1.1)	1.9 (1.0)	0.037	1.6 (1.1)	0.072
Blue fish: sardines, tuna, salmon	1.0 (1.0)	1.1 (1.0)	1.0 (1.1)	0.7 (0.8)	0.230	1.0 (1.1)	0.114
Shellfish	0.4 (0.5)	0.4 (0.5)	0.4 (0.5)	0.3 (0.6)	0.052	0.4 (0.5)	0.112
Pizza, croquettes	0.2 (0.5)	0.2 (0.4)	0.2 (0.6)	0.2 (0.4)	0.876	0.2 (0.6)	0.981
Bread	6.5 (1.7)	6.6 (1.4)	6.6 (1.7)	6.0 (2.1)	0.136	6.6 (1.6)	0.046
Ham,sausages	2.5 (2.0)	2.7 (1.9)	2.4 (2.1)	2.2 (2.0)	0.056	2.6 (2.0)	0.233
Fresh cheese	1.0 (1.5)	0.8 (1.5)	1.1 (1.5)	1.2 (1.5)	0.087	1.0 (1.5)	0.295
Cured cheese or cream cheese	1.1 (1.6)	1.3 (1.7)	1.1 (1.6)	1.0 (1.4)	0.272	1.2 (1.7)	0.384
Citric fruits: orange, mandarin	4.1 (4.1)	4.1 (4.6)	4.0 (4.0)	4.3 (3.8)	0.624	4.1 (4.2)	0.352
Other fruits: apple, pear, peach, etc.	9.6 (6.3)	10.8 (6.5)	9.5 (6.4)	7.4 (4.7)	0.013	10.0 (6.5)	0.020
Canned fruits	0.06 (0.4)	0.05 (0.1)	0.07 (0.5)	0.05 (0.02)	0.767	0.07 (0.4)	0.863
Natural fruit juices	1.4 (2.7)	1.4 (2.5)	1.4 (2.9)	1.1 (2.4)	0.498	1.4 (2.7)	0.348
Commercial fruit juices	0.40 (1.4)	0.5 (1.8)	0.41 (1.3)	0.30 (0.7)	0.461	0.4 (1.5)	0.616
Nuts: hazelnuts, almonds, walnuts	2.2 (2.6)	2.7 (2.8)	2.1 (2.5)	1.6 (2.7)	0.027	2.4 (2.6)	0.026
Dairy desserts	0.7 (1.5)	0.6 (1.5)	0.7 (1.6)	0.7 (1.0)	0.477	0.7 (1.6)	0.224
Cream cakes	0.2 (0.4)	0.12 (0.3)	0.17 (0.5)	0.26 (0.4)	0.072	0.2 (0.4)	0.023
Snack bags	0.4 (0.7)	0.4 (4.6)	0.4 (07)	0.5 (1.1)	0.766	0.4 (0.7)	0.940
Candies	0.11 (0.7)	0.10 (0.5)	0.13 (0.8)	0.08 (0.3)	0.915	0.1 (0.7)	0.726
Ice cream	0.39 (1.0)	0.36 (0.8)	0.44 (1.2)	0.22 (0.4)	0.568	0.4 (1.1)	0.341
Commercial sugary drinks	0.3 (0.9)	0.3 (0.8)	0.3 (0.9)	0.2 (1.1)	0.271	0.3 (0.9)	0.124
Commercial low calorie drinks	0.3 (1.2)	0.2 (1.2)	0.2 (0.8)	0.7 (2.1)	0.022	0.2 (1.0)	0.008
Wine	3.1 (4.2)	3.6 (3.7)	3.2 (4.6)	1.8 (3.2)	0.008	3.3 (4.3)	0.010
Beer	0.6 (1.6)	0.8 (1.6)	0.5 (1.6)	0.4 (1.5)	0.002	0.6 (1.6)	0.030
Beer without alcohol	0.2 (1.0)	0.1 (0.7)	0.3 (1.2)	0.1 (0.5)	0.334	0.3 (1.1)	0.411
Distilled: whisky, etc.	0.3 (1.4)	0.4 (1.9)	0.3 (1.3)	0.02 (0.1)	0.668	0.3 (1.5)	0.407

*: ANOVA or the Kruskal-Wallis test. †: t-test or Mann-Whitney U test
SD: Standard Deviation

and cakes. According to MNA-sf, 5.4% of the whole sample was classified as “at risk of malnutrition”, with significant differences between groups (2.0% in robust, 4.7% in pre-frail, and 15.6% in frail; p = 0.003). BMI was in the overweight range in men, with no significant differences between groups (29, 28, and 27 for frail, pre-frail and robust, respectively). BMI was significantly higher in frail and pre-frail women in comparison to robust women (30, 30, and 26, respectively; p < 0.001). Nutritional status was not related with dietary intake of the various foods considered except for salads, green beans and eggs, which were more frequent in well nourished.

