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Weakness: The most frequent criterion among pre-frail and frail older Portuguese

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ABSTRACT

Aim: In Portugal, the burden of pre-frailty and frailty in community-dwelling older adults is still unknown. The purpose of this study is to estimate the frequency of frailty in a Portuguese sample with ≥ 65 years and to evaluate its associated factors. We also intend to identify which criterion has more impact on the diagnosis of frailty.

Methods: 1457 older adults with ≥ 65 years from the Nutrition UP 65 study were evaluated in a cross-sectional analysis. Frailty was identified according to Fried et al. by the presence of three or more of the following factors: unintentional weight loss, self-reported exhaustion, slowness, weakness and low physical activity. Pre-frailty was defined as the presence of one or two of these criteria. The association between individuals' characteristics and frailty status was analysed through logistic regression analysis.

Results: The frequency of pre-frailty and frailty is 54.3% and 21.5%, respectively. In older adults classified as pre-frail or frail, 76.7% presented weakness and 48.6% exhaustion. In multivariate analyses, frailty was associated with age > 75, lower education level, being single, divorced or widower, being professionally inactive, poor self-perception of health status, not drinking alcohol, being obese and undernourished or at undernutrition risk.

Conclusion: This condition is very prevalent in Portuguese older adults, one fifth are frail whereas half are pre-frail. Weakness identified by low handgrip strength is the most prevalent criterion in pre-frail and frail Portuguese older adults.

1. Introduction

Frailty is a common clinical syndrome in older adults. It is characterised by multisystem dysregulations, leading to a loss of dynamic homeostasis, decreased physiologic reserve and increased vulnerability for poor health outcomes, such as falls, incident disability, hospitalization, and mortality (Chen, Mao, & Leng, 2014; Xue, 2011).

Several methodologies have been proposed to identify frailty (Fried et al., 2001; Rockwood et al., 2005; Romero-Ortuno, Walsh, Lawlor, & Kenny, 2010). Fried's frailty scale has been the most extensively tested for its validity and is the most widely used instrument in frailty research (Bouillon et al., 2013). Fried et al. suggested that individuals should be classified as normal, pre-frail or frail based on the following factors: unintended weight loss, exhaustion, weakness, slow walking speed and low physical activity. Frailty was considered as the presence of three or more of these characteristics and pre-frailty when one or two characteristics were present (Fried et al., 2001). Older adults categorised according to this definition, showed differences in the level of social, psychological and physical functioning between the three stages (Op het Veld et al., 2015).

In a systematic review where the prevalence of pre-frailty and frailty reported by studies in the community in older adults with 65 years or older was pooled, the average prevalence of pre-frailty was 41.6% and frailty of 10.7% (Collard, Boter, & Schoevers, 2012). Frailty numbers ranged substantially from 4% to 59.1% between the analysed studies. Nevertheless, when only studies using Fried's definition were analysed,

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frailty prevalence ranged from 4% to 17% (Collard et al., 2012).

To our knowledge, only one study in Portugal has reported the frequency of pre-frailty (44%) and frailty (56%) among 50 institutionalized older adults using Fried's criteria (Vieira et al., 2016). Thus, the burden of this condition among Portuguese older adults living in the community is still unknown. This is of major relevance because the proportion of older people in Portugal is increasing (Instituto Nacional de Estatística, 2015) and, consequently, the number of individuals at risk of frailty.

Using data from the Nutrition UP 65 study, we aim to identify the frequency of frailty in a sample of Portuguese with 65 years or older, and to evaluate its associated factors. We also intend to evaluate the contribution of the different criteria for the diagnosis of frailty.

2. Methods

This study used data from the Nutrition UP 65 study which is a cross-sectional observational study conducted in Portugal. Details regarding the recruitment, selection and measures were outlined elsewhere (Amaral et al., 2016). Briefly, Nutrition UP 65 included a sample of 1500 Portuguese with ≥65 years old, representative of the Portuguese older population in terms of age, sex, education and regional area. Individuals presenting any condition that precluded the collection of venous blood samples or urine (eg, dementia or urinary incontinence) were excluded from the study. For the current analysis, 43 individuals were excluded due to incomplete data regarding frailty assessment. Therefore, a total of 1457 older adults were included.

2.1. Data collection

Data were collected between December 2015 and June 2016 and information on each subject was gathered by means of an interview conducted by previously trained registered nutritionists, also responsible for anthropometric and functional data collection. Demographic data, cohabitation, professional occupation, lifestyle practices, health status and clinical history, cognitive performance, and nutritional status data were collected using a structured questionnaire. Lifestyle practices included current tobacco use and number of alcoholic drinks daily. Chronic diseases were evaluated by the presence of asthma; chronic bronchitis, chronic obstructive pulmonary disease, or emphysema; myocardial infarction or chronic consequences of myocardial infarction; coronary heart disease or angina pectoris; hypertension; stroke or chronic consequences of a stroke; arthrosis; lumbar pain or other chronic lumbar problems; neck pain or other chronic neck problems; diabetes; hepatic cirrhosis; allergies; chronic renal disease, including renal failure; urinary incontinence or bladder control problems; depression; other disease, diagnosed in the past year. The variable was categorised as: absence of chronic diseases; presence of 1 chronic disease; or presence of 2 or more chronic diseases (Holzer, Siebenhuener, Bopp, & Minder, 2014).

2.2. Cognitive and nutritional assessment

Cognitive performance was assessed by the Portuguese version of the Mini Mental State Examination. The cut-off scores for cognitive impairment are as follows: individuals with no education, ≤15 points; 1 to 11 years of school completed, ≤22 points; and > 11 years of school completed, ≤27 points (Guerreiro, 2010). The Portuguese version of the Mini-Nutritional Assessment® - Short Form (MNA-SF) was also applied. A participant scoring ≤7 out of 14 points was classified as undernourished, one that scores between 8 and 11 is at risk of undernutrition and one scoring between 12 and 14 points was considered well-nourished (Nestle Nutrition Institute, 2009).

