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Analysis of the characteristics and components for the frailty syndrome in older adults from central Chile. The PIEI-ES study

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ABSTRACT

Objective: To determine the prevalence and to characterize frailty in elderly subjects in four urban provincial capitals and two rural communes from Maule Region in Chile.
Design: Cross-sectional study.
Participants: 1205 participants aged 65 and older.
Methods: The dataset was obtained from the PIEI-ES Study. Frailty syndrome was determined according to the criteria proposed by Fried. Data collection included questionnaires.
Results: The study sample included 1205 individuals, of which 68% were females. Mean age was 73 years. The overall prevalence of frailty was 24.6%. Increase prevalence of frailty was observed in people 80 years old and older, both in women and men. Using adjusted logistic regression, advanced frailty state was more likely to occur in subjects with cognitive impairment.
Conclusion: This study provides evidence that frailty may be related with cognitive functioning, educational level and nutritional status in older adults.

1. Introduction

The world's population is growing and aging due to declining fertility rates and/or rising life expectancy (Christensen, Doblhammer, Rau, & Vaupel, 2009; Lunenfeld, 2008). From 1970 to 2010, global male life expectancy at birth increased from 56 to 67 years and global female life expectancy at birth increased from 61 to 73 years (Wang et al., 2012). Although epidemiologic studies show that 11% of the world's population is over 60 years of age, by 2050 this number is expected to increase to 22% (Kanasi, Ayilavarapu, & Jones, 2016). Chile is not oblivioous to this situation. During the last 30 years, the population has experienced a process of accelerated demographic aging and it is expected that by 2050 older adults will represent about 28% (CELADE, 2007). These changes will impact individuals, families, governments, and private-sector organizations, as they seek to answer questions related to the burden of disease and disability (Global Burden of Disease Study 2013 Collaborators, 2015).

Aging can be defined as the decline and deterioration of functional properties at the cellular, tissue and organ level. This loss of functional properties yields to a loss of homeostasis and decreased adaptability to internal and external stress, leading to an increased vulnerability to disease and mortality (Fedarko, 2011). Age is the main risk factor for the most prevalent diseases in developed countries: cancer, cardiovascular and neurodegenerative diseases, among others (Niccoli & Partridge, 2012). Age-associated diseases and the subsequent disability pose challenges for modern societies. However, ageing and its consequences affect people unevenly. Hence, specific markers of the underlying biological ageing process are needed to help identify people at

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increased risk of age-associated physical and cognitive impairments and ultimately, death (Geda et al., 2010).

Frailty is a syndrome that leads to practical harm in the lives of older people, since it is related to increased risk of dependency, falls, hospitalization, institutionalization and death (Walston et al., 2006). Frailty is theoretically defined as a clinically recognizable state of increased vulnerability resulting from aging-associated decline in reserve and function across multiple physiologic systems (Xue, 2011). The validated and widely utilized five-item frailty criteria for screening: self-reported exhaustion, slowed performance (by walking speed), weakness (by grip strength), unintentional weight loss (10lbs in the past year), and low physical activity are composite outcomes of multiple organ systems (Bandeen-Roche et al., 2006). The prevalence of frailty in community-dwelling older adults ranges between 4.0% and 59.1% (Collard, Boter, Schoevers, & Oude Voshaar, 2012). A prevalence of frailty between 26.7% and 42.6% has been reported in Latin America (Alvarado, Zunzunegui, Beland, & Bamvita, 2008).

Increase in life expectancy is one of the highest achievements of humankind (Oeppen & Vaupel, 2002); however, age-related frailty and its association with chronic diseases is a mounting challenge for individuals, families, and for social, economic, and healthcare systems (Mitnitski et al., 2015). The promotion of healthy ageing and interventions aimed at delaying the frailty process in all older people must assume a central role in medical care and research as well as in the formulation of national health and social policies (Puts et al., 2016; Sims, Kerse, Naccarella, & Long, 2000). Despite all these data, further research is required to characterize the frailty phenotype and the participation of Fried's frailty components. In addition, in this type of studies it is necessary to evaluate the associated factors, whose type and influence may vary according to the population studied. In this article, we examined the prevalence of frailty status according to Fried's criteria and its associated factors, among the older adult population in the Maule Region (Chile).

