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ORIGINAL ARTICLE

Frailty and sarcopenia in Bogotá: results from the SABE Bogotá Study

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Abstract
Background Latin American countries like Colombia are experiencing a unique aging process due to a mixed epidemiological regime of communicable and non-communicable diseases.
Aims To estimate the prevalence of frailty and sarcopenia among older adults in Colombia and identify variables associated with these conditions.
Methods Data come from the "Salud Bienestar y Envejecimiento" (SABE) Bogotá Study, a cross-sectional study conducted in 2012 in Bogotá, Colombia. Sociodemographic, health, cognitive and anthropometric measures were collected from 2000 community-dwelling adults aged 60 years and older. Frailty variable was created using the Fried phenotype and sarcopenia following the European Working Group on Sarcopenia in Older People algorithm. Logistic regression analyses were used to identify factors associated with frailty and sarcopenia.
Results A total of 135 older adults are frail (9.4 %), while 166 have sarcopenia (11.5 %). Older age and female gender have a significant association with both conditions (Frailty: Age OR 1.05, 95 % CI 1.03–1.06, Gender OR 1.44, 95 % CI 1.12–1.84; Sarcopenia: Age 1.04, 95 % CI 1.02–1.07, Gender OR 1.51, 95 % CI 1.05–2.17). Depression was also significantly associated with frailty (OR 1.17, 95 % CI 1.12–1.22), while smoking was significantly associated with sarcopenia (OR 2.38, 95 % CI 1.29–4.37). Finally, higher function, measured by independence in IADL (Instrumental Activities of Daily Living) was significantly associated with less frailty (OR 0.74, 95 % CI 0.64–0.86). Education, higher number of comorbidities, better MMSE score, activities of daily living disability and alcohol consumption were not significantly associated with frailty or sarcopenia.
Conclusions Frailty, sarcopenia and multimorbidity are overlapping, yet distinct conditions in this sample. There are potentially reversible factors that are associated with frailty and sarcopenia in this sample. Future studies need to analyze the best way to prevent these conditions, and examine individuals that have frailty, sarcopenia and comorbidities to design interventions to improve their quality of life.

Keywords Frailty · Sarcopenia · Comorbidity · Bogotá · Colombia

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Introduction

In the past decade, frailty and sarcopenia have gained the attention of clinicians and researchers worldwide and are now the focus of many clinical trials and epidemiological studies [1–4]. It is commonly accepted that frailty increases the vulnerability of older adults due to decreased physiological function in multiple systems, affecting their ability

to respond to stressors [5–8]. It is also accepted that it is associated with many adverse events [9–12]. Despite the multiple definitions used to conceptualize and measure frailty, the adverse consequences of this syndrome are well recognized and have been identified in many different population groups around the world [10, 11, 13–15]. On the other hand, sarcopenia has been defined as the age-related decrease in muscle mass and quality [3, 16, 17]. Important advances in sarcopenia have been achieved with acceptance of a single definition and validation studies that have shown its replicability and internal validity [18, 19].

Some studies have shown a close relationship between frailty and sarcopenia and have tried to find interventions that can help prevent or improve the status of adults suffering from both conditions [20, 21]. Translation of these findings to specific populations such as older adults in Latin America is difficult given the limited information available on these conditions in this region.

There is evidence that aging follows a unique pattern in Latin America due to the epidemiological transition occurring in the region and the double burden of communicable and non-communicable diseases previously reported in the literature [22, 23]. To date, only a few studies have provided information separately on frailty and sarcopenia in older Latin American adults [14, 24–26]. The studies analyzing frailty have used both the Frailty Phenotype proposed by Fried and colleagues using the Cardiovascular Health Study and the Frailty Index proposed by Rockwood and colleagues using the Canadian Study of Health and Aging [10, 27]. The studies analyzing sarcopenia have used the definition proposed by the European Working Group on Sarcopenia in Older People [19].