Table 2 Macronutrient intake, calorie intake and calorie expenditure by frailty groups.

	Robust	Pre-Frail	Frail	P (3 groups)*	Non-frail	P (frail vs non-frail) †
Total calorie intake (Kcal/day)	1698.5 (297)	1652.4 (329)	1560.6 (299)	0.049	1669.6 (318)	0.031
Fat intake (Kcal/day)	528.6 (127)	518.0 (155)	487.6 (119)	0.267	522.0 (145)	0.130
• Polyunsaturated	122.1 (37)	114.9 (38)	107.8 (36)	0.078	117.6 (37)	0.101
• Monosaturated	230.2 (70)	218.0 (80)	200.7 (63)	0.053	222.6 (76)	0.077
• Saturated	199.3 (57)	195.0 (66)	180 (58)	0.231	196.6 (63)	0.105
Protein intake (Kcal/day)	318.4 (70)	315.4 (68)	309.3 (64)	0.749	316.6 (68)	0.501
Protein intake rate	111.7 (32)	109.4 (27)	108.8 (31)	0.856	110.3 (29.6)	0.756
Carbohydrate intake (Kcal/day)	788.9 (152)	762.5 (158)	726.9 (165)	0.080	772.4 (157)	0.072
Fibre intake (gr/day)	25.4 (5.5)	24.0 (5.9)	21.8 (6.5)	0.002	24.5 (5.8)	0.004
Alcohol intake (Kcal/day)	44.0 (41)	41.7 (53)	22.8 (36)	0.005	42.6 (48)	0.003
Calorie expenditure throughphysical activity/day (Kcal/day)	277.0 (163)	221.4 (150)	75.9 (68)	<0.001	242.2 (157.5)	<0.001
Total calorie expenditure (Kcal/day)	1786.9 (268)	1670.6 (244)	1451.3 (165)	<0.001	1714.1 (259.3)	<0.001
Energy balance (Kcal/day)	-88.3 (416)	-18.3 (393)	+109.2 (315)	0.018	-44.5 (403.1)	0.005

Protein intake rate: [protein intake/theoretical protein requirements according to body weight]*100.Theoretical protein requirements were considered 1 g of proteins/kg of weight/day.
Energy balance: total calorie intake – total calorie expenditure (in Kcal/day)
*: ANOVA or the Kruskal-Wallis test. †: t-test or Mann-Whitney U test

Table 2 compares total energy intake, lipid, protein and carbohydrate calorie intake, total fibre and alcohol intake as well as energy expenditure through physical exercise, total energy expenditure (metabolic rate + expenditure through physical exercise) and energy balance (total energy intake - total energy expenditure) between groups. It shows that frail persons had lower overall calorie intake, lower fibre and alcohol intake, as well as lower calorie expenditure and higher positive energy balance. Calorie expenditure through physical exercise ≤ 100 Kcal/day was a risk factor for frailty with an OR = 14.4 (95% CI: 7.06 - 29.5, p < 0.001).

Discussion

The results of the present study show that: a) a community-dwelling older population in a town on the west coast of the Mediterranean Sea tended to have a diet rich in nuts, fruits and vegetables, b) they had a good nutritional status, c) there were no major differences in protein intake between frail and non-frail persons, d) frail persons had a lower intake of salads, nuts, fruits and fibre, and e) frail persons had lower calorie intake and a much lower calorie expenditure than non-frail persons with a greater positive energy balance.

Nutrition is thought to play a major role in the development of frailty. Weight loss is one of the defining criteria of frailty [5] and large observational studies have suggested that poor nutritional status promotes frailty [13]. Weight loss is highly indicative of frailty (it has a high specificity), although relatively few frail persons have this frailty criteria (it has a low sensitivity) [14] indicating that other risk factors such as low physical activity, co-morbidities or chronic inflammation are also of critical relevance in the genesis of frailty. Frail persons have lower energy, macronutrient and micronutrient intake than non-frail persons [15]. The results of the present study agree with the existing evidence in showing a lower calorie intake in frail persons. However, we observed no differences between frailty groups in macronutrient intake (mainly protein and fat intake) although frail persons clearly ate less fruit, nuts, vegetables and fibre. Fruits and vegetables are important components of the Mediterranean diet and have been identified as a relevant part of the diet in preventing age-related diseases [16, 17]. There is growing evidence that adherence to the Mediterranean diet protects individuals against cardiovascular diseases and other chronic diseases, some cancers [18, 19], mobility decline, low walking speed and low physical activity, suggesting a relationship between diet and frailty [20, 21]. Although the majority of studies on the health benefits of fruits and vegetables do not include older populations, there is growing evidence that fruit and vegetable intake in older adulthood can prevent cognitive impairments and dementia, heart diseases, functional decline and walking speed [22, 23]. A recent publication by Chan et al. showed that higher vegetable and fruit intake was associated with a lower prevalence of sarcopenia in older Chinese men [24]. Moreover, higher serum carotenoid levels are associated with improved muscle strength and bone density in older people [25-27], suggesting that fresh fruit and vegetable intake, the main source of vitamins, carotenoids and micronutrients with anti-oxidative capacity, can protect against physical function decline, frailty and disability. On the other hand, protein intake has been inversely related to loss of lean mass in community-dwelling older people in the Health, Ageing, and Body Composition Study (ABC Study) [7] and high protein intake showed a 32% reduction in the risk of frailty in postmenopausal women in the Women's Health Initiative [28]. However, the role of protein supplementation in reducing the risk of sarcopenia and frailty is controversial since a systematic review including 62 randomized clinical trials (with 10,187 participants) showed little evidence on the benefit of this intervention in improving functionality and showed no significant