2. Methods

2.1. Participants and study design

A cross-sectional study was conducted between September 2016 and October 2017 in health care centers located in the Maule Region, in central Chile. The sample of 1205 older adults aged 65 and older was randomly selected from four urban provincial capitals and two rural communes per capital. The proportions of older adults (women and men) from urban capitals and rural communes were determined by the relative amount of the adult population over 65 years of age based on data from the National Socioeconomic Characterization Survey (CASEN) (CASEN, 2013). Thus, the sample size calculation was made considering a significance level of 0.05 (two-sided), 80% power, loss to follow-up rate of 20% and a prevalence of frailty syndrome in Chile of ≈22% (Alvarado et al., 2008). Older adults who could not walk or refused to participate were excluded. All participants or their proxies signed an informed consent. The study was approved by the Scientific Ethics Committee from the University of Talca. After being recruited, all subjects immediately underwent a standardized assessment including interviews and physical examinations.

2.2. Diagnosis of frailty syndrome

According to Fried et al (Fried et al., 2001), frailty-defining criteria was based on the presence or absence of the following five measurable components: slowness, weakness, weight loss, exhaustion, and low physical activity. Briefly, slowness was defined according to a cut-off (< 0.8 m/s) on three-meter walking at an usual pace, adjusted for sex and height according to the standards of the Short Physical Performance Battery (Guralnik et al., 1994). To assess weakness, strength was measured with an Electronic Handgrip Dynamometer (Camry, City Industry, USA), according to a sex-specific cut-off (male < 27 kg, female < 15 kg) (Arroyo et al., 2007). Unintentional weight loss was defined as self-reported loss of at least 5 kg in the previous 6 months (Albala et al., 2017). Exhaustion was classified when participants provided a positive answer to any of the following two questions from the Center for Epidemiological Studies Depression Scale: "I felt that anything I did was a big effort" and "I felt that I could not keep on doing things" at least 3 to 4 days a week" (Garcia-Garcia et al., 2011). Finally, low physical activity was defined by difficulty walking using two questions "Do you have difficulty walking a block?" or "Do you have difficulty climbing several flights of stairs without resting?" (Albala et al., 2017; Santos-Eggimann, Cuenoud, Spagnoli, & Junod, 2009). Subjects were classified as frail if they met three or more of these components, as pre-frail if subjects met one or two components, and non-frail or robust if none of the components was present (Garcia-Garcia et al., 2011).

2.3. Data collection

Data were also collected on comorbidity, from medical diagnoses and the information given by the subject. The questionnaires included socio-demographic (age, gender, educational level, living alone, and residence area), cognitive impairment with cutoff point ≤13 points (Mini-Mental State Examination) (Quiroga, Albala, & Klaasen, 2004) and nutrition screening (Mini-Nutritional Assessment [MNA] Short-Form) (Lera, Sanchez, Angel, & Albala, 2016). The functional risk was assessed using a score validated in Chile (Functional Assessment of Older Adults or EFAM) (Mancilla, Ramos, & Morales, 2016). In addition anthropometric variables (weight, height and waist circumference) were measured. Abdominal obesity was defined with waist circumference > 102 cm in men and > 88 cm in women (ATP III criteria).

2.4. Statistical analysis

Data obtained were analyzed using the SPSS Statistics software version 17 (SPSS Inc., Chicago, Ill., USA). Continuous variables were expressed as mean ± SD and 95% CI. Categorical variables were expressed as percentages and 95% confidence interval (CI). In the analysis of differences between groups, chi-squared test was used to assess differences in proportions, and the Student *T*-test or the Mann-Whitney test, as appropriate, to assess differences in means. Continuous variables were grouped to create ordinal categorical (binary) variables. Logistic regression models were performed to analyze the association between frailty and studied variables, unadjusted, and adjusted by age and gender. Also the presence of multicollinearity was evaluated in regression analysis. The *p*-values lower than 0.05 were considered statistically significant.

