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Original Study

Prediction of the Incidence of Falls and Deaths Among Elderly Nursing Home Residents: The SENIOR Study

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ABSTRACT

Objective: The objective of this study was to evaluate, among nursing home residents, the extent to which the various operational definitions of frailty predict mortality and falls at 1 year.
Methods: We studied 662 participants from the Sample of Elderly Nursing home Individuals: An Observational Research (SENIOR) cohort aged 83.2 ± 8.99 years, including 484 (72.5%) women and living in nursing homes. Among this cohort, 584 and 565 participants, respectively, were monitored over 12 months for mortality assessment and for occurrence of falls (ie, by mean of their medical records). Each patient was subjected to a clinical examination at baseline, during which many original clinical characteristics were collected. Stepwise regression analyses were carried out to predict mortality and falls.
Results: Among the participants included in the study, 93 (15.9%) died and 211 (37.3%) experienced a fall during the 1-year of follow-up. After adjustment, none of the definitions of frailty assessed predicted the 1-year occurrence of negative health outcomes. When comparing the clinical characteristics of deceased participants and those still alive, being a man (OR = 1.89; 95% CI: 1.19-3.01; $P = .002$) and being diagnosed with sarcopenia (OR = 1.7; 95% CI: 1.1-2.92; $P = .03$) were independent factors associated with 1-year mortality. Other independent factors that were significantly associated with the 1-year occurrence of falls were the results obtained with the Tinetti test (OR = 0.93; 95% CI: 0.87-0.98; $P = .04$), with the grip strength test (OR = 0.95; 95% CI: 0.90-0.98, $P = .03$), and with the isometric strength test of elbow extensors (OR = 0.93; 95%CI: 0.87-0.97; $P = .04$).
Conclusions: Within the operational definitions of frailty assessed, none is sufficiently sensitive to predict the occurrence of falls and deaths at 1 year among nursing home residents. Globally, the frequency of undesirable health outcomes seems to be higher among participants with lower muscle strength and mobility. Medical strategy or adapted physical activity, with the aim of improving specific isometric muscle strength and mobility could potentially, but significantly, reduce the occurrence of falls and even deaths.

Causes of morbidity and mortality are major public health problems in modern societies with aging populations and the increase in the number of institutionalized persons.[1] Previous studies have shown that 20% to 24% of deaths occur in nursing homes.[2] Falls are also prevalent among nursing home residents, affecting 30% to 50% of the population, with approximately 1.5 falls occurring per nursing home bed per year.[3]

Whereas the concept of frailty is quite well established in the scientific literature, there is no consensual operational definition.[4,5] A recent systematic review identified 67 operational definitions of frailty[6] and, currently, only one of these has been validated in the specific population of nursing home residents, the FRAIL-Nursing Home scale (FRAIL-NH).[7] It is acknowledged that frailty increases the likelihood of developing negative health outcomes, including falls

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and deaths[8]. According to the recent meta-analysis published by Vermeiren et al,[8] frail participants have a risk of mortality increased by 2.55 [odds ratio (OR) = 2.55; 95% confidence interval (CI): 1.76–3.70], and the risk of falls increased by 2.06 (OR = 2.06; 95% CI: 1.28-3.34). An interesting operational definition of frailty, to use in the nursing home setting, could be the one that best predicts the occurrence of these negative health outcomes.

Other intrinsic risk factors for falls are generally recognized, such as age, functional abilities, chronic diseases, gait disturbances, and fear of falling.[9–12] These factors have been identified among community-dwelling older people or among hospitalized patients, but very few studies have been performed in a nursing home setting. In a previous prospective study conducted in nursing homes, we have shown that very few factors were independently associated with the incidence of falls.[13] In this study, a low body mass index (BMI) was the only variable significantly associated with a 2-year risk of mortality. Because our previous study included a small number of residents and few confounding variables in the analysis, it is important to confirm and to complete these observations.[13]

On the basis of these findings, the present study aimed to identify the most predictive operational definition of frailty for mortality and falls, after 1-year of follow-up, among nursing home residents, taking into account intrinsic risk factors for such negative health outcomes.

Methods

Study Design

The analysis was based on the data from the Sample of Elderly Nursing home Individuals: an Observational Research (SENIOR) cohort, which is a prospective longitudinal study of Belgian nursing home residents, in which participants are evaluated each year.[14] The present analysis is focused on data collected at baseline and on negative health outcomes occurring during the first year of follow-up. The study was approved by the Ethics Committee of the University Teaching Hospital of Liège under number 2013/178.