2.3. Anthropometric measurements

Anthropometric measurements were collected following standard procedures (Stewart, Marfell-Jones, Olds, & Ridder, 2011). Intra and inter-rater observer error was calculated and ranged from 0.05 to 0.34% and 0.19 to 1.48%, respectively. Standing height was obtained with a calibrated stadiometer (SECA 213, SECA GmbH, Hamburg, Germany), with 0.1 cm resolution. For participants with visible kyphosis or when it was impossible to measure standing height due to participant's paralysis or due to mobility or balance limitations, height was obtained indirectly from non-dominant hand length (Guerra, Fonseca, Pichel, Restivo, & Amaral, 2014), measured with a calibrated paquimeter (Fervi Equipment, Vignola, Italy), with 0.1 centimeter resolution. Body weight (in kilograms) was measured with a calibrated portable electronic scale (SECA 803, SECA GmbH, Hamburg, Germany) with 0.1 kg resolution, with the participants wearing light clothes. When it was not possible to weigh a patient, body weight was estimated from mid-upper arm and calf circumferences (Chumlea, Guo, Roche, & Steinbaugh, 1988). Mid upper arm, waist and calf circumferences were measured with a metal tape measure (Lufkin W606 PM, Lufkin, Sparks, Maryland, USA), with 0.1 cm resolution. Triceps skinfold thickness was obtained using a Holtain Tanner/Whitehouse (Holtain, Ltd., Crosswell, United Kingdom) skinfold calliper, with 0.2 mm resolution.

2.4. Muscle strength and function

Non-dominant hand grip strength (HGS) was measured with a calibrated Jamar Plus Digital Hand Dynamometer (Sammons Preston Inc., Bolingbrook, Illinois, USA), with 0.1 Kgf resolution. Individuals were asked to sit in a chair without arm rest, with their shoulders adducted, their elbows flexed 90° and their forearms in neutral position, as recommended by the American Society of Hand Therapists (Fess, 1992). Each participant performed three measurements with a one minute pause between them and the higher value, recorded in kilogram-force (kgf), was used for the analysis. When the individual was unable to perform the measurement with the non-dominant hand, the dominant hand was used.

Walking time was measured over a distance of 4.6 m with a chronometer (School electronic stopwatch, Dive049, Topgim, Portugal) and walking time in seconds was recorded. Participants were asked to walk at their usual pace in an unobstructed corridor. Those unable to walk due to mobility or balance limitations were considered frail for this criterion (n = 28).

2.5. Self-reported exhaustion and physical activity levels

Self-reported exhaustion was measured using two items from the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977). The following two statements were read: "I felt that everything I did was an effort" and "In the last week I could not get going." The exhaustion criterion was considered present if a participant answered "a moderate amount of the time" or "most of the time" to the question: "How often in the last week did you feel this way?".

Physical activity was assessed by the short form of the International Physical Activity Questionnaire (Craig et al., 2003). Information regarding the previous seven days, namely on how many days and how much time the participant spent: walking or hiking (at home or at work, moving from place to place, for recreation or sport), sitting (at a desk, visiting friends, reading, studying or watching television), moderate activities (carrying light objects, hunting, carpentry, gardening, cycling at a normal pace or tennis in pairs) and vigorous activities, namely lifting heavy objects, agriculture, digging, aerobics, swimming, playing football and cycling at a fast pace was gathered.

A weighted estimate of total physical activity (MET-minutes per week) from all reported activities per week was obtained through the sum of the duration of the activity × frequency per week × MET intensity of each activity domain included in the questionnaire, which was then converted to kilocalories expended per week (Craig et al., 2003).

2.6. Frailty status

Frailty, according to Fried et al. frailty phenotype, encompasses the assessment of the five following criteria: shrinking: evaluated by self-reported unintentional weight loss (> 4.5 kg lost unintentionally in prior year); weakness: evaluated as low HGS adjusted for gender and BMI [Men: ≤29 kgf (BMI ≤ 24 kg/m^2), ≤30 kgf (BMI 24.1–26 kg/m^2), ≤30 kgf (BMI 26.1–28 kg/m^2), ≤32 kgf (BMI > 28 kg/m^2)/Women: ≤17 kgf (BMI ≤ 23 kg/m^2), ≤17.3 kgf (BMI 23.1–26 kg/m^2), ≤18 kgf (BMI 26.1–29 kg/m^2), ≤21 kgf (BMI > 29 kg/m^2)]; poor endurance and energy: evaluated as self-reported exhaustion; slowness: walking time measurement adjusted for gender and standing height; and low physical activity: kilocalories expended per week, adjusted for gender (men < 383 Kcals/week and women < 270 Kcals/week). If one or two of these criteria were present, the individual was characterized as pre-frail. Frailty was defined as the presence of three or more criteria (Fried et al., 2001).

2.7. Ethics

This research was conducted according to the guidelines established by the Declaration of Helsinki, and the study protocol was approved by the Ethics Committee of the department of "Ciências Sociais e Saúde" (Social Sciences and Health) from the "Faculdade de Medicina da Universidade do Porto" (PCEDCSS – FMUP 15/2015) and by the Portuguese National Commission of Data Protection (9427/2015). All study participants signed an informed consent form.

2.8. Statistical analyses

Statistical analyses were performed with IBM SPSS Statistics 23 (SPSS, Inc, an IBM Company, Chicago, IL). Descriptive analyses were conducted to show the characteristics of the study sample according to frailty status. Kolmogorov-Smirnov test was used to evaluate the normality of the distribution for quantitative variables and results were presented as median and interquartile range (IQR) for non-normal data. For categorical variables, results were expressed as number of participants (percentage). Included and excluded individuals were compared using Chi-square test or Fisher's exact test. Prevalence of each individual frailty criteria was also estimated according with frailty status.