3. Results

The characteristics of the sample by gender, age, body mass index (BMI), abdominal obesity, living alone, residence area, years of education, cognitive and functional ability scales, and nutritional status are shown in Table 1. The study sample included 1205 individuals (816 women and 389 men). Mean age was 73 ± 5.9 years and 68% (65.0–70.4) were females. There were no gender differences for years of education (mean 7.2; 95% CI 7.0–7-5), prevalence of cognitive impairment 19% (95% CI 16.8–21.3) and nutritional risk 23% (95% CI 21.0–25.9). Significant differences in BMI (29 ± 5.4 kg/m^2 vs., 28 ± 4.5 kg/m^2), abdominal obesity (78% vs., 49%), living alone (28% vs., 17%), residence area (urban: 79% vs., 73%; rural: 21% vs., 27%), functional ability (functional risk: 44% vs., 39%) and nutritional risk (27% vs., 15%) were noted between women and men (Table 1). In older people with functional risk, the prevalence of frailty was 91% (Pearson's chi-squared test: $P < 0.001$).

Baseline comparison of geographical area according to frailty status

Table 1
Characteristics of the subjects.

Variable	Women (n = 816)	Men (n = 389)	Total (n = 1205)
Gender, % (95% CI)	68 (65.0–70.4)	32 (29.7–35.0)	100
Age (years), mean ± SD***	73 ± 5.9	73 ± 5.8	73 ± 5.9
BMI (kg/m^2), mean ± SD*	29 ± 5.4	28 ± 4.5	29 ± 5
Abdominal obesity, % (95% CI)***	78 (74.7–80.5)	49 (43.8–53.9)	68 (65.7–71.0)
Living alone, % (95% CI)***	28 (24.7–30.9)	17 (13.4–21.1)	24 (21.8–26.8)
Residence area, % (95% CI)*			
Urban	79 (76.5–82.1)	73 (68.6–77.6)	77 (74.9–79.8)
Rural	21 (17.9–23.4)	27 (22.4–31.4)	23 (20.2–25.0)
Years of education, mean (95% CI)	7.3 (7.0–7.6)	7.1 (6.7–7.6)	7.2 (7.0–7.5)
Functional ability, % (95% CI)*			
Autovalent with risk	44 (41.0–48.0)	39 (33.7–43.6)	43 (39.8–45.4)
Autovalent without risk	55 (51.8–58.7)	61 (56.1–66.1)	57 (54.3–60.0)
Cognitive impairment, % (95% CI)	19 (16.8–22.4)	18 (14.1–21.9)	19 (16.8–21.3)
Nutritional risk, % (95% CI)***	27 (24.1–30.3)	15 (12.0–19.4)	23 (21.0–25.9)

Continuous variables were analyzed using Mann Whitney test and categorical variables (proportions) using Pearson's chi-squared test. BMI: body mass index and CI: confidence interval.

* $P < 0.05$.

*** $P < 0.001$.

Table 2
Distribution of frailty status in the Maule Region (Chile).

Location	Total	Robust (N = 440) %	Pre-Frail (N = 469) %	Frail (N = 296) %
Curicó *	207	48.3	34.3	17.4
Molina **	51	39.2	49.0	11.8
Rauco **	21	52.4	38.1	9.5
Talca *	357	28.3	37.3	34.5
Pelarco **	13	23.1	61.5	15.4
San Clemente **	77	28.6	40.3	31.2
Linares *	161	43.5	38.5	18.0
Longaví **	69	46.4	29.0	24.6
Parral **	54	14.8	66.7	18.5
Cauquenes *	146	37.7	38.4	24.0
Chanco **	17	47.1	29.4	23.5
Pelluhue **	32	31.3	43.8	25.0
Total	**1205**	**36.5**	**38.9**	**24.6**