The present study estimates the prevalence of both frailty and sarcopenia in a representative sample of older adults in Bogotá, Colombia and analyzes the factors associated with both conditions. We will use the Frailty Phenotype and the European Consensus on Sarcopenia to define each condition and analyze the profile of older adults presenting each condition separately and together.

Methods

Study design

Data were obtained from the "Salud Bienestar y Envejecimiento" (SABE) Bogotá Study, a cross-sectional survey conducted in Bogotá, Colombia in 2012. The study was designed using a probabilistic sampling scheme by clusters (housing segments) with block stratification. A total of 2000 adults over 60 years of age were interviewed. All respondents were community dwelling, and the sample is representative of urban and rural areas of the city. The sample is statistically representative of population 60 years and older in the city and 81.9 % of eligible adults agreed to participate in the study.

The instrument used in the SABE Bogotá study was derived from the international instrument designed for the original SABE study conducted in 5 Latin American capital cities between 1999 and 2000 [28]. The instrument was modified and adapted to Colombia's context and sections on disability and violence were added to the survey. Additionally, a biographical component was included that summarizes mobility trajectories, family structure, residence, work history and self-reported health in the previous 35 years. The research protocol was approved by the IRB at Pontificia Universidad Javeriana. All study participants signed informed consent. A pilot project with 30 individuals aged 60 and older and selected to be representative of the target population in the city, was conducted before going to the field to validate the questionnaire and identify potential problems related to the survey. Based on the results from this pilot project, adjustments were made to improve the questionnaire and make the survey easier to administer.

Teams composed of a supervisor, three or four surveyors and one expert in anthropometric measurements were created. A team of experts composed of the principal investigator or a co-investigator, a professional trained in conducting field interviews, a statistician and the field coordinator, trained each team.

General characteristics of the 1442 individuals included in the current study with complete information to construct the Frailty and Sarcopenia variables are presented in Table 1. The mean age is 70.7 (SD = 7.7) years, the sample is mostly compromised of women, and the mean level of education is 5.3 (SD = 4.3) years. The mean MMSE score is 15.6 (SD = 3.7) and hypertension is the most common medical condition, occurring in 58.4 % of the participants. Mean ADL 98.1 (SD = 6.8) ratings indicated high levels of functional independence in activities of daily living. Similarly, percentage of adults with only 0 or 1 affected IADL is 84.6 % indicating high levels of independence in instrumental activities of daily living as well.

Dependent variables

Frailty

A modified version of the Frailty Phenotype proposed by Fried and colleagues in 2001 was used to measure frailty [10]. We used the same 5 components of the original frailty measure in the Cardiovascular Health Study: (1) weight loss, (2) grip strength, (3) walking speed, (4) exhaustion and (5) physical activity. As done in previous studies, we

Table 1 General characteristics of the sample ($n = 1442$)

Variable	Total Percent or mean (±SD)
Sociodemographic	
Age (years)	70.7 (±7.7)
Women	61.0 %
Education (years)	5.3 (±4.3)
Clinical	
Comorbidities	
Hypertension	58.4 %
Diabetes	17.7 %
Acute MI[a]	9.3 %
Cancer	5.4 %
Stroke	4.2 %
Life-style	
Drinking (yes)	19.0 %
Smoking (yes)	6.4 %
Mental	
MMSE score[b]	15.6 (±3.7)
GDS[c] score	3.8 (±3.2)
Functional	
ADL function [34][d]	98.1 (±6.8)
IADL function (number of affected IADL) [35][e]	
0 Affected	63.7 %
1 Affected	20.9 %
2 Affected	6.9 %
3 Affected	4.5 %
4 Affected	1.6 %
5 Affected	<1 %
6 Affected	<1 %
7 Affected	<1 %
8 Affected	<1 %
Anthropometric	
BMI (kg/m^2)[f]	27.5 (±4.7)
Calf circumference (cm)	34.5 (±4.0)
Grip strength (kg)	23.0 (±9.5)
Walking speed (m/s)	0.67 (±0.3)