A logistic regression was carried out and the crude and adjusted odds ratios (OR) and their respective 95% confidence intervals (CI) were calculated as measures of association in two different models, with pre-frailty and frailty as dependent variables. Gender, age, interviewer, regional area, residential status, marital status, professional status, smoking status, alcohol consumption, self-assessed health status, cognitive function, BMI classification and undernutrition status were variables included in the models. Unanswered questions or missing values for marital status (n = 1), professional status (n = 5), alcohol consumption (n = 2), self-assessed health status (n = 4) and BMI classification (n = 3), were included in the reference groups. Regarding BMI classification, underweight individuals were also included in the reference group due to its small number (n = 3).

Confidence intervals were computed at 95% and statistical significance was defined by $p < 0.05$.

Table 1
Characteristics of study participants, according to frailty status*.

	N (%)		
	Normal 353 (24.2)	Pre-frailty 791 (54.3)	Frailty 313 (21.5)
Gender			
Women	164 (46.5)	462 (58.4)	216 (69.0)
Men	189 (53.5)	329 (41.6)	97 (31.0)
Age (years), median (IQR)	70.0 (6.0)	74.0 (10.0)	80.0 (10.0)
Age			
65–75 years	286 (81.0)	448 (56.6)	97 (31.0)
> 75 years	67 (19.0)	343 (43.4)	216 (69.0)
Regional Area			
North	121 (34.3)	238 (30.1)	98 (31.3)
Centre	92 (26.1)	202 (25.5)	90 (28.8)
Lisbon	84 (23.8)	208 (26.3)	85 (27.2)
Alentejo	41 (11.6)	67 (8.5)	21 (6.7)
Algarve	6 (1.7)	38 (4.8)	14 (4.5)
Madeira	9 (2.5)	18 (2.3)	1 (0.3)
Azores	0 (0.0)	20 (2.5)	4 (1.3)
Residence			
Home	348 (98.6)	757 (95.7)	280 (89.5)
Care home	5 (1.4)	34 (4.3)	33 (10.5)
Education level			
Without education	15 (4.2)	113 (14.3)	78 (24.9)
1–4 years	232 (65.7)	555 (70.2)	213 (68.1)
5–12 years	72 (20.4)	94 (11.9)	18 (5.8)
Higher education	34 (9.6)	29 (3.7)	4 (1.3)
Marital status			
Single	23 (6.5)	57 (7.2)	30 (9.6)
Married or common-law marriage	229 (64.8)	371 (46.9)	83 (26.5)
Divorced	25 (7.1)	62 (7.8)	27 (8.6)
Widower	76 (21.5)	300 (37.9)	173 (55.3)
Professional status			
Active	15 (4.3)	13 (1.6)	2 (0.6)
Not active	337 (95.7)	776 (98.4)	309 (99.4)
Smoking status			
Non-smoker	334 (94.6)	757 (95.7)	300 (95.8)
Smoker	19 (5.4)	34 (4.3)	13 (4.2)
Alcohol consumption			
None	92 (26.1)	410 (52.0)	209 (66.8)
Moderate (W: ≤1/day; M: ≤2/day)	211 (59.8)	300 (38.0)	86 (27.5)
Excessive (W: > 1/day; M: > 2/day)	50 (14.2)	79 (10.0)	18 (5.8)
Cognitive function (MMSE)			
Normal	346 (98.0)	745 (94.2)	272 (86.9)
Impaired	7 (2.0)	46 (5.8)	41 (13.1)
Self-perception of health status			
Very good	34 (9.7)	24 (3.0)	9 (2.9)
Good	141 (40.1)	219 (27.8)	36 (11.5)
Fair	164 (46.6)	406 (51.5)	145 (46.5)
Poor	12 (3.4)	121 (15.3)	92 (29.5)
Very poor	1 (0.3)	19 (2.4)	30 (9.6)
Self-reported chronic diseases (number)			
None	11 (3.1)	20 (2.5)	1 (0.3)
1	38 (10.8)	65 (8.3)	17 (5.4)
≥2	303 (86.1)	700 (89.2)	294 (94.2)
Undernutrition status (MNA-SF)			
Not undernourished	334 (94.6)	683 (86.3)	210 (67.1)
Undernutrition risk	19 (5.4)	103 (13.0)	90 (28.8)
Undernutrition	0 (0.0)	5 (0.6)	13 (4.2)

IQR – Interquartile range; W – Women; M – Men; MMSE – Mini mental state examination; MNA-SF – Mini nutritional assessment – Short form.
*Column percentages may not add to 100% due to rounding. Information was not obtained: Marital status n = 1 (0.1%); Professional status n = 5 (0.3%); Alcohol consumption n = 2 (0.1%); Self-perception of health status n = 4 (0.2%); Self-reported chronic diseases n = 8 (0.5).

3. Results

The 1457 participants evaluated were aged 65–100 years old, in which 57.0% were between 65 and 75 years, and 57.8% were women. Excluded individuals did not differ from included individuals in all the studied characteristics, except for regional area ($p = 0.005$), BMI ($p = 0.033$) and alcohol consumption ($p = 0.012$), where excluded individuals were more likely to be underweight or have normal weight and not drinking alcohol (Supplementary Table 1). However, even without statistically significant differences, excluded individuals were more frequently women and also more frequently classified as cognitively impaired, as undernourished or at undernutrition risk.