Based on the predominance of the population: * Urban capitals and ** rural communes. Pearson's chi-squared test: $P < 0.001$ between groups.

is shown in Table 2. The total prevalence of frailty in all cities from the Maule Region was 24.6%, where the city of Rauco showed fewer older people with frailty (9.5%) and Talca had the highest percentage of frail older people (34.5%). Moreover, the frequency in the whole sample of robust and pre-frail was 36.5% and 38.9%, respectively.

Table 3 shows comparisons in the components for frailty by gender. A high prevalence of weakness (28.5%), exhaustion (35.2%), low physical activity (34.0%) and slowness (33.1%) were observed in the sample. These four components for frailty status were found at a higher and significantly different frequency between women and men (weakness: 25.7% vs., 34.4%; exhaustion: 39.6% vs 26.0%; low physical activity: 37.6% vs 26.5% and slowness: 35.9% vs 27.2%). The lowest frequency was found for weight loss (9.9%), which was similar between women and men. Less than 10% of the sample, for women and men presented only four or five frailty components.

The prevalence of frailty by gender and groups of age (65–70, 71–79 and ≥80 years) is shown in Fig. 1. The frequency of total frailty was higher in women (27.1%) than in men (19.3%) (Pearson's chi-squared test: $p < 0.001$). In people 80 years old and older a significant increase

Table 3
Frequency of frailty components by gender.

	Women (N = 816)	Men (N = 389)	Total (N = 1205)
Frequency of Frailty Components (%)			
Slowness**	35.9	27.2	33.1
Weakness**	25.7	34.4	28.5
Weight loss	10.8	8.0	9.9
Exhaustion***	39.6	26.0	35.2
Low physical activity***	37.6	26.5	34.0
Number of Frailty Components (%)			
0*	34.4	40.9	36.5
1	19.6	24.2	21.1
2	18.9	15.7	17.8
3**	17.5	11.1	15.4
4	8.1	7.7	8.0
5	1.5	0.5	1.2
Total Frail (≥3 points)	27.1	19.3	24.6

Pearson's chi-squared test: *$P < 0.05$, **$P < 0.01$ and ***$P < 0.001$ between gender.

in the prevalence of frailty was observed both in women (65–70 years: 21% to ≥80 years: 44%) and men (65–70 years: 15% to ≥80 years: 24%). Of the components of frailty status, those that had a significant increase (Pearson's chi-squared test: $P < 0.001$) in its prevalence in women (percentage of increase of 65–70 to ≥80 years groups) by groups of age were slowness (34%), weakness (24%) and low physical activity (17%) and in men were weakness (18%), slowness (17%) and low physical activity (16%). Thus, regardless of gender, some components of frailty (slowness, weakness and low physical activity) have a greater increase with age.

Associations between subject characteristics and frailty status by unadjusted logistic regression are shown in Table 4. In both conditions (frail vs. robust and frail vs. pre-frail) the prevalence of frailty was more likely to occur in older people with the following characteristics: women, age ≥75 years, abdominal obesity, education ≤8 years, cognitive impairment and nutritional risk. The relation of these characteristics with frailty status was evaluated by multivariable logistic regression (Table 5). When all covariates were included in both models (frail vs. robust and frail vs. pre-frail), a significant relation remained with age ≥75 years, cognitive impairment, education ≤8 years, nutritional risk and abdominal obesity. In addition, the regression analyzes rule out the presence of multicollinearity (tolerance > 0.10 and variance inflation factor < 4).