effect on reduction of mortality, except for undernourished persons [29, 30]. In the present study we did not find differences in protein intake between study groups. These results may be explained by the fact that all study groups showed good protein intake according to the international recommendations for older people (1 g -1.5 g of proteins/Kg/day). The ABC Study established a link between protein intake and loss of lean body mass when protein intake was insufficient or low (0.7 g of proteins/kg/day) in comparison to high protein intake (1.1 g of proteins/kg/day). In our study, protein intake was in the high protective range in all groups.

Regarding exercise, the present study showed a reduction in physical activity as the frailty process developed, with a significant reduction of total calorie expenditure in pre-frail with respect to robust persons and frail with respect to pre-frail persons. The reduction in total calorie expenditure in frail persons was much greater than the reduction in total calorie intake. These results indicate a positive energy balance in frail persons, leading to a sarcopenic obesity pattern. These results agree with most scientific evidence on the effect of physical activity on muscle strength in older persons. A review of the Cochrane Collaboration that summarized 49 clinical trials concluded that there was good evidence for the effectiveness of exercise programs in older people [8] and another meta-analysis including 8 clinical trials showed that exercise was able to improve walking speed, balance and functional capacity in frail older people [9]. Physical inactivity and loss of muscle strength form a vicious circle difficult to break. Poor muscle strength is the most prevalent frailty component and has been related to physical activity [14]. Changing habits and motivating older people to practice regular physical exercise is a necessary and major challenge for health professionals to prevent frailty and functional decline.

The present study has three main limitations, a) the cross-sectional design does not allow causal relationships to be established, but only associations between variables, because of the temporal ambiguity between frailty and studied risk factors, b) the relatively small sample size which limits the statistical power for small effects and low-prevalence risk factors and c) Indicators of total calorie intake and total calorie expenditure were estimated by validated questionnaires, which provide estimations with known limited accuracy. This possible misclassification is the same for all three study groups, so it can reduce the expected effect but not introduce any bias.

Conclusion

In conclusion, nutrition and physical activity are probably the greatest modifiable predictors of heath in old age. The present study showed that in an older population with sufficient calorie and protein intake in a largely Mediterranean diet, lower micronutrient intake of nuts, fruits and vegetables was a risk factor for frailty. Moreover, lower calorie expenditure through physical activity was also related to frailty and to predispose to a positive energy balance and a sarcopenic obesity pattern. Health care practitioners must encourage and motivate older people to exercise regularly and maintain good dietary habits including both good calorie and protein intake and good micronutrient (mainly vitamins, antioxidants and trace elements) intake.

Acknowledgement

This study was funded by grants from the Spanish Ministry of Health: Instituto de Salud Carlos III, Fondo de Investigación Sanitaria (PI 13 / 00931).

Conflict of Interest

The authors declare that they have no conflict of interest.

References

1 Morley J, Vellas B, van Kan GA, Anker SD, Bauer JM, et al. (2013) Frailty consensus: a call to action. JAMDA 14: 392-397.

2 Collard RM, Boter H, Schoevers RA, Oude VRC (2012) Prevalence of frailty in community-dwelling older persons: a systematic review. J Am Geriatr Soc 60: 1487-1492.

3 Vellas B, Cestac P, Morley JE (2012) Implementing frailty into clinical practice: we cannot wait. J Nutr Health Ageing 16: 599-600.

4 Rockwood K, Song X, Mac KC, Bergman H, Hogan DB, et al. (2005) A global clinical measure of fitness and frailty in elderly people. CMAJ 173: 489-495.

5 Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, et al. (2001) Frailty in older adults: evidence for a phenotype. J Gerontol Med Sci 56: 146-156.

6 Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K, et al. (2013) Frailty in elderly people. Lancet 381: 752-762.

7 Houston DK, Nicklas BJ, Ding J, Harris TB, Tylavsky FA, et al. (2008) Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. Am J ClinNutr 87: 150-155.