The characteristics of the study sample by frailty status are presented in Table 1. Frequency of pre-frailty and frailty according to Fried's criteria was 54.3% and 21.5%, respectively. More than one third of older adults were obese, according with BMI (38.9%) and pre-frail and frail individuals were more likely to be in this category. Almost 83% of the participants had low education level (≤4 years of schooling). In addition, the majority of the individuals reported having chronic diseases (97.3%), and 31.8% considered their health status as good or very good.

Results regarding anthropometric, functional and physical activity measures are presented in Table 2. BMI distribution by frailty status varied according to gender. Higher BMI values were observed in frail women ($p \leq 0.001$). Frail men presented and lower calf and mid-arm muscle circumferences values ($p \leq 0.001$).

Concerning the functional measures included in frailty criteria (HGS, walking time and physical activity), lower values were observed across frailty stages for both men and women (Table 2), with men generally performing better than women for all tests (data not shown).

The results of logistic regression are displayed in Table 3. In this multivariate analysis, frailty was associated with age > 75 (OR 7.33, CI 4.14–12.97), higher education level (OR 0.03, CI 0.01–0.15), being married or in common-law marriage (OR 0.51, CI 0.29–0.88), being professionally inactive (OR 6.67, CI 1.13–39.32), poor or very poor self-perception of health status (OR 12.56, CI 5.18–30.47), moderate alcohol consumption (OR 0.23, CI 0.13–0.42), obesity (OR 5.24, CI 2.35–11.68) and being undernourished or at undernutrition risk (OR 16.30, CI 6.71–39.56). Pre-frailty was also associated with most of these variables, marital and professional status.

Fig. 1 shows the distribution of the five criteria: weakness assessed by HGS, exhaustion, walking time, physical activity and unintentional weight loss, according to frailty status. Weakness was by far the most prevalent criterion in the total number of older adults with pre-frailty or frailty (76.7%), followed by exhaustion (48.6%). Unintentional weight loss was only reported in 10.3% of the participants with these conditions.

Table 2
Anthropometric, functional and physical activity measures[†].

	Normal	Pre-frailty	Frailty	*p*-value
BMI (kg/m^2), median (IQR)				
Women	27.7 (5.0)	29.7 (6.7)	30.4 (7.2)	< 0.001[a]
Men	27.9 (4.3)	28.5 (5.2)	28.4 (7.6)	0.387[a]
BMI classification (WHO), n (%)				
Underweight/Normal weight	73 (20.7)	114 (14.4)	53 (17.1)	< 0.001[b]
Overweight	187 (53.0)	355 (44.9)	105 (33.9)	
Obesity	93 (26.3)	322 (40.7)	152 (49.0)	
MAMC (cm), median (IQR)				
Women	22.2 (3.2)	22.6 (4.0)	22.4 (3.9)	0.269[a]
Men	25.6 (3.5)	24.4 (4.0)	23.4 (3.0)	< 0.001[a]
Waist circumference, n (%)				
Women: ≤ 80 cm; Men: ≤ 94 cm	63 (17.8)	88 (11.1)	29 (9.6)	< 0.001[b]
Women: 81–88 cm; Men: 95–102 cm	105 (29.7)	157 (19.8)	42 (14.0)	
Women: > 88 cm; Men: > 102 cm	185 (52.4)	546 (69.0)	230 (76.4)	
Calf circumference (cm), median (IQR)				
Women	35.5 (4.1)	35.5 (4.2)	35.2 (5.1)	0.847[a]
Men	37.0 (4.0)	35.8 (4.5)	35.0 (4.4)	< 0.001[a]
Maximal HGS (kgf), median (IQR)				
Women	23.0 (4.9)	17.4 (5.8)	14.5 (5.6)	< 0.001[a]
Men	37.8 (8.9)	27.6 (8.7)	21.4 (8.4)	< 0.001[a]
Walking time (s), median (IQR)				
Women	4.2 (1.4)	5.5 (2.6)	8.9 (4.5)	< 0.001[a]
Men	4.1 (1.4)	5.1 (2.3)	8.3 (5.8)	< 0.001[a]
Physical activity (MET·min·wk-1), median (IQR)				
Women	2826.0 (4432.0)	1636.5 (2444.0)	146.0 (600.0)	< 0.001[a]
Men	2772.0 (3235.0)	1729.5 (4013.0)	219.0 (796.0)	< 0.001[a]

BMI – Body mass index; IQR – Interquartile range; WHO – World Health Organization; MAMC – Mid-arm muscle circumference; HGS – Handgrip strength; MET – Metabolic equivalent.

[†] Column percentages may not add to 100% due to rounding. Missing cases: BMI n = 3 (0.2%), Waist circumference n = 12 (0.8%), Walking time n = 46 (3.2%).

[a] Kruskal-Wallis test.

[b] Qui-square test.

4. Discussion

According with Fried's frailty scale, pre-frailty and frailty are very frequent in Portuguese older adults. Almost three quarters of the individuals presented at least one frailty criterion, and older individuals were more likely to be affected. Moreover, these individuals showed more frequently low HGS, over other criteria. Several factors, such as being professionally inactive, having poor or very poor self-assessed health status, obesity and being undernourished or at undernutrition risk were associated with worse frailty status.