[a] *Acute MI* acute myocardial infarction

[b] *MMSE* abbreviated mini mental state examination 0–19 scoring points

[c] *GDS* geriatric depression scale 0–15 scoring points

[d] *ADL* activities of daily living—Barthel scale 0–100 scoring points

[e] *IADL* instrumental activities of daily living—Lawton scale 0–8 scoring points

[f] *BMI* body mass index

also coded individuals with no alterations in any component of the phenotype as non-frail, those with alteration in one or two components as pre-frail, and those with alteration in three or more components as frail [10]. Additionally, given the differences of our population compared to the population studied in the Cardiovascular Health Studies, we followed what other researchers have done and modified the cut-off points set to identify alterations in walking speed, and grip strength [13, 29, 30]. Despite this, we followed the same methodology used by Fried and colleagues to make the data comparable. Finally, the Minnesota Leisure Activity (MLA) Questionnaire used in the Cardiovascular Health Study had limited application to our population; we, therefore, used 4 questions from the Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire to measure physical activity [31]. Studies conducted in Mexico have used these same questions and have compared consistency and reliability with the MLA obtaining similar results [32]. Table 2 shows how each component was measured and the cut-off point used to determine if an individual had an alteration for each particular component.

Sarcopenia

To measure sarcopenia we followed the guidelines proposed in the European Consensus published in 2010 [19]. As part of the anthropometric evaluation of the study participants, grip strength, walking speed and calf circumference were measured. To create the variable, we followed the algorithm proposed by Cruz-Jentoft and collaborators [19]. We initially analyzed walking speed and based on the walking speed, we then analyzed grip strength or calf circumference. Unlike the European consensus we did not use 0.8 m/s as the cut-off point for walking speed. Based on our sample characteristic, we divided the sample in quintiles due to the distribution of walking speed results and we then selected the lowest quintile as the reference for slow walking speed. Hence, older adults with walking speed in the second to fifth quintile, with grip strength below 30 kg for men and 20 kg for women and calf circumference below 31 cm were considered to have sarcopenia. Additionally, those adults with walking speed in the lowest quintile and calf circumferences under 31 cm were also considered to have sarcopenia; all other adults were considered free of sarcopenia. Table 3 summarizes the prevalence of adults with alteration in the three anthropometric measures used to construct the sarcopenia variable.

Independent variables

Variables included for descriptive purposes and as part of the regression models included sociodemographic factors such as: age in years, gender and education in years. Comorbidities were also included both as dichotomous variables for each of five medical conditions that were explored in the Survey (Hypertension, diabetes, heart

Table 2 Components and cut-off points used in the construction of the Frailty Phenotype and prevalence of affected individuals ($n = 1442$)

Component	Definition	Prevalence *n* (%)
Weight loss	Unintentional weight loss of more than 5 kg in the past year	85 (5.9 %)
Weakness	Lowest 20 % of grip strength (kg) by age and quartiles of BMI (kg/m2)	358 (24.8 %)
	Cut-off points for men	
	Strength ≤20 kg for BMI ≤23.7	
	Strength ≤24 kg for BMI 23.8–26.0	
	Strength ≤24 kg for BMI 26.1–28.6	
	Strength ≤24 kg for BMI >28.6	
	Cut-off points for women	
	Strength ≤12 kg for BMI ≤25.0	
	Strength ≤14 kg for BMI ≤25.1–28.0	
	Strength ≤14 kg for BMI 28.1–31.0	
	Strength ≤14 kg for BMI >31.0	
Exhaustion	Affirmative response in more than 3 days to one or more of the following questions: in the last week, how many days did you feel that everything you did was an effort? And, how many days did you feel that you did not want to do anything?	368 (25.5 %)
Walking speed	Lowest 20 % of time required to walk 2.4 m by gender and mean height	382 (26.5 %)
	Cut-off points for men	
	Time ≥6 s for height ≤162.0 cm	
	Time ≥5 s for height >162.0 cm	
	Cut-off points for women	
	Time ≥6 s for height ≤150.0 cm	
	Time ≥5 s for height >150.0 cm	
Physical activity	Lowest 20 % of performing activities (i.e. walking, recreational activities or sports) performed in the last 7 days	280 (19.4 %)