Population

The sample comprised participants from the SENIOR cohort, living in 28 nursing homes in the Province of Liège and who have been monitored over 1 full year. The selection criteria for the population were (1) to be oriented (ie, to get informed consent), (2) to be able to stand and walk (ie, walking technical assistance allowed), and (3) to be a volunteer.

Data Collected

Diagnosis of frailty

At baseline, all participants received a diagnosis of frailty based on 11 different operational definitions.

Clinical frailty scale.[15] This is based on a clinical evaluation in the domains of mobility, energy, physical activity, and function, using descriptors and figures to stratify elderly adults according to their level of vulnerability. The score ranges from 1 (robust health) to 7 (complete functional dependence on others).

Edmonton frail scale.[16] This samples 8 domains (cognitive impairment, health attitudes, social support, medication use, nutrition, mood, continence, functional abilities). A score range from 0 to 3 is a robust state, 4 to 5 is a slightly frail state, 6 to 8 is a moderately frail state, and 9 to 17 is a severely frail state.

Frail scale status[17]: This has 5 components: fatigue, resistance, ambulation, illness, and loss of weight. Scores range from 0 to5 and represent frail (3-5), prefrail (1-2), and robust (0) health states.

Frailty index[18]: This is expressed as a ratio of deficits present to the total number of deficits considered. Frailty index includes 40 variables and the calculation was performed on the maximum number of deficits collected. Thus, participants were considered as frail when the ratio of deficits present to the total number of deficits considered was 0.25 (ie, lowest quartile) or more.[19,20]

Frailty phenotype[21]: This is a deficit across 5 domains. Thus, phenotype of frailty was identified by the presence of three or more of the following components: shrinking, weakness, poor endurance and energy, slowness, and a low level of physical activity. The presence of 1 or 2 deficits indicates a prefrail condition, and a total of 3 or more deficits indicate frailty whereas the absence of deficits indicates a robust state.

Groningen frailty indicator[22]: This consists of 15 self-reported items and screens for loss of functions and resources in 4 domains: physical, cognitive, social, and psychological. Scores range from 0 (not frail) to 15 (very frail). A Groningen Frailty Indicator score of 4 or higher was regarded as frail.

Sega grid[23]: This establishes a risk profile of frailty and provides reporting of problems and factors that may influence functional decline, including age, provenance, drugs, mood, perceived health, history of falls, nutrition, comorbidities, instrumental activities of daily living, mobility, continence, feeding, and cognitive functions. A score of 0, 1, or 2 is given for each item and a total over 11 points indicates a "very frail" condition, a score between 8 and 11 points indicates a frail condition while a score below 8 is a slightly frail condition.

Share frailty instrument[24]: Using the 5 share frailty instrument variables (fatigue, loss of appetite, grip strength, functional difficulties, and physical activity), D-factor scores were determined using the share frailty instrument formula and, based on the D-factor score value, the participant could then be categorized as nonfrail, prefrail, or frail.

Strawbridge questionnaire[25]: This defines frailty as difficulty in 2 or more functional domains (physical, cognitive, sensory, and nutritive). A score greater than or equal to 3 in more than 1 domain is considered vulnerable.

Tilburg frailty indicator (TFI)[26]: The TFI consists of 2 parts. Part A contains 10 questions on determinants of frailty and diseases (multimorbidity); part B contains 3 domains of frailty (quality of life, disability, and healthcare utilization) with a total of 15 questions on components of frailty. The threshold above which the participant is considered as frail is 5 points.

FRAIL-NH score[7]: This score covers 8 areas (F = fatigue, R = resistance, A = ambulation, I = incontinence (version 1) or polypharmacy (version 2), L = weight loss, N = nutritional approach, H = help with dressing). The sum score ranged from 0 to 14. The FRAIL-NH has a suggested cut-off value of 7 for frailty.[27]

Clinical Characteristics Collected

Other sociodemographic and clinical data were collected at baseline: age, sex, anthropometric measurements, BMI, technical assistance for walking, drug consumption, and the patient's medical history. In addition, the following evaluations were carried out: daily energy expenditure evaluated by the Minnesota Leisure Time Activities Questionnaire,[28] cognitive skills assessed with the Mini-Mental State Examination,[29] Nutritional status estimated by the Mini-Nutritional Assessment,[30] quality of life assessed by both the EQ-5D [31] and the Short Form Health Survey (SF-36) questionnaires,[32] activities of daily living estimated by the Katz index,[33] gait and body balance assessed using the Tinetti,[34] the Timed Up and Go,[35] and the