The frequency of pre-frailty (54.3%) and frailty 21.5%) was higher compared with the original report in the Cardiovascular Health Study (6.9%) (Fried et al., 2001). In Europe, the frequency of frailty and of pre-frailty was evaluated in ten different countries and it was found that southern European countries presented a higher frequency of frailty and pre-frailty, indicating the possibility of an existing north-south gradient (Santos-Eggimann, Cuénoud, Spagnoli, & Junod, 2009). Although Portugal was not included in this study, based in the cultural similarities, a comparable frequency of frailty and pre-frailty to that observed in other southern European countries was expected. When our results were compared with those from these countries, frailty frequency (21.5%) was lower than in Spain (27.3%) and in Italy (23%) but higher than in Greece (14.7%) (Santos-Eggimann et al., 2009). However, pre-frailty frequency was higher (54.3%) compared to the previously reported in Spain (50.3%), Italy (45.6%) and Greece (44.9%) (Santos-Eggimann et al., 2009). Similarly, results from FRADEA study (Spain) have shown a high frequency of pre-frailty (48.5%) and frailty (21.3%), but they also included a larger number of institutionalized older adults (21.3% versus 4.9% in our sample) (Abizanda Soler et al., 2011), which has been associated with worsen frailty status (Garrido, Serrano, Bartolome, & Martinez-Vizcaino, 2012; Gonzalez-Vaca et al., 2014). On the other hand, data from the InCHIANTI study, in Italy, reported much lower values 37.8% and 6.5% for pre-frailty and frailty, respectively (Ble et al., 2006). Analogous results were observed in Toledo study for healthy ageing (Garcia-Garcia, 2011) and FRALLE survey (Jurschik et al., 2012), in Spain, in which frailty prevalence was 8.4% in the first, and 9.6% in the second. Pre-frailty values were slightly higher for the two latest studies (41.8% and 47%) (Garcia-Garcia, 2011;Jurschik et al., 2012).

Even though Fried's frailty definition was used in the aforementioned studies, variations in the results may be the result of the

Table 3
Results from the bivariate and multivariate logistic regression analyses, regarding pre-frailty and frailty status.

	Pre-frailty				Frailty			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	OR (CI 95%)	*p*-value	OR (CI 95%)	*p*-value	OR (CI 95%)	*p*-value	OR (CI 95%)	*p*-value
Gender								
Women	1		1		1		1	
Men	0.62 (0.48-0.80)	< 0.001	0.93 (0.68–1.28)	0.657	0.39 (0.28–0.54)	< 0.001	0.64 (0.36–1.13)	0.124
Age								
65–75 years	1		1		1		1	
> 75 years	3.27 (2.42–4.42)	< 0.001	2.66 (1.87–3.77)	< 0.001	9.51 (6.65–13.60)	< 0.001	7.33 (4.14–12.97)	< 0.001
Residence								
Home	1		1		1		1	
Care home	3.13 (1.21–8.06)	0.018	1.95 (0.67–5.72)	0.222	8.20 (3.16–21.29)	< 0.001	3.52 (0.91–13.58)	0.068
Education level								
Without education	1		1		1		1	
1–4 years	0.32 (0.18–0.56)	< 0.001	0.58 (0.32–1.07)	0.080	0.18 (0.10–0.32)	< 0.001	0.31 (0.13–0.73)	0.008
5–7 years	0.17 (0.09–0.32)	< 0.001	0.33 (0.17–0.66)	0.002	0.05 (0.02–0.10)	< 0.001	0.09 (0.03–0.29)	< 0.001
Higher education	0.11 (0.05–0.24)	< 0.001	0.20 (0.09–0.46)	< 0.001	0.02 (0.01–0.07)	< 0.001	0.03 (0.01–0.15)	< 0.001
Marital status								
Single, divorced or widower	1		1		1		1	
Married or common-law marriage	0.48 (0.37–0.62)	< 0.001	0.83 (0.60–1.14)	0.239	0.20 (0.14–0.27)	< 0.001	0.51 (0.29–0.88)	0.016
Professional status								
Active	1		1		1		1	
Not active	2.46 (1.20–5.03)	0.014	2.10 (0.89–4.94)	0.090	3.67 (1.21–11.09)	0.021	6.67 (1.13–39.32)	0.036
Smoking status								
Non-smoker	1		1		1		1	
Smoker	0.79 (0.44–1.40)	0.421	1.46 (0.77–2.77)	0.253	0.76 (0.37–1.57)	0.460	1.43 (0.42–4.85)	0.565
Alcohol consumption								
None	1		1		1		1	
Moderate (W: ≤1/day; M: ≤2/day)	0.32 (0.24–0.42)	< 0.001	0.42 (0.30–0.59)	< 0.001	0.18 (0.13–0.26)	< 0.001	0.23 (0.13–0.42)	< 0.001
Excessive (W: > 1/day; M: > 2/day)	0.35 (0.23–0.54)	< 0.001	0.51 (0.31–0.83)	0.007	0.16 (0.09–0.29)	< 0.001	0.14 (0.05–0.43)	0.001
Cognitive function (MMSE)								
Normal	1		1		1		1	
Impaired	3.05 (1.36–6.83)	0.007	2.08 (0.83–5.20)	0.117	7.45 (3.29–16.87)	< 0.001	2.62 (0.71–9.64)	0.148
Self-perception of health status								
Very good or good	1		1		1		1	
Fair	1.78 (1.36–2.32)	< 0.001	1.71 (1.26–2.32)	0.001	3.38 (2.28–5.02)	< 0.001	2.20 (1.21–4.00)	0.010
Poor or very poor	7.74 (4.24–14.10)	< 0.001	4.89 (2.58–9.27)	< 0.001	35.91 (18.60–69.30)	< 0.001	12.56 (5.18–30.47)	< 0.001
BMI classification (WHO)								
Underweight/Normal weight	1		1		1		1	
Overweight	1.22 (0.86–1.71)	0.265	1.64 (1.10–2.45)	0.016	0.73 (0.48–1.12)	0.148	1.38 (0.66–2.92)	0.394
Obesity	2.22 (1.53–3.22)	< 0.001	2.70 (1.75–4.15)	< 0.001	2.13 (1.38–3.29)	0.001	5.24 (2.35–11.68)	< 0.001
Undernutrition status (MNA-SF)								
Not undernourished	1		1		1		1	
Undernutrition or undernutrition risk	2.78 (1.68–4.61)	< 0.001	2.69 (1.53–4.75)	0.001	8.62 (5.13–14.49)	< 0.001	16.30 (6.71–39.56)	< 0.001

OR – Odds ratio; CI – Confidence interval; W – Women; M – Men; MMSE – Mini mental state examination; BMI – Body mass index; WHO – World Health Organization; MNA-SF – Mini nutritional assessment – Short form.

differences within the frailty criteria used. Namely in the SHARE study, which reported higher frequencies when compared with other studies conducted in the same areas. In these, operationalization of the criteria was different from the Cardiovascular Health Study, except for weakness, which can explain the contradictory results across studies. Nevertheless, the present study reveals much higher frequencies of pre-frailty and frailty even when compared with results from studies with fewer differences in the used criteria (Ble et al., 2006; Fried et al., 2001;Garcia-Garcia, 2011).