Table 3 Components and cut-off points used to construct sarcopenia and prevalence of affected individuals ($n = 1442$)

Component	Definition	Prevalence *n* (%)
Walking speed		
Normal		1060 (73.5 %)
Slow	Lowest 20 % of time required to walk 2.4 m by gender and mean height	382 (26.5 %)
Grip strength		
Normal		688 (47.7 %)
Weak	Less than 30 kg for men and less than 20 kg for women	754 (52.3 %)
Calf circumference		
Normal		1269 (88.0 %)
Low	Less than 31 cm regardless of gender	173 (12.0 %)

attack, stroke, and cancer) and as a continuous variable resulting from a sum of the number of condition (0–5) present in an individual. Individuals were asked: "Has a doctor or nurse ever told you that you suffer from…" for each medical condition.

Two lifestyle variables were also included in the analyses: alcohol consumption and smoking. Alcohol consumption was evaluated using the question: "In the last 3 months, on average, how many days of the week have you had alcoholic beverages?" Responses were divided into four categories: (1) no alcohol consumption, (2) 1–2 glasses per day, (3) 3–5 glasses per day (4) more than 5 glasses per day. The variable was then dichotomized by grouping categories 2–4 as alcohol consumption and category 1 as no alcohol consumption. Smoking was assessed asking individuals if they were currently smoking or had

ever smoked. Answers were divided into four categories: (1) never smoked, (2) former smoker, (3) smokes less than 5 cigarettes per day, (4) smokes more than 5 cigarettes per day. This variable was also dichotomized by grouping categories 1 and 2 as not smoking and 3 and 4 as smoking.

Cognitive function was assessed using the modified version of the Mini Mental State Exam validated in the initial SABE studies [28]. The modified version ranges from 0 to 19 with a higher score representing better cognitive function. Likewise, depression was assessed using the Geriatric Depression Scale [33]. This scale has 15 questions that can be answered as yes or no. A higher score represents more depressive symptoms.

Functional status was evaluated using the Barthel Index for Activities of Daily Living (ADL) and the Lawton scale for Instrumental Activities of Daily Living (IADL) [34, 35]. The Barthel Index ranges from 0 to 100 with higher scores representing higher functional status. The Lawton scale includes eight activities and the score ranges from 0 to 8 with higher scores representing higher functional status.

Finally, anthropometric measures included in the study were weight in kilograms, height in centimeters, calf circumference in centimeters, grip strength in kilograms and walking speed in meters per second. Body mass index (BMI) was estimated by dividing weight (kg) by height in meters squared (m^2).

Statistical analyses

Univariate analyses were initially used to explore extreme values, normal distribution and to describe all variables included in the study (Central tendency measures). Categorical variables are presented using frequencies and percentages and continuous variables are presented using means and standard deviations. Bivariate models were then used to identify which independent variables were associated with frailty and sarcopenia. Frailty was analyzed first as a categorical variable with frail and pre-frail subjects compared to non-frail subjects. Sarcopenia was only analyzed as a dichotomous variable. Chi-square tests to compare differences by gender were performed. Additionally, two multivariate regression models were estimated. The first model included frailty as the dependent variable. Using logistic regression models odds ratios and 95 % confidence intervals were obtained to identify variables associated with being frail or pre-frail versus non-frail. The second model included sarcopenia as the dependent variable and estimated the odds of having sarcopenia for each covariable. The statistical level of significance was set at $p < 0.05$. Data were analyzed using SAS version 9.3 (SAS Institute, Cary, North Carolina-USA).

Results

For our study, we excluded 558 adults from our analyses because they had missing data for one or more components required for the construction of the frailty or sarcopenia variables. Compared to the subjects who remained in the study, those who were excluded (558) were older, more likely to be female, had more years of education, yet slightly lower MMSE scores, and more ADL and IADL limitations ($p < 0.05$).