Short Physical Performance Battery[36] tests, and gait speed and strength assessed by grip strength, according to the protocol defined by Roberts et al,[37] and the isometric strength of 8 different muscle groups according to the protocol defined by Buckinx et al,[38] body composition assessed by bioelectrical impedance analysis,[39] fear of falling assessed by an auto-reported questionnaire (Falls self-Efficacy Scale [FES-1]),[40] and peak expiratory flow assessed by the Mini-Wright's peak flow meter. Finally, sarcopenia, where present, was diagnosed with the definition proposed by the European Working Group on Sarcopenia in Older People. This corresponds to a loss of muscle mass (ie, assessed by bioelectrical impedance analysis) plus either a loss of muscle strength (ie, assessed by grip strength) or a loss of physical performance (ie, assessed by Short Physical Performance Battery [SPPB] test).[36]

Occurrence of Falls and Death

The occurrence of negative health outcomes was monitored and recorded over a 12-month follow-up period. Falls and deaths were retrospectively collected from the medical records, computerized or otherwise, available in the institutions. In Belgium, caregivers have an obligation to keep these data up to date.

Statistical Analysis

Quantitative variables that were normally distributed were expressed as a mean ± standard deviation, and quantitative variables that were not normally distributed were reported as the median and percentiles (25th-75th). The Shapiro-Wilk test verified the normal distribution of all parameters. Qualitative variables were reported as absolute and relative frequencies (%). The associations between operational definitions of frailty and negative health outcomes (ie, falls and deaths) were assessed with ORs and 95% CI. In addition, a comparison between characteristics of deceased and still alive participants, but also between participants who fell and those who did not, was performed using the Student t test (or nonparametric Mann-Whitney test) for continuous variables and by means of the χ^2 test for categorical variables. Finally, stepwise logistic regression analyses were used to test the association between clinical characteristics that differ between the 2 groups and the negative health outcomes. The data analyses were performed using Statistica12 software (TIBCO Statistica, Palo Alto, CA). The results were considered statistically significant when the 2-tailed *P* values were less than .05.

Results

Population

Out of the 662 participants included in the SENIOR cohort, 584 were monitored during 12 months for a mortality assessment. During the study period, 78 participants were lost to the follow-up: 20 participants moved and 58 participants were living in 2 nursing homes that refused to continue the study for an additional year. The assessment of falls during the 1 year of follow-up was performed among 565 participants (ie, we did not obtain the data for 2 nursing homes (58 participants), and data were incomplete for an additional 39 participants). The flow chart of this study is presented in Figure 1.

The SENIOR population, comprising 72.5% women, was aged 83.2 ± 8.99 years. All the demographic and clinical characteristics of this population are described elsewhere.[14]

Prediction of Falls

Among the 565 participants included in this analysis, 211 (37.3%) suffered at least 1 fall during the first year of follow-up.

When comparing all the characteristics of participants who fell at least once during the year of follow-up and participants who did not fall, some significant differences were observed. Those who fell were older ($P = .003$) and had a lower BMI ($P = .006$) than those who did not. Only 1 out of the 11 operational definitions of frailty assessed was associated with the occurrence of falls after 12 months - the Groningen indicator (OR = 1.56; 95% CI: 1.1-2.41). The fallers had also a lower calf circumference ($P = .003$) and a lower arm circumference ($P = .01$) than nonfallers. They were also more likely to use a walking support ($P = .02$) and to be at risk of malnutrition ($P = .01$). They had a lower energy expenditure ($P = .01$), and they were more likely to be frail according to the Groningen indicator ($P = .01$). The domain "emotional role functioning" of the SF-36 was lower ($P = .02$), and the fear of falling was higher ($P = .002$). Finally, functional and muscular abilities were lower when assessed with the Tinetti test ($P = .0002$), the TUG test ($P = .001$), the SPPB test ($P < .0001$), as were the grip strength ($P = .0002$) and the isometric strength of 8 different muscle groups (*P* value ranged between .01 and .0003) (Table 1).

After adjustment on all variables that were significantly different between falling participants and nonfalling participants, only the Tinetti test ($P = .04$), the grip strength ($P = .03$), and the isometric strength of the elbow extensors ($P = .04$) were significantly associated independently with the occurrence of falls at 1 year. The higher the score in these tests, the less risk of falling (Table 2).

Prediction of Death

Among the 584 participants included in the mortality assessment, 93 (15.9%) died during the first year of follow-up.