Due to the higher frequency of this syndrome among Portuguese older adults, the prevalence of each frailty criterion is expected to be much higher, than the previously found in other studies. In the present study, a higher prevalence of weakness among pre-frail and frail older adults was observed and exhaustion was the second most prevalent criterion. In contrast, other studies reported larger prevalence of exhaustion over weakness with similar patterns in the three less prevalent criteria presented (Drey, Pfeifer, Sieber, & Bauer, 2011; Santos-Eggimann et al., 2009). In the Cardiovascular Health Study, low activity was the most prevalent criterion, followed by slowness and weakness in second. Weight loss was the less frequent criterion, as observed in the present study (Fried et al., 2001). Nevertheless, in the InCHIANTI study, different patterns were observed in the first three more prevalent criteria, slowness was the first, weakness the second, and exhaustion the third (Ble et al., 2006). Results concerning the onset of frailty showed that weakness was the most common first manifestation, despite the significant heterogeneity in the initial manifestations of frailty, with early development of weight loss or exhaustion predicting more rapid onset of the frailty syndrome (Xue, Bandeen-Roche, Varadhan, Zhou, & Fried, 2008). While the cross-sectional nature of present study does not allow us to establish temporal inferences, weakness was still the most prevalent criterion in the pre-frail participants.

This study extends the findings of others, showing that frailty

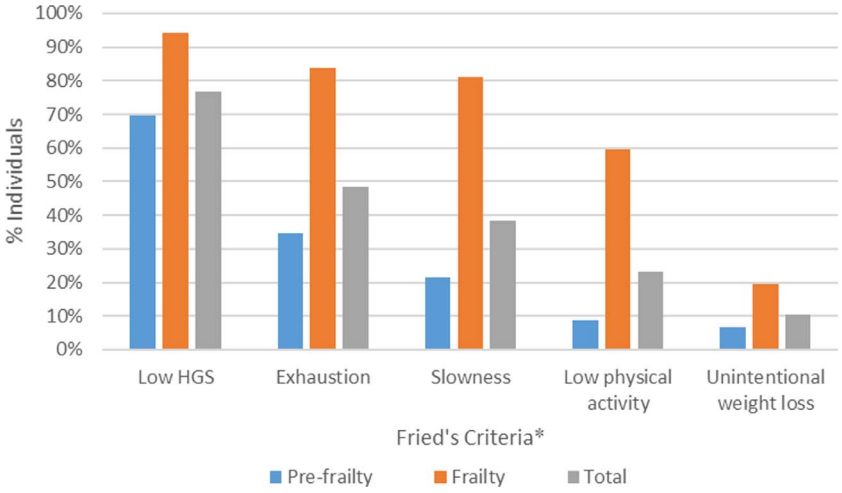

Fig. 1. Distribution of the five frailty criteria among pre-frail and frail older adults.
HGS – Handgrip strength
* Cut-off points: HGS – Men: ≤29 kgf (BMI ≤ 24 kg/m^2), ≤30 kgf (BMI 24.1–26 kg/m^2), ≤30 kgf (BMI 26.1–28 kg/m^2), ≤32 kgf (BMI > 28 kg/m^2) / Women: ≤17 kgf (BMI ≤ 23 kg/m^2), ≤17.3 kgf (BMI 23.1–26 kg/m^2), ≤18 kgf (BMI 26.1–29 kg/m^2), ≤21 kgf (BMI > 29 kg/m^2); Exhaustion – Modified 10-item CES-D ("I felt that everything I did was an effort" ≥3 days in the past week or "I could not get 'going'" ≥3 days in the past week); Slowness: Men: ≥7 seconds (height ≤ 173 cm), ≥6 seconds (heigh > 173 cm) / Women: ≥7 seconds (height ≤ 159 cm), ≥6 seconds (height > 159 cm); Low physical activity – Men < 383 Kcals/week / Women < 270 Kcals/week; Unintentional weight loss: > 4.5 kg lost unintentionally in prior year.

prevalence increased with age, which may be associated to the physiologic changes inherently associated with the ageing process. Nevertheless, the expected positive association between female gender and frailty status was not observed, even though women were in a higher number in the present study (Collard et al., 2012). Additionally, a moderate and an excessive alcohol consumption was inversely associated with frailty status. Comparable results were reported by a systematic review aimed to study the relationship between alcohol consumption and frailty risk (Kojima, Liljas, Iliffe, Jivraj, & Walters, 2017). However, the possibility of reverse causality has been pointed out, in which the reduction in alcohol consumption starts when individuals become more frail (Kojima et al., 2017).

Present results show that a lower educational level was also associated with higher frequency of pre-frailty and frailty. One possible explanation to this association may be the fact that individuals with more education have more access to information and better healthy behavior awareness, and also a higher socioeconomic status. Considering Portugal background, these were the individuals with a privileged access to education. Although in the Cardiovascular Health study, differences regarding education level were not found (Hirsch et al., 2006), similar results reported by several other studies are in line with our findings (Espinoza, Jung, & Hazuda, 2012; Hoogendijk et al., 2014; Szanton, Seplaki, Thorpe, Allen, & Fried, 2010). Plus, in the Longitudinal Aging Study Amsterdam (LASA), it was observed that low education level was associated with frailty, but although the prevalence of frailty increased over time, the rate of increase did not vary across education levels (Hoogendijk et al., 2014).