Table 4 shows the prevalence of frailty or sarcopenia in our sample. The prevalence of frailty is 9.4 % in the total sample and the prevalence of sarcopenia is 11.5 %.

Table 4 Prevalence of frailty or sarcopenia by gender ($n = 1442$)

	Men	Women	Total
Non frail[a]	240 (42.7 %)	311 (35.3 %)	551 (38.2 %)
Pre frail[b]	275 (48.9 %)	481 (54.7 %)	756 (52.4 %)
Frail[c]	47 (8.4 %)	88 (10.0 %)	135 (9.4 %)
No sarcopenia	507 (90.2 %)	769 (87.4 %)	1276 (88.5 %)
Sarcopenia[d]	55 (9.8 %)	111 (12.6 %)	166 (11.5 %)

[a] Non frail (none of the five components affected)

[b] Pre frail (one or two components affected)

[c] Frail (three or more components affected)

[d] Sarcopenia (individuals with normal walking speed, low grip strength and low muscle mass and those with slow walking speed and low muscle mass)

Table 5 Multivariate logistic regression models predicting frailty (pre-frail and frail) or sarcopenia ($n = 1442$)

Covariable	Frailty			Sarcopenia		
	OR	95 % CI		OR	95 % CI	
Age	1.05	1.03	1.06	1.04	1.02	1.07
Women vs. men	1.44	1.12	1.84	1.51	1.05	2.17
Education (years)	0.98	0.96	1.01	1.01	0.97	1.05
Comorbidities	1.11	0.96	1.28	0.83	0.67	1.01
MMSE score[a]	0.97	0.92	1.02	0.96	0.90	1.02
GDS score[b]	1.17	1.12	1.22	1.03	0.98	1.08
IADL disability[c]	0.74	0.64	0.86	0.89	0.78	1.03
ADL disability[d]	0.97	0.93	1.01	1.00	0.98	1.03
Drinking	0.90	0.67	1.21	0.65	0.39	1.09
Smoking	1.50	0.93	2.41	2.38	1.29	4.37

OR odds ratios

[a] MMSE (abbreviated mini mental state examination 0–19 scoring points)

[b] GDS (Geriatric depression scale 0–15 scoring points)

[c] IADL (instrumental activities of daily living—Lawton scale 0–8 scoring points)

[d] ADL (activities of daily living—Barthel index (0–100 scoring points)

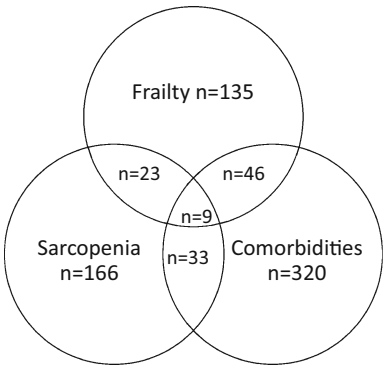

Fig. 1 Venn diagram showing the relationship between frailty, sarcopenia and comorbidities ($n = 1442$)

Women have higher rates of frailty and sarcopenia than men. More than half of the sample is pre-frail and similar to what is summarized above, a higher percentage of women are pre-frail compared to men.

Table 5 shows the results of the logistic regression models analyzing which covariables are associated with being pre-frail and frail or predicting sarcopenia. Older age, and female gender are significantly associated with both being pre-frail and frail and having sarcopenia. Additionally, higher depressive symptoms are associated with being pre-frail and frail. Similarly, smoking was significantly associated with having sarcopenia. On the other hand, higher functionality in instrumental activities of daily living is significantly associated with being non-frail.

Figure 1 shows a Venn diagram relating frailty, sarcopenia and comorbidities. A total of 135 older adults in our sample have frailty, 166 have sarcopenia and 320 have 2 or more of the five self-reported medical conditions, labeled comorbidities for this figure. In the overlapping areas, a count of individuals with two or more of the conditions is included. Only nine individuals have the three conditions simultaneously.