When comparing baseline clinical characteristics of participants who died during the year of follow-up and those still alive at the end

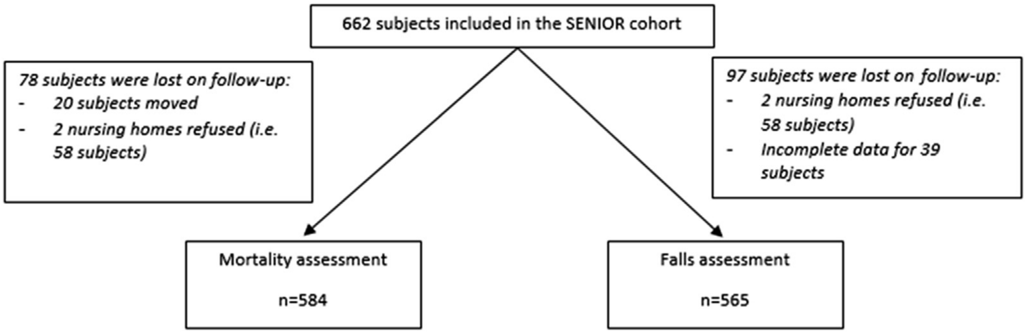

Fig. 1. Flow chart of the study.

Table 1
Clinical Characteristics of Participants Falling and Those Not Falling

Characteristics	Have Fallen (n = 211)	Did Not Fall (n = 354)	*P* Value
Age (y)	84.3 ± 8.5	81.9 ± 9.4	.003
Sex (women)	164 (77.7)	249 (70.3)	.14
BMI (kg/m^2)	25.2 ± 5.7	26.6 ± 5.4	.006
Frailty assessment			
Fried definition (yes)	122 (57.8)	181 (51.2)	.17
Tilburg instrument (yes)	82 (36.4)	102 (28.1)	.37
Strawbridge questionnaire (yes)	84 (37.3)	90 (24.8)	.60
Share frailty instrument (yes)	65 (28.9)	98 (26.9)	.07
Sega gird (yes)	116 (54.9)	124 (35.1)	.65
Groningen indicator (yes)	158 (74.9)	232 (65.5)	.01
Frailty index (yes)	10 (4.44)	14 (3.45)	.58
Frailty scale status (yes)	36 (16)	41 (11.3)	.60
Edmonton scale (yes)	120 (56.9)	182 (51.4)	.83
Clinical frailty scale (yes)	82 (36.4)	108 (29.8)	.63
Frail-NH version 1 (yes)	15 (7.11)	19 (5.37)	.40
Frail-NH version 2 (yes)	35 (16.6)	48 (13.6)	.33
Waist circumference (cm)	97 ± 13.4	122 ± 47	.37
Calf circumference (cm)	32.5 ± 4.4	33.6 ± 4.2	.003
Arm circumference (cm)	27.6 ± 4.4	28.7 ± 5.7	.01
Wrist circumference (cm)	16.6 ± 2.4	16.8 ± 2.5	.4
Walking support (yes)	134 (63.5)	185 (52.2)	.02
Drugs consumed (number)	10.4 ± 3.9	9.9 ± 6.6	.36
Medical history (number)	5.8 ± 3.8	5.2 ± 3.7	.18
MMSE (/30)	24.1 ± 4.3	24.4 ± 4.4	.41
Minnesota (kcal/d)	728 ± 708	911 ± 714	.01
MNA			
Normal nutritional status	124 (58.8)	245 (69.2)	.09
Risk of malnutrition	70 (33.2)	72 (20.3)	.01
Malnutrition	15 (7.1)	20 (5.6)	.80
Body composition			
ALM/ht^2 (kg/m^2)	8.5 ± 4.5	8.6 ± 2.8	.8
Body fat (%)	25.8 ± 12.7	26.9 ± 12.2	.32
Sarcopenia (yes)	85 (40.3)	120 (33.9)	.09
SF-36			
Physical functioning	0.41 ± 0.28	0.59 ± 0.27	.17
Social role functioning	0.86 ± 0.20	0.88 ± 0.21	.30
Physical role functioning	0.82 ± 0.34	0.87 ± 0.32	.17
Vitality	0.46 ± 0.19	0.49 ± 0.36	.23
Bodily pain	0.72 ± 0.28	0.84 ± 0.39	.46
General health perception	0.63 ± 0.18	0.65 ± 0.20	.21
Emotional role functioning	0.89 ± 0.30	0.94 ± 0.22	.02
Mental heath	0.61 ± 0.22	0.63 ± 0.21	.33
EuroQol five dimensions questionnaire (EQ-5D)	0.54 ± 0.23	0.57 ± 0.25	.39
EuroQol- Visual Analogue Scale (EQ-VAS) (%)	69.2 ± 15.1	69.6 ± 18.1	.81
Katz score (6-24)	11.7 ± 3.3	11.3 ± 5.3	.34
Fear of falling (/64)	34.7 ± 16.6	30.3 ± 16.2	.002
Tinetti test (/28)	21.1 ± 6.6	23.1 ± 5.7	.0002
TUG test (seconds)	29.2 ± 23.9	23.7 ± 16.2	.001
SPPB test (/12)	4.7 ± 2.9	5.9 ± 3.3	<.0001
Gait speed (m/s)	0.65 ± 0.32	0.74 ± 0.36	.07
Grip strength (kg)	16.7 ± 8.2	20.4 ± 12.8	.0002
Peak expiratory flow (mL/min)	142 ± 81.9	150 ± 93.9	.32
Isometric strength			
Knee flexors (N)	78.5 ± 39.8	92.8 ± 37.8	.0006
Knee extensors (N)	90.2 ± 43.1	110.9 ± 57.9	.0003
Ankle flexors (N)	65.6 ± 31.7	83.7 ± 41.2	.005
Ankle extensors (N)	81.6 ± 35.9	96.1 ± 59.5	.01
Hip abductors (N)	65.9 ± 35.8	75.7 ± 43.3	.03
Hip extensors (N)	67.8 ± 43.4	82.5 ± 49.8	.004
Elbow flexors (N)	84.8 ± 37.6	96.1 ± 42.5	.01
Elbow extensors (N)	58.3 ± 26.6	67.3 ± 29.9	.004