In the NHANES study, frailty prevalence was highest among obese followed by overweight participants (Smit, Winters-Stone, Loprinzi, Tang, & Crespo, 2013). Even though, present data showed that overweight status was only associated with pre-frailty, whereas obesity was positively associated with both pre-frailty and frailty. These results are in line with data from Women Health and Aging study (Blaum, Xue, Michelon, Semba, & Fried, 2005). For each BMI category, a similar pattern to the one described for all categories concerning the prevalence of frailty criteria was observed (Blaum et al., 2005). In this sample, overweight and obese people have lower physical activity levels and higher levels of exhaustion, which can explain this association as physical activity and exhaustion are both criteria used to determine frailty status. Additionally, professionally inactive people were also more physical inactive (data not shown).

The results regarding the association of pre-frailty and frailty with undernutrition status demonstrated that frail older adults are also more likely to be undernourished or at undernutrition risk. Indeed, the close association between these syndromes was previously highlighted (Bollwein et al., 2013). It is worth noting that questions about weight loss and mobility are included in the MNA-SF and are similar to some frailty criteria.

This study has some strengths. It used data from a nationwide sample of the Portuguese older adult population. Although forty-three individuals were excluded, when included and excluded individuals were compared, differences between them were only observed regarding the regional area, BMI and alcohol consumption. Even though, the possibility that the lack of statistical significance is related with the low number of excluded individuals and a consequence of type II error cannot be ruled out.

The cross-sectional design of this study is a limitation, as we are unable to determine the direction of the associations established. Fried's criteria to evaluate frailty status was adopted, however the International Physical Activity Questionnaire was chosen instead of the Minnesota Leisure Time Activities Questionnaire. The latter was used in the proposed definition to assess physical activity levels, which can lead to variations in the results. However, studies about this matter are still lacking.

5. Conclusion

This condition is very prevalent in Portuguese older adults, one fifth are frail whereas half are pre-frail. Nevertheless, comparison with other studies is hampered by the differences between them. Age > 75, being professionally inactive, poor self-perception of health status, being obese and undernourished or at undernutrition risk increased frailty risk, whereas a higher education level, being married or living together and alcohol consumption were associated with a decreased frailty risk. Pre-frail and frail Portuguese older adults manifest low HGS as the most prevalent criterion, over other frailty criteria.

Conflicts of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.archger.2017.10.018.

References

Abizanda Soler, P., Lopez-Torres Hidalgo, J., Romero Rizos, L., Lopez Jimenez, M., Sanchez Jurado, P. M., Atienzar Nunez, P., et al. (2011). [Frailty and dependence in Albacete (FRADEA study): Reasoning, design and methodology]. *Revista Espanola De Geriatria Y Gerontologia, 46*(2), 81–88.

Amaral, T. F., Santos, A., Guerra, R. S., Sousa, A. S., Álvares, L., Valdiviesso, R., et al. (2016). Nutritional strategies facing an older demographic: The Nutrition UP 65 study protocol. *JMIR Research Protocols, 5*(3).

Blaum, C. S., Xue, Q. L., Michelon, E., Semba, R. D., & Fried, L. P. (2005). The association between obesity and the frailty syndrome in older women: The Women's Health and Aging Studies. *Journal of the American Geriatrics Society, 53*(6), 927–934.

Ble, A., Cherubini, A., Volpato, S., Bartali, B., Walston, J. D., Windham, B. G., et al. (2006). Lower plasma vitamin E levels are associated with the frailty syndrome: The InCHIANTI Study. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 61*(3), 278–283.

Bollwein, J., Volkert, D., Diekmann, R., Kaiser, M. J., Uter, W., Vidal, K., et al. (2013). Nutritional status according to the mini nutritional assessment (MNA®) and frailty in community dwelling older persons: A close relationship. *The Journal of Nutrition, Health & Aging, 17*(4), 351–356.

Bouillon, K., Kivimaki, M., Hamer, M., Sabia, S., Fransson, E. I., Singh-Manoux, A., et al. (2013). Measures of frailty in population-based studies: An overview. *BMC Geriatrics, 13*(1), 64.

Chen, X., Mao, G., & Leng, S. X. (2014). Frailty syndrome: An overview. *Clinical Interventions in Aging, 9*, 433–441.

Chumlea, W. C., Guo, S., Roche, A. F., & Steinbaugh, M. L. (1988). Prediction of body weight for the nonambulatory elderly from anthropometry. *Journal of the American Dietetic Association, 88*(5), 564–568.

Collard, R. M., Boter, H., & Schoevers, R. A. (2012). Oude Voshaar RC: Prevalence of frailty in community-dwelling older persons: A systematic review. *Journal of the American Geriatrics Society, 60*(8), 1487–1492.

Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., et al. (2003). International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise, 35*(8), 1381–1395.

Drey, M., Pfeifer, K., Sieber, C. C., & Bauer, J. M. (2011). The Fried frailty criteria as inclusion criteria for a randomized controlled trial: Personal experience and literature review. *Gerontology, 57*(1), 11–18.

Espinoza, S. E., Jung, I., & Hazuda, H. (2012). Frailty transitions in the San Antonio Longitudinal Study of Aging. *Journal of the American Geriatrics Society, 60*(4), 652–660.

Fess, E. (1992). *Clinical assessment recommendations.* Chicago: American Society of Hand Therapist.

Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., et al. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(3), M146–M157.