8 Foster A (2009) Rehabilitation for older people in long term care. Cochrane database of systematic reviews 1: CD004294.

9 Chou CH, Hwang CL, Wu YT (2012) Effect of exercise on physical function, daily living activities, and quality of life in the frail older adults: a meta-analysis. Arch Phys Med Rehabil 93: 237-244.

10 Trinidad I, Fernández J, Cucó G, Biarnés E, Arija V, et al. (2008) Validación de un cuestionario de frecuencia de consumo alimentario corto: reproducibilidad y validez. Nutr Hosp 23: 242-252.

11 Lilamand M, Kelaiditi E, Cesari M, Raynaud SA, Ghisolfi A, et al. (2015) Validation of the Mini Nutritional Assessment-Short Form in a Population of Frail Elders without Disability. Analysis of the Toulouse Frailty Platform Population in 2013. J Nutr Health Aging 19: 570-574.

12 Hagstromer M, Oja P, Sjostrom M (2006) The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. PublicHealthNutr 9: 755-762.

13 Bartali B, Frongillo EA, Guralnik JM, Stipanuk MH, Allore HG, et al. (2008) Serum micronutrient concentrations and decline in physical function among older persons. JAMA 299: 308-315.

14 Papiol M, Serra PM, Vico J, Jerez N, Salvador N, et al (2015). Poor muscle strength and low physical activity are the most prevalent frailty components in community-dwelling older adults. J Aging Phys Act.

15 Semba RD, Bartali B, Zhou J, Blaum C, Ko CW, et al. (2006) Low serum micronutrient concentrations predict frailty among older women livingin the community. J Gerontol A BiolSci Med Sci 61: 594-599.

16 Hung HC, Joshipura KJ, Jiang R, Hu FB, Hunter D, et al. (2004) Fruit and vegetable intake and risk of major chronic disease. J Natl Cancer Inst 96: 1577-1584.

17 Anlasik T, Sies H, Griffiths HR, Mecocci P, Stahl W, et al. (2005). Dietary habits are major determinants of the plasma antioxidant status in healthy elderly subjects. Br J Nutr 94: 639-642.

18 Sofi F, Abbate R, Gensini GF, CasiniA (2010) Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. Am J ClinNutr 92: 1189-1196.

19 Couto E, Boffetta P, Lagiou P, Ferrari P, Buckland G, et al. (2011) Mediterranean dietary pattern and cancer risk in the EPIC cohort. Br J Cancer 104: 1493-1499.

20 Milaneschi Y, Bandinelli S, Corsi AM, Lauretani F, Paolisso G, et al. (2011) Mediterranean diet and mobility decline in older persons. Exp Gerontol 46: 303-308.

21 Bollwein J, Diekmann R, Kaiser MJ, Bauer JM, Uter W, et al (2013). Dietary quality is related to frailty in community-dwelling older adults. J Gerontol A Biol Sci Med Sci 68: 483-489.

22 Polidori MC, Praticó D, Mangialasche F, Mariani E, Aust O, et al. (2009) High fruit and vegetable intake is positively correlated with antioxidant status and cognitive performance in healthy subjects. J Alzheimers Dis 17:921-927.

23 Scarmeas N, Stern Y, Tang MX, Mayeux R, Luchsinger JA, et al. (2006) Mediterranean diet and risk for Alzheimer's disease. Ann Neurol 59:912-921.

24 Chan R, Leung J, Woo J (2016) A prospective cohort study to examine the association between dietary patterns and sarcopenia in Chinese community-dwelling older people in Hong Kong. J Am Med Dir Assoc.

25 Semba RD, Lauretani F, Ferrucci L (2007) Carotenoids as protection against sarcopenia in older adults. Arch BiochemBiophys 458: 141-145.

26 Lauretani F, Semba RD, Bandinelli S, Dayhoff-Brannigan M, Giacomini V, et al. (2008) Low plasma carotenoids and skeletal muscle strength decline over 6 years. J Gerontol A BiolSci Med Sci 63: 376-383.

27 Alipanah N, Varadhan R, Sun K, Ferrucci L, Fried LP, et al. (2009) Low serum carotenoids are associated with a decline in walking speed in older women. J Nutr Health Aging13: 170-175.

28 Beasley JM, LaCroix AZ, Neuhouser ML, Huang Y, Tinker L, et al. (2010) Protein intake and incident frailty in the Women's Health Initiative observational study. J Am GeriatrSoc 58:1063-1071.

29 Milne AC, Potter J, Vivanti A, Avenell A (2009) Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database Syst Rev 2: CD003288.

30 Beasley JM, Shikany JM, Thomson CA (2013) The role of dietary protein intake in the prevention of sarcopenia of aging. Nutr Clin Pract 28: 684-690.