ALM/ht^2, appendicular lean mass divided by height square; MMSE, Mini-Mental State Examination; MNA, Mini-Nutritional Assessment; NH, nursing home; TUG, Timed Up and Go.

of the year, the first group was significantly older (*P* = .007) and the proportion of women was lower (*P* = .04) than in the second group. Two out of the 11 operational definitions of frailty assessed seemed to predict the 1-year mortality among nursing home residents: the Tilburg Indicator (OR = 2.2; 95% CI: 1.41-3.47), and the Share Frailty Instrument (OR = 1.94; 95% CI: 1.21-3.09). Deceased participants were also more likely to live in nursing homes with care (*P* = .01) than nondeceased ones. They had a lower arm circumference (*P* = .02) as well as a lower percent of body fat (*P* = .04). Deceased participants were also more likely to be sarcopenic (*P* = .001). The items "general health perception" and "emotional role functioning" of the SF-36 were also lower (*P* = .009 and .001, respectively). Finally, physical performance, assessed with the Tinetti test (*P* < .0001) and the SPPB test (*P* < .0001), were lower among deceased participants than among those still living (Table 3).

Table 2
Association Between Clinical Characteristics and the 1-Year Risk of Falling After Adjustment

Clinical Characteristics	OR (95% CI)
Tinetti test	0.93 (0.87–0.98)
Grip strength	0.95 (0.9–0.98)
Isometric strength of the elbow extensors	0.93 (0.89–0.97)

After adjustment on all variables that were significantly different between deceased participants and those still living, being a man (OR: 1.89, 95% CI: 1.19-3.01, *P* = .002) and the presence of sarcopenia (OR = 1.7, 95% CI: 1.1-2.92, *P* = .03) were independent factors associated with 1-year mortality (Table 4).

Discussion

The number of people living in nursing homes increases in line with the aging of the population. In Belgium, 125,000 people live in nursing homes; this is about 8% of people aged 65 years or older and more than 42% of those over 85 years .[41] The most frequent events causing the most consequences in nursing homes include falls and deaths.[2,3] Also note that delirium, undernutrition, and polypharmacy are common in this setting.[42,43] To adequately prevent these negative health outcomes, it is necessary to identify the risk factors. Therefore, this study, performed in nursing homes, aimed to evaluate the extent to which the various operational definitions of frailty predict falls and mortality at 1 year. A large number of confounding clinical variables were also taken into account in this analysis, included original measurement of the isometric strength of 8 different muscle groups.