4. Discussion

The main purpose of this research was to characterize the prevalence of the frailty syndrome in older people from the Maule Region (Chile) and to assess components leading to the condition. Using Fried's criteria to diagnose frailty syndrome, the present article showed that the total prevalence of frailty was 24.6% in 1205 elderly people and the pre-frailty prevalence was 38.9%. Meanwhile the prevalence of frailty was much higher in women (27.10%) than in men (19.3%). Albala et al., conducted a similar study in Santiago (capital of Chile) and described that the frequency observed for pre-frailty (63.8%) and frailty (total 13.9%; women 16.4% and men 8.7%) was over 60% of the older population (Albala et al., 2017). The differences observed with the study of Albala et al., can be explained by the proportion of people of rural origin. These findings must be compared to those reported in Peru 27.8% (Runzer-Colmenares et al., 2014), Brazil 9.1% (Moreira & Lourenco, 2013), Mexico 24.9% (Garcia-Pena, Avila-Funes, Dent, Gutierrez-Robledo, & Perez-Zepeda, 2016), Germany 2.6% (Buttery, Busch, Gaertner, Scheidt-Nave, & Fuchs, 2015) and Spain (8.4%)

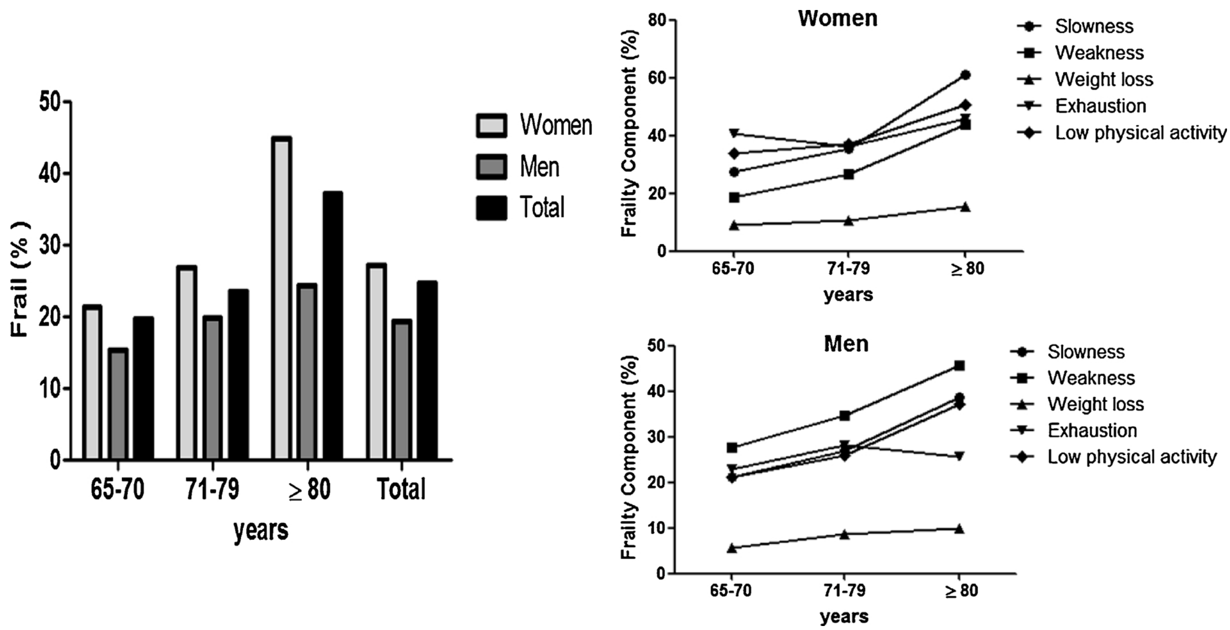

Fig. 1. Prevalence of frail and its components by gender and age.

(Garcia-Garcia et al., 2011), where the components of frailty defined by Fried et al., were considered.