Discussion

This study analyzes the prevalence of frailty and sarcopenia using data of the first cross-sectional population-based study of older adults in Bogotá, Colombia. We found that 9.4 % of older adults in Bogotá are frail and 11.5 % have sarcopenia. Older age and female gender significantly increased the odds of both frailty and sarcopenia in this sample. Depression significantly increased the odds of frailty only. Smoking increased the odds of only sarcopenia. Higher IADL score significantly decreased the odds of frailty.

Our prevalence data are similar to what other authors have reported in longitudinal studies of Hispanic populations [11, 36]. We, therefore, think that both frailty and sarcopenia can be studied in our population group using internationally validated measures such as the frailty phenotype proposed by Fried and colleagues [10] and the sarcopenia definition proposed by the European Working Group on Sarcopenia in Older People [19]. Given the shortage of population studies on aging, these results can help us understand frailty and sarcopenia in Latin American populations. These data are a first step towards validating international guidelines regarding how to identify and manage these conditions [37].

Despite similarities reported in this study, it is interesting to note that the average score for variables like walking speed in our sample is considerably low (0.67–0.3 m/s). Given the accepted cut-off point of 0.8 m/s, this finding poses questions related to the health of our subjects. One possibility is that given the high prevalence of conditions such as hypertension and diabetes, many of our older adults are suffering from complications related to those conditions or to the treatment used for those conditions. In addition to the effect of chronic conditions, the effect of malnutrition could also be playing a role in overall health of our sample. We previously reported that malnutrition and risk of malnutrition was close to 40 % in our sample [38]. These factors need to be further analyzed in longitudinal studies to establish causality and design interventions.

Our findings demonstrate that in Bogotá, Colombia, frailty, sarcopenia and multimorbidity coexist and overlap; however, they are separate entities that affect individuals differently and have implications for health and quality of life among older adults. Following the current trend in aging research, analyzing older adults with a single condition or a syndrome is no longer considered sufficient or the best way to conduct aging research given that most older adults present with coexisting conditions [39–42]. Interventions must be designed that target multiple conditions. Thus, in addition to showing that sarcopenia, frailty and comorbidities are overlapping yet independent conditions, we identified 23 adults (1.6 % of the sample) that need interventions for both frailty and sarcopenia, 46 adults (3.2 % of the sample) that need interventions for both frailty and comorbidities, and 33 adults (2.3 % of the sample) that need interventions for sarcopenia and comorbidities. Identifying the type of interventions required by each group must be analyzed in later studies.

This study has several strengths. We used the first population-based study of adults over 60 in Colombia to explore conditions that affect their health and quality of life. This study followed the international guidelines previously used in other capital cities in Latin America and was modified to fit the social and historical situation of Colombia. Additionally, we used constructs previously

validated in similar populations to create our dependent variables. This study also has some limitations. The SABE Bogotá study is a cross-sectional study so causation cannot be determined. Additionally, modifications to the frailty phenotype and the sarcopenia definition could introduce bias to our analyses. Nevertheless, we have comparable prevalence estimates and have used modifications to the outcome measures previously reported in the literature. In addition, a large percentage of the cohort was excluded from the current study because there was missing data necessary for the construction of the frailty and sarcopenia variables ($n = 558$). As reported, excluded individuals were significantly different from the excluded population, which introduces bias to our study. Data should be interpreted with this information in mind. Finally, as with other population-based studies, data are self-reported, so recall bias could affect our results.

This study is the first step towards informing researchers and clinicians so interventions that can help reduce frailty or sarcopenia in older adults in Colombia can be designed. We have shown that age and gender are associated with frailty and sarcopenia. These variables cannot be modified. Other variables, however, such as functional status, depression and smoking are susceptible to change. Further studies should explore these variables and contribute to developing interventions designed to prevent or reduce frailty and sarcopenia among older adults in Colombia.

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Compliance with ethical standards

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Conflict of interest The authors report no conflict of interest for the current manuscript.