In this study, none of the operational definitions of frailty has shown its ability to predict falls at 1 year. A 9-year longitudinal study published in 2015 highlighted that the FRAIL-NH predicts incident falls among nursing home residents.[27] Our results did not confirm this fact. We have 2 hypotheses that can explain this difference. The first is that Luo et al[27] used a cut-off of 5 to determine frailty with the FRAIL-NH while we used the cut-off value of 7, as originally foreseen.[7] The second is that the population is probably different because of the difference between nursing homes in different countries and because of the selection criteria of the SENIOR population (the frailest participants were probably excluded).

Nevertheless, our results are consistent with the literature regarding the independent risk factors for falls among the elderly. The SENIOR study revealed 3 important variables associated with the occurrence of falls.

The first is the Tinetti test, which is a tool designed to assess the risk of falls in the elderly.[44] The Tinetti score was significantly associated with recurrent falls (OR = 1.66; 95% CI: 1.03-2.67) in a population of community-dwelling older people followed during one year.[45] These results are consistent with those presented in this article confirming the importance of optimal body balance and gait in the prevention of falls.

Table 3
Clinical Characteristics of Deceased Participants and Those Still Living

Characteristics	Deceased (n = 93)	Not Deceased (n = 491)	*P* Value
Age (y)	85.2 ± 7.982	82.4 ± 9.2	.007
Sex (female)	57 (61.3)	368 (74.9)	.04
BMI (kg/m^2)	26.1 ± 5.6	25.3 ± 5.7	.17
Frailty assessment			
Fried definition (yes)	38 (42.2)	118 (22.8)	.06
Tilburg instrument (yes)	51 (54.8)	197 (40.0)	.02
Strawbridge questionnaire (yes)	59 (65.5)	286 (55.5)	.13
Share frailty instrument (yes)	51 (54.8)	190 (38.6)	.01
Sega gird (yes)	54 (58.1)	308 (62.7)	.91
Groningen indicator (yes)	69 (76.7)	353 (68.1)	.25
Frailty Index (yes)	50 (55.6)	300 (57.9)	.94
Frailty Scale Status (yes)	35 (38.9)	286 (55.5)	.20
Edmonton scale (yes)	70 (75.3)	217 (44.2)	.16
Clinical Frailty Scale (yes)	22 (24.4)	66 (11.9)	.81
Frail-NH version 1 (yes)	7 (7.53)	28 (5.69)	.49
Frail-NH version 2 (yes)	15 (13.2)	70 (14.2)	.35
Waist circumference (cm)	98.2 ± 13.6	115 ± 33.5	.64
Calf circumference (cm)	32.7 ± 4.2	33.2 ± 4.3	.85
Arm circumference (cm)	27 ± 4.6	28.4 ± 5.3	.02
Wrist circumference (cm)	16.7 ± 2.6	16.6 ± 2.5	.60
Walking support (yes)			
Drugs consumed (number)	10.1 ± 5.9	10.1 ± 4.3	.95
Medical history (number)	4.8 ± 3.3	5.5 ± 3.8	.22
MMSE (/30)	23.4 ± 5.1	24.2 ± 4.5	.07
Minnesota (kcal/d)	735 ± 956	868 ± 819	.17
MNA			
Normal nutritional status	52 (55.9)	330 (67.0)	.08
Risk of malnutrition	31 (33.3)	120 (24.4)	.16
Malnutrition	7 (7.5)	28 (5.7)	.77
Body composition			
ALM/ht^2 (kg/m^2)	8.2 ± 1.9	8.6 ± 3.6	.32
Body fat (%)	23.4 ± 12.2	26.6 ± 13	.04
Sarcopenia (yes)	50 (53.7)	162 (32.9)	.001
SF-36			
Physical functioning	0.39 ± 0.28	0.54 ± 0.29	.36
Social role functioning	0.84 ± 0.24	0.88 ± 0.20	.12
Physical role functioning	0.83 ± 0.35	0.86 ± 0.33	.56
Vitality	0.43 ± 0.18	0.49 ± 0.32	.09
Bodily pain	0.71 ± 0.30	0.81 ± 0.22	.60
General health perception	0.59 ± 0.20	0.65 ± 0.19	.009
Emotional role functioning	0.84 ± 0.22	0.94 ± 0.35	.001
Mental heath	0.61 ± 0.21	0.63 ± 0.21	.46
EQ-5D	0.55 ± 0.26	0.57 ± 0.23	.34
EQ-VAS (%)	66.2 ± 15.9	69.8 ± 17.8	.07
Katz score (6-24)	12.3 ± 4.1	11.3 ± 4.7	.06
Fear of falling (/64)	32.5 ± 15.1	31.6 ± 16.4	.63
Tinetti test (/28)	20.1 ± 5.9	22.7 ± 6.9	<.0001
TUG test (s)	28.4 ± 27.6	25.3 ± 17.8	.17
SPPB test (/12)	4.5 ± 3.1	5.7 ± 3.2	<.0001
Gait speed (m/s)	0.67 ± 0.34	0.70 ± 0.34	.51
Grip strength (kg)	17.3 ± 9.8	19.2 ± 11.6	.15
Peak expiratory flow (mL/min)	132 ± 73.6	149 ± 91.8	.11
Isometric strength			
Knee flexors (N)	77 ± 39.1	88 ± 38.5	.49
Knee extensors (N)	95.6 ± 54.8	103 ± 47.2	.27
Ankle flexors (N)	64.8 ± 34.9	78.4 ± 64.8	.10
Ankle extensors (N)	87.2 ± 53.9	90.8 ± 40.4	.62
Hip abductors (N)	65.9 ± 37.1	72.4 ± 41.2	.96
Hip extensors (N)	69.5 ± 43.4	77.7 ± 48.6	.23
Elbow flexors (N)	83.7 ± 37.4	92.3 ± 41.8	.14
Elbow extensors (N)	63.3 ± 28	62.3 ± 29.2	.70