Few studies have been conducted that measure the prevalence of frailty in elderly persons living in rural areas. The prevalence of frailty in older adults from Maule Region showed differences (between 9.5% to 34.5%) among different geographic locations, reflecting the impact of the environment, socioeconomics, and medical services, among others. However, in this study no differences were observed between frail elderly people from urban and rural areas. Other studies have described that frail elderly individuals in urban and rural areas had significant differences in terms of their prior experience of falls; the number of falls; the intake of hypertension medication, arthritis medication, and painkillers, discomfort when walking; physical activity; and the safety score of their home environments (Yoo, Kim, Yim, & Jeon, 2016; Yu et al., 2012). Differences in frailty status have been observed between rural and urban areas in very old dwellers, which reflect differences in deficit accumulation, and on the impact of gender on survival (Song, MacKnight, Latta, Mitnitski, & Rockwood, 2007). The Maule region in Chile has been typically an agricultural area, so many of the current older adults living in cities have worked in the farm at some point in their lives. The latter can explain the lack of differences in the rate of frailty between subjects living in urban and rural areas.

The results obtained in this study contribute to reinforce the predictive validity of the concept of frailty as well as its role in the health status of the elderly (Avila-Funes et al., 2008). Interventions for the frailty syndrome should be aimed at preventing or reducing the severity of the condition. Hence, effective interventional strategies have large benefits for elderly individuals on key components of frailty (Chen, Mao, & Leng, 2014). A community-based cohort study targeting older adults aged 65 and over identified three distinct subgroups with different frailty phenotypes: non-mobility-type (weight loss and exhaustion), mobility-type frailty (slowness and weakness), and low physical activity. Thus in this study we identified that the frequency for non-mobility-type was 20%, and for mobility-type frailty and low physical activity was 47% and 85%, respectively. Older people with a mobility-type frailty had poorer body composition, worse bone health, poorer cognitive function, lower survival, and poorer overall health outcomes with respect to the robust group (Liu et al., 2017). In this context, we found that some components of frailty status (slowness, weakness and low physical activity) increase in people 80 years and older, both in women and men. Slow walking speed is in itself a widely used criterion in geriatric assessment, becoming a good single estimator of frailty (Castell et al., 2013). Decline in strength (weakness) has been attributed to the loss of muscle mass and muscle quality referred to as sarcopenia, resulting from anatomic and biochemical changes in the aging muscle (Xue, 2011). Weakness is also considered a biomarker for aging and a predictor of disability, morbidity and mortality (Sayer & Kirkwood, 2015). In addition, poor muscle strength is closely associated with low physical activity, suggesting that training programs may revert or prevent the frailty process (Papiol et al., 2016). Likewise, it has been

Table 4
Unadjusted logistic regression for associations between subject's characteristics and frailty status.

Variable	Frail vs., Robust		Frail vs., Pre-frail	
	OR (95% CI)	*P*-Value	OR (95% CI)	*P*-Value
Women	1.67 (1.20–2.31)	**0.002**	1.46 (1.05–2.01)	**0.024**
Age ≥75 years	2.41 (1.77–3.27)	< **0.001**	1.98 (1.47–2.67)	< **0.001**
BMI ≥25 kg/m^2	1.05 (0.73–1.52)	0.776	0.96 (0.67–1.38)	0.825
Abdominal obesity	1.76 (1.27–2.45)	**0.001**	1.46 (1.05–2.03)	**0.023**
Living alone	1.33 (0.94–1.87)	0.105	1.13 (0.81–1.57)	0.479
Rural area	0.75 (0.52–1.07)	0.110	0.89 (0.62–1.27)	0.504
Years of education ≤8 years	2.04 (1.47–2.82)	< **0.001**	1.60 (1.16–2.21)	**0.005**
Cognitive impairment	7.94 (5.22–12.09)	< **0.001**	3.39 (2.42–4.75)	< **0.001**
Nutritional risk	3.88 (2.70–5.56)	< **0.001**	1.94 (1.41–2.66)	< **0.001**

OR: odds ratio, CI: confidence interval and BMI: body mass index.

Table 5
Multivariable logistic regression for frailty status.