Statement of human and animal rights All procedures performed in this study were in accordance with the ethical standards of the Pontificia Universidad Javeriana institutional review board and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

1. Abellan Van Kan G, Rolland Y, Bergman H et al (2008) The I.A.N.A task force on frailty assessment of older people in clinical practice. J Nutr Health Aging 12:29–37
2. Bauer JM, Sieber CC (2008) Sarcopenia and frailty: a clinician's controversial point of view. Exp Gerontol 43:674–678. doi:10.1016/j.exger.2008.03.007
3. Baumgartner R, Koehler KM, Gallagher D et al (1998) Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 147:755–763
4. Faber MJ, Bosscher RJ, Paw MJCA et al (2006) Effects of exercise programs on falls and mobility in frail and pre-frail older adults: a multicenter randomized controlled trial. Arch Phys Med Rehabil 87:885–896
5. Abellan Van Kan G, Rolland YM, Morley JE et al (2008) Frailty: toward a clinical definition. J Am Med Dir Assoc 9:71–72
6. Bergman H, Hogan DB, Karunananthan S (2008) Frailty: a clinically relevant concept? Can J Geriatr 11:124–129
7. Fried LP, Walston JD (1998) Frailty and failure to thrive. In: Hazzard WR, Blass JP, Ettinger WH Jr, Halter JB, Ouslander J (eds) Principles of geraitric medicine and gerontology, vol 4. McGraw Hill, New York, pp 1387–1402
8. Walston J, Hadley EC, Ferrucci L et al (2006) Research agenda for frailty in older adults: toward a better understanding of physiology and etiology: summary from the American Geriatrics Society/National Institute on Aging Research Conference on Frailty in Older Adults. J Am Geriatr Soc 54:991–1001
9. Bergman H, Ferrucci L, Guralnik J et al (2007) Frailty: an emerging research and clinical paradigm–issues and controversies. J Gerontol A Biol Sci Med Sci 62:731–737
10. Fried LP, Tangen CM, Walston JD et al (2001) Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 56:M146–M156
11. Ottenbacher KJ, Graham JE, Al Snih S et al (2009) Mexican Americans and frailty: findings from the Hispanic established populations epidemiologic studies of the elderly. Am J Public Health 99:673–679
12. Rockwood K, Fox RA, Stolee P et al (1994) Frailty in elderly people: an evolving concept. CMAJ 150:489–495
13. Al Snih S, Graham JE, Ray LA et al (2009) Frailty and incidence of activities of daily living disability among older Mexican Americans. J Rehabil Med 41:892–897
14. Alvarado BE, Zunzunegui MV, Beland F et al (2008) Life course social and health conditions linked to frailty in Latin American older men and women. J Gerontol A Biol Sci Med Sci 63:1399–1406
15. Cesari M, Leeuwenburgh C, Lauretani F et al (2006) Frailty syndrome and skeletal muscle: results from the Invecchiare in Chianti study. Am J Clin Nutr 83:1142–1148
16. Marcell TJ (2003) Sarcopenia: causes, consequences, and preventions. J Gerontol A Biol Sci Med Sci 58:M911–M916
17. Morley JE (2008) Sarcopenia: diagnosis and treatment. J Nutr Health Aging 12:452–456
18. Studenski SA, Peters KW, Alley DE et al (2014) The FNIH sarcopenia project: rationale, study description, conference recommendations, and final estimates. J Gerontol A Biol Sci Med Sci 69:547–558. doi:10.1093/gerona/glu010
19. Cruz-Jentoft AJ, Baeyens JP, Bauer JM et al (2010) Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 39:412–423. doi:10.1093/ageing/afq034
20. Cesari M, Colloca G, Zamboni V et al (2008) Sarcopenia and frailty in older women. In: Benninghouse BT, Rosset AG (eds) Women and aging: new research, 1st edn. Nova Science Publishers Inc, Hauppage
21. Cruz-Jentoft AJ (2013) Perspective: protein and exercise for frailty and sarcopenia: still learning. J Am Med Dir Assoc 14:69–71
22. Palloni A, Pinto-Aguirre G, Pelaez M (2002) Demographic and health conditions of ageing in Latin America and the Caribbean. Int J Epidemiol 31:762–771