MMSE, Mini-Mental State Examination; MNA, Mini-Nutritional Assessment; NH, nursing home; TUG, Timed Up and Go.

The second is the grip strength which is thought to reflect general body strength and has been used as a predictor of falls in epidemiologic studies. For example, a 3-year prospective cohort study of 1365 community-dwelling persons, aged 65 years and older, highlighted that grip strength was an independent predictor of recurrent falls (OR = 2.32; 95% CI 1.71-3.13).[46] The association was stronger than in the SENIOR cohort but can be

Table 4
Association Between Clinical Characteristics and the 1-Year Risk of Death After Adjustment

Clinical Characteristics	OR (95% CI)
Sex (male)	1.89 (1.19–3.01)
Presence of sarcopenia	1.70 (1.10–2.92)

explained by the differences in the outcomes (ie, recurrent falls and at least 1 fall in the SENIOR study) and in the population under study (ie, community-dwelling people and nursing home residents in the SENIOR study).

The third is the isometric strength of the elbow extensors, which has been poorly investigated in the scientific literature related to the risk of falls. A hypothesis is that participants weak at the triceps level have more difficulty to react when they lose balance or when they stumble and, therefore, are more likely to fall. A systematic review and meta-analysis published in 2004, including prospective cohort studies that included measurement of muscle strength with follow-up for occurrence of falls among older adults, showed that tricep strength was at the limit of the significance for the risk of falls (ie, OR = 1.3; 95% CI:1.0-1.8).[47]

In summary, after adjustment for confounding variables, only the Tinetti test, the grip strength, and the isometric strength of the elbow extensors were independently associated with the occurrence of falls.

From a clinical point of view, it seems important to note that, even if after adjustments of these variables were no longer significant, the fallers had a significantly lower maximal isometric strength than the nonfallers in univariate analysis. This was true for the 8 muscle groups tested. This is the first study that evaluated the relationship between the isometric strength and the risk of falls among nursing home residents, but these measurements, although promising, would require further investigation. Indeed, it is recognized that maximal isometric strength is associated with physical functional capacity among elderly people.[48] The maintenance of adequate strength could, therefore, be favorable for the mobility and for the risk of falls among the elderly.

This study has also shown that among 11 current definitions of frailty, none was sufficiently sensitive to predict mortality at 1 year. Nevertheless, a recent systematic review highlighted that 2 tools appear as potentially relevant for screening frailty in a primary care setting[49]: the Tilburg Indicator and the Share Frailty Instrument. Indeed, Pialoux showed that these tools had very good psychometric properties and were predictive of mortality. Although the present SENIOR study shows a trend in these variables to predict death in univariate analysis, these data were not confirmed in multivariate analysis. Luo et al[27] showed that the FRAIL-NH predicts mortality (hazard ratio: 2-3.73). This has not been confirmed in the SENIOR study, probably because of the difference in population included and in cut-off used. Because 1 operational definition of frailty has been previously validated in a cohort of nursing home residents, the absence of a predictive value of the frailty definitions found in our study needs to be confirmed in further prospective studies. The predictive value for mortality of the Frailty Index proposed by Rockwood has been tested in the INCUR study (ie, the Incidence of pNeumonia and related ConseqUences in nursing home Residents), which is a longitudinal cohort study of 773 older persons living in 13 French nursing homes.[50] A positive association between the frailty index and 1-year mortality has been found in this study, but this significant association has not been confirmed in the SENIOR study. However, the INCUR study took into account very few confounding clinical variables and the results of this study were only adjusted for age and sex, which may explain the difference with the results observed in the SENIOR cohort. In addition, it is acknowledged the predictive value of the Frailty Index decreases for persons with many deficits because of the ceiling effect.[50] Thus, probably this association was weaker in our cohort of nursing home residents because they had many deficits and were closer to one outcome (ie, mortality). A new tool, the multidimensional prognostic index, has been found to predict mortality in patients with a variety of clinical conditions.[51–54] Currently, no study has validated this tool in a cohort of nursing home residents. It would be interesting to validate the multidimensional prognostic index in this specific population to obtain data complementary to those provided by other operational definitions of frailty regarding the prediction of negative health outcomes.