Garcia-Garcia, F. J., Gutierrez Avila, G., Alfaro-Acha, A., Amor Andres, M. S., De Los Angeles de la Torre Lanza, M., Escribano Aparicio, M. V., et al. (2011). The prevalence of frailty syndrome in an older population from Spain. The Toledo study for healthy aging. *The Journal of Nutrition, Health & Aging, 15*(10), 852–856.

Garrido, M., Serrano, M. D., Bartolome, R., & Martinez-Vizcaino, V. (2012). [Differences in the expression of the frailty syndrome in institutionalized elderly men and women with no severe cognitive decline]. *Revista Espanola De Geriatria Y Gerontologia, 47*(6), 247–253.

Gonzalez-Vaca, J., de la Rica-Escuin, M., Silva-Iglesias, M., Arjonilla-Garcia, M. D., Varela-Perez, R., Oliver-Carbonell, J. L., et al. (2014). Frailty in INstitutionalized older adults from ALbacete The FINAL Study: Rationale, design, methodology, prevalence and attributes. *Maturitas, 77*(1), 78–84.

Guerra, R. S., Fonseca, I., Pichel, F., Restivo, M. T., & Amaral, T. F. (2014). Hand length as an alternative measurement of height. *European Journal of Clinical Nutrition, 68*(2), 229–233.

Guerreiro, M. (2010). *Testes de rastreio de defeito cognitivo e demência: Uma perspectiva prática].* 8 26 (1).

Hirsch, C., Anderson, M. L., Newman, A., Kop, W., Jackson, S., Gottdiener, J., et al. (2006). The association of race with frailty: The Cardiovascular Health Study. *Annals of Epidemiology, 16*(7), 545–553.

Holzer, B. M., Siebenhuener, K., Bopp, M., & Minder, C. E. (2014). Overcoming cut-off restrictions in multimorbidity prevalence estimates. *BMC Public Health, 14*.

Hoogendijk, E. O., van Hout, H. P. J., Heymans, M. W., van der Horst, H. E., Frijters, D. H. M., Broese van Groenou, M. I., et al. (2014). Explaining the association between educational level and frailty in older adults: Results from a 13-year longitudinal study in the Netherlands. *Annals of Epidemiology, 44*, e2.

Instituto Nacional de Estatística (2015). *Envelhecimento da população residente em Portugal e na União Europeia].*

Jurschik, P., Nunin, C., Botigue, T., Escobar, M. A., Lavedan, A., & Viladrosa, M. (2012). Prevalence of frailty and factors associated with frailty in the elderly population of Lleida, Spain: The FRALLE survey. *Archives of Gerontology and Geriatrics, 55*(3), 625–631.

Kojima, G., Liljas, A., Iliffe, S., Jivraj, S., & Walters, K. (2017). A systematic review and meta-analysis of prospective associations between alcohol consumption and incident frailty. *Age and Ageing*, 1–9.

Nestle Nutrition Institute, MNA Mini Nutritional Assessment, 2009 [Available from: http://www.mna-elderly.com/forms/mini/mna_mini_portuguese.pdf].

Op het Veld, L. P. M., van Rossum, E., Kempen, G. I. J. M., de Vet, H. C. W., Hajema, K., & Beurskens Fried, A. J. H. M. (2015). phenotype of frailty: Cross-sectional comparison of three frailty stages on various health domains. *BMC Geriatrics, 15*(1), 77.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*(3), 385–401.

Rockwood, K., Song, X., MacKnight, C., Bergman, H., Hogan, D. B., McDowell, I., et al. (2005). A global clinical measure of fitness and frailty in elderly people. *CMAJ: Canadian Medical Association Journal, 173*(5), 489–495.

Romero-Ortuno, R., Walsh, C. D., Lawlor, B. A., & Kenny, R. A. (2010). A frailty instrument for primary care: Findings from the Survey of Health, Ageing and Retirement in Europe (SHARE). *BMC Geriatrics, 10*, 57.

Santos-Eggimann, B., Cuénoud, P., Spagnoli, J., & Junod, J. (2009). Prevalence of frailty in middle-aged and older community-dwelling europeans living in 10 countries. *The Journals of Gerontology Series ABiological Sciences and Medical Sciences, 64a*(6), 675–681.

Smit, E., Winters-Stone, K. M., Loprinzi, P. D., Tang, A. M., & Crespo, C. J. (2013). Lower nutritional status and higher food insufficiency in frail older US adults. *The British Journal of Nutrition, 110*(1), 172–178.

Stewart, A., Marfell-Jones, M., Olds, T., & Ridder, H. (2011). International standards for anthropometric assessment Potchefstroom, South Africa. *International Society for the Advancement of Kinanthropometry*.

Szanton, S. L., Seplaki, C. L., Thorpe, R. J., Allen, J. K., & Fried, L. P. (2010). Socioeconomic status is associated with frailty: The Women's Health and Aging Studies. *Journal of Epidemiology and Community Health, 64*(1), 63–67.

Vieira, A. I., Nogueira, D., de Azevedo Reis, E., da Lapa Rosado, M., Vania Nunes, M., & Castro-Caldas, A. (2016). Hand tactile discrimination, social touch and frailty criteria in elderly people: A cross sectional observational study. *Archives of Gerontology and Geriatrics, 66*, 73–81.

Xue, Q. L., Bandeen-Roche, K., Varadhan, R., Zhou, J., & Fried, L. P. (2008). Initial manifestations of frailty criteria and the development of frailty phenotype in the Women's Health and Aging Study II The Journals of Gerontology Series A. *Biological Sciences and Sedical Sciences, 63*(9), 984–990.

Xue, Q. L. (2011). The frailty syndrome: Definition and natural history. *Clinics in Geriatric Medicine, 27*(1), 1–15.