23. Samper-Ternent R, Michaels-Obregon A, Wong R et al (2012) Older adults under a mixed regime of infectious and chronic diseases. Salud Publ Mex 54:487–495
24. Arango-Lopera VE, Arroyo P, Gutierrez-Robledo LM et al (2013) Mortality as an adverse outcome of sarcopenia. J Nutr Health Aging 17:259–262
25. Garcia-Gonzalez JJ, Garcia-Pena C, Franco-Marina F et al (2009) A frailty index to predict the mortality risk in a population of senior Mexican adults. BMC Geriatr 9:47
26. Perez-Zepeda MU, Gutierrez-Robledo LM, Arango-Lopera VE (2013) Sarcopenia prevalence. Osteoporos Int 24:797
27. Rockwood K, Mitnitski A (2007) Frailty in relation to the accumulation of deficits. J Gerontol A Biol Sci Med Sci 62:722–727
28. Albala C, Lebrao ML, Leon Diaz EM et al (2005) The Health, Well-Being, and Aging ("SABE") survey: methodology applied and profile of the study population. Rev Panam Salud Publ 17:307–322
29. Alley DE, Shardell MD, Peters KW et al (2014) Grip strength cutpoints for the identification of clinically relevant weakness. J Gerontol A Biol Sci Med Sci 69:559–566. doi:10.1093/gerona/glu011
30. Ottenbacher KJ, Ostir GV, Peek MK et al (2005) Frailty in older mexican americans. J Am Geriatr Soc 53:1524–1531
31. Stewart AL, Mills KM, King AC et al (2001) CHAMPS physical activity questionnaire for older adults: outcomes for interventions. Med Sci Sports Exerc 33:1126–1141
32. Avila-Funes JA, Pina-Escudero SD, Aguilar-Navarro S et al (2011) Cognitive impairment and low physical activity are the components of frailty more strongly associated with disability. J Nutr Health Aging 15:683–689
33. Yesavage JA, Brink TL, Rose TL et al (1982) Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res 17:37–49
34. Mahoney FI, Barthel DW (1965) Functional Evaluation: the Barthel Index. Md State Med J 14:61–65
35. Barberger-Gateau P, Commenges D, Gagnon M et al (1992) Instrumental activities of daily living as a screening tool for cognitive impairment and dementia in elderly community dwellers. J Am Geriatr Soc 40:1129–1134
36. Runzer-Colmenares FM, Samper-Ternent R, Al Snih S et al (2014) Prevalence and factors associated with frailty among Peruvian older adults. Arch Gerontol Geriatr 58:69–73. doi:10.1016/j.archger.2013.07.005
37. Morley JE, Vellas B, van Kan GA et al (2013) Frailty consensus: a call to action. J Am Med Dir Assoc 14:392–397. doi:10.1016/j.jamda.2013.03.022
38. Chavarro-Carvajal D, Reyes-Ortiz C, Samper-Ternent R et al (2015) Nutritional assessment and factors associated to malnutrition in older adults: a cross-sectional study in Bogota Colombia. J Aging Health 27:304–319. doi:10.1177/0898264314549661
39. Hughes LD, McMurdo ME, Guthrie B (2013) Guidelines for people not for diseases: the challenges of applying UK clinical guidelines to people with multimorbidity. Age Ageing 42:62–69. doi:10.1093/ageing/afs100
40. Kadam UT, Croft PR (2007) Clinical multimorbidity and physical function in older adults: a record and health status linkage study in general practice. Fam Pract 24:412–419
41. Wolff JL, Starfield B, Anderson G (2002) Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. Arch Intern Med 162:2269–2276
42. Boyd CM, Darer J, Boult C et al (2005) Clinical practice guidelines and quality of care for older patients with multiple comorbid diseases: implications for pay for performance. JAMA 294:716–724