After adjustment on confounding variables, frailty was not independently associated with mortality in the SENIOR cohort whereas the male sex and the presence of sarcopenia were predictive of death. The association between sarcopenia and mortality has already been highlighted in other studies and has been confirmed in the present study in a specific population of nursing home residents. The meta-analysis by Beaudart et al, including 12 studies, showed a higher rate of mortality among sarcopenic participants (OR = 3.596; 95% CI: 2.96-4.37).[55] Out of the 12 studies included in the analysis, 2 concerned nursing home residents. The subgroup analysis, performed on these 2 studies, also shows that participants with sarcopenia were at higher risk of death compared with participants without sarcopenia (OR = 3.32; 95% CI: 1.84-5.98).[55] Several recent studies have also demonstrated that the male sex was a risk factor for death. For example, a point scoring system to predict the 10-year mortality was developed based on a prospective cohort study of 2244 elderly individuals (older than 60 years of age) from the southwest Seoul Study. This score includes the following variables: age, male sex, smoking, diabetes, systolic blood pressure, triglyceride, total cholesterol, white blood cell count, and hemoglobin. In this study, being a man is associated with mortality (hazard ratio = 1.84; 95% CI: 1.41-2.39). These data are consistent with those of the SENIOR cohort (ie, OR = 1.89; 95% CI: 1.19-3.01).[56] Another longitudinal study of 1011 elderly dependent patients living at home monitored over 1 year shows that women have a lower risk of death (OR = 0.67; 95% CI: 0.50-0.91), which is consistent with our results.[57]

This study has limitations that suggest caution in the interpretation of the results. Foremost, the external validity of this study is limited due to the selection criteria of the SENIOR population. Indeed, to be included in the SENIOR study, residents needed to volunteer to participate and be able to walk. The frailest participants have probably been excluded from this analysis, which may have limited the predictive value of the operational definitions of frailty. The nursing home population is very heterogeneous making the results sensitive to the selection criteria. The values of 11 different operational definitions of frailty for predicting the occurrence of negative health outcomes were tested, but there are many other definitions. A recent meta-analysis identified more than 60 such operational definitions of frailty including different dimensions (ie, physical, emotional, psychosocial, etc.). The choice of one or other definition can lead to totally different results. Finally, a limitation to bear in mind is that only a small part of the explanatory variables for falls and death were taken into account. Indeed, these health outcomes are multifactorial, and very few studies have been exhaustive.

The present study offers interesting perspectives. The first is to confirm these data over the long term but also in other prospective cohorts of institutionalized participants to identify the most appropriate definition of frailty in the specific population of nursing home residents. This manuscript also suggests that, beyond the frailty status, some clinical data would deserve more attention with respect to the prediction of negative health events. The predictive factors of adverse outcomes identified in this study have a significant clinical impact. Medical strategy, or adapted physical activity, with the aim of improving specific isometric muscle strength and mobility could reduce the occurrence of falls, and even deaths, among the institutionalized populations.

In conclusion, within the scope of the operational definitions of frailty assessed, none is predictive of short-term occurrence of falls and deaths among nursing home residents. Globally, the frequency of undesirable health outcomes seems to be higher among participants with lower muscle strength and mobility. When taking into account potential confounding characteristics, after a 12-month follow-up period, the male sex and the presence of sarcopenia are independently associated with mortality, whereas the Tinetti test, grip strength, and isometric strength of the elbow extensors are associated with the occurrence of falls. In view of these results, there is a potential to reduce falls and deaths significantly by means of strategical public health and clinical interventions.

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