Covariates	Frail vs., Robust			Frail vs., Pre-frail		
	Tolerance	VIF	OR (95% CI)	Tolerance	VIF	OR (95% CI)
Women	0.901	1.110	1.61* (1.09–2.39)	0.885	1.130	1.28 (0.89–1.84)
Age ≥75 years	0.946	1.057	2.24*** (1.58–3.19)	0.941	1.063	1.87*** (1.36–2.58)
Mild cognitive impairment	0.901	1.110	6.07*** (3.87–9.53)	0.933	1.071	2.80*** (1.97–3.97)
Years of education (≤8 years)	0.962	1.040	1.59* (1.11–2.31)	0.956	1.046	1.25 (0.88–1.77)
Nutritional risk	0.935	1.070	3.13*** (2.09–4.68)	0.953	1.049	1.78** (1.27–2.51)
Abdominal obesity	0.902	1.109	1.63* (1.10–2.42)	0.904	1.106	1.49* (1.03–2.15)

OR: odds ratio, CI: confidence interval and VIF: variance inflation factor.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

demonstrated that regular physical activity is safe for both frail and non-frail (McPhee et al., 2016). In fact, moderate and vigorous physical activity reduced the progression of frailty in older adults (Rogers et al., 2017). The clinical relevance of these findings, lies in the fact that slowness, weakness and low physical activity were the most common initial manifestation of the frailty phenotype.

Approximately 2 out of 10 older adults demonstrate frailty. This study demonstrated, after adjusting for potentially confounding variables such as age and gender, that frailty is associated with cognitive impairment and years of education (≤8 years). These results are in agreement with an association between frailty and cognitive status (Albala et al., 2017). Older adults with low educational level had higher odds of being frail compared with those with a higher educational level, even over a period of 13 years. A large part of the association between educational level and frailty was explained by income, self-efficacy or autonomy, deficient nutrition, chronic diseases and cognitive impairment (Hoogendijk et al., 2014). Indeed, it has been shown that the presence of common brain pathologies including cerebrovascular, Alzheimer's, and Parkinson's diseases are associated with more rapid progression of frailty and in particular with more rapid decline of walking speed. These associations did not vary with the presence of clinical dementia, baseline level of disability, or the presence of chronic health conditions. In other words, physical frailty in the body reflected the accumulation of diverse subclinical brain pathologies (Buchman, Yu, Wilson, Schneider, & Bennett, 2013).

In this study, we demonstrated a direct relation between poor nutritional status, as assessed by the MNA, and frailty. Frailty and nutritional risk are two closely related, but distinct concepts that share common determinants in the elderly population. Furthermore, it has been reported that when compared to robust elders, frail individuals suffered significantly more anorexia, decreased mobility, neuropsychological disorders, polymedication, impaired self-related health and eating dependency, which are all major risk factors for malnutrition (Boulos, Salameh, & Barberger-Gateau, 2016). On the other hand, there was a lack of association between BMI and frailty which may be due to the presence of sarcopenic obesity (Jarosz & Bellar, 2009). In fact, being overweight is highly prevalent in our study sample reaching nearly 80% both in women and men. So, this is in accordance with the idea that the condition and muscle quality in aging (reflected in lowness and weakness), are more relevant than the BMI.

This article presents some strengths and limitations. As strengths, we have evaluated different parameters on a large population-based sample of subjects from Maule Region (Chile). The major limitation of this study may be the use of Fried's frailty phenotype criteria, which does not include dimensions related to cognitive impairment. Others limitations are the assessments in different settings (cities) and that a cross-sectional study does not allow to evaluate causality of the different covariates.

5. Conclusion

This study explored medical, biological and geographical factors that may associate with the frailty syndrome. Therefore, a better understanding of the independent contribution of each frailty component to the different adverse-health outcomes would assist the formulation of measures for prevention of irreversible disability or other adverse outcomes, thereby contributing to better quality of life for the older people. In conclusion, this study provided evidence of differences for cognitive functioning, educational level and nutrition in frailty status among older adults.

Conflict of interest

The authors have no conflicts of interest to disclose.

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