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ORIGINAL ARTICLE

Relationship between frailty, physical performance and quality of life among nursing home residents: the SENIOR cohort

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Abstract
Background The aim of this study was to assess the relationship between frailty and a large number of indicators related to physical and muscular performance as well as quality of life.
Methods This is an analysis of data collected at baseline in the Sample of Elderly Nursing home Individuals: an Observational Research (SENIOR) cohort including nursing home residents. Subjects are volunteer, oriented and able to walk (walking assistance allowed) nursing home residents in Belgium. A large number of demographic and clinical characteristics, including physical and muscular performance, were collected from each patient. The prevalence of frailty in this population was assessed using Fried's definition.
Results In total, 662 subjects are included in this analysis. The mean age of the sample is 83.2 ± 8.99 years, and 484 (73.1 %) are women. In this population of nursing home residents, the prevalence of frailty is 25.1 %, pre-frailty, 59.8 % and robustness, 15.1 %. Compared to non-frail subjects, frail subjects have lower physical and muscular performances and a lower quality of life.
Conclusion Frailty, according to Fried's definition, seems to be associated with several clinical indicators suggesting a higher level of disability and an increased propensity to develop major clinical consequences. Follow-up data of the SENIOR cohort will be helpful in confirming these findings, establishing cause–effect relationships and identifying the most predictive components of physical frailty for adverse outcomes in nursing homes.

Keywords Frailty · Physical performances · Quality of life · Nursing home

Introduction

Ageing is associated with a progressive and significant decrease in muscle function (i.e. muscle strength and muscle performance) [1], which is recognized as a common feature of the frailty syndrome [2, 3]. Frailty is defined as a clinical state of increased vulnerability to poor resolution of homoeostasis after a stressor event that increases the risk of adverse outcomes, including falls, delirium and disability [4]. In an ageing world, it is important to focus on the early signs and indicators of future adverse events to prevent ageing-related functional decline and to promote and increase healthy life years [5]. Therefore, the identification of frail individuals has been recognized as a priority for effective implementation of healthy ageing strategies. The frail elderly tend to depend more on others due to their limitations in physical function compared to the robust elderly [6], and maintenance of function is more important to the elderly than healing from diseases [7]. Because of the burden of frailty and its costs to both the individual and society, this clinical state is of concern, given the ageing population. Therefore, it seems essential to public health to

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implement screening for frailty. However, limited data exist regarding the predictors or consequences of frailty in the nursing home setting. In the literature, several studies assessing the clinical components of frailty exist, but each of these studies is focused on restricted clinical characteristics [8–10]. Based on these observations, we decided to implement an ongoing longitudinal study following elderly nursing home residents, called the Sample of Elderly Nursing home Individuals: an Observational Research (SENIOR) cohort, to assess the relationship between frailty and a large number of socio-demographic and clinical characteristics, including physical performance. The aim of the present paper is to offer an overview of the data collected in this study and to present the baseline characteristics of the subjects enrolled in the SENIOR cohort. Data on the prevalence of frailty will also be presented in this manuscript. Finally, physical performance will be compared between frail and robust subjects.

Methods

Population

The Sample of Elderly **N**ursing home Individuals: an **O**bservational Research (SENIOR) cohort is a prospective longitudinal study of Belgian nursing home residents. The selection criteria of the population were (1) living in a nursing home in the Province of Liège that was included in this study; (2) being oriented, to provide informed consent and understand the questionnaires; and (3) being able to walk and stand, including with technical assistance. The study was approved by the Ethics Committee of the University teaching Hospital of Liège under number 2013/178.

Data collected

All subjects were interviewed by a clinical research assistant for a mean time of 1 h to obtain the socio-demographic and anamnestic data. Clinical characteristics of each patient were collected to assess their physical and muscular performances. Data have been collected in the same order, as mentioned below. Note that two different clinical research assistants were in charge of the data collection and were trained to standardize this collection.

Frailty diagnosis

Fried defines frailty as a deficit in five domains. Thus, the phenotype of frailty was identified by the presence of three or more of the following components: weight loss (self-reported unintentional weight loss of more than 4.5 kg in the past year), weakness (dynamometer-measured grip strength below the established cut-off based on gender and BMI), poor endurance and energy (self-reported exhaustion measured by two items from the Centre for Epidemiological Studies depression scale), slowness (walking speed on 4.5 m distance below the established cut-off based on gender and height) and low physical activity level (self-reported time spent in physical activity in the past 7 days based on the Minnesota scale below the established cut-off based on sex). The presence of one or two deficits indicates a pre-frail condition, and a total of three or more deficits indicate frailty, while the absence of deficits indicates a robust state [2].

Physical and muscular performances

Tinetti test The Tinetti test, or Performance-Oriented Mobility Assessment (POMA), was used to assess body balance and gait abnormalities. This assessment is one of the most widely used tests in this field. This test consists of 16 items: 9 for body balance and 7 for gait. The maximum score is 16 for body balance, 12 for gait and thus 28 for the global score (balance + gait). In general, a score below 19 indicates a high risk of falls, a score between 19 and 24 indicates a moderate risk of falls, and 28 points indicates no risk of falls [11, 12].

Timed Up and Go test The Timed Up and Go test is a modified version of the "Get Up & Go" test. This test measures basic mobility and dynamic equilibrium capabilities in a complex task in the elderly [13, 14]. From a sitting position, the subject has to stand up, walk 3 m, turn around, walk back and sit down again. The time needed to complete the task is recorded and used for analysis [15]. A time of more than 30 s indicates a high level of dependence. A time of between 20 and 30 s indicates uncertain mobility and a risk of falling. A time of <20 s indicates independence of the subject [13, 16].

SPPB test The Short Physical Performance Battery (SPPB) test is composed of three separate tests: balance, 4-m gait speed and a chair stand test. A score between 0 and 4 is assigned on each test, and the three tests are weighted equally. Therefore, the maximum score is 12 points. The cut-off value used to assess poor physical performance is ≤ 8 points, according to the EWGSOP group (European Working Group on Sarcopenia in Older People) [17].

Gait speed Gait speed, which is a component of the SPPB test, is also recognized to assess physical performance [18]. A walking speed <0.8 m/s is considered to indicate poor physical performance [17]. Patients were instructed to walk

at their comfortable speed, as they safely could be, without running, from one cone to the next, placed 4 m apart.

Grip strength Handgrip strength of the subjects was measured using a hydraulic dynamometer (Seahan Corporation, MSD Europe Bvba, Belgium). The device was calibrated at the beginning of the study to 10, 40 and 90 kg. Subjects were asked to squeeze the dynamometer as long and as tightly as possible or until the needle stopped rising. Three measurements for each hand, alternating sides, were performed, and the best of the six grip strength measurements was used for statistical analysis [19].

Grip work Grip work, or the fatigue resistance test, consists of squeezing a dynamometer as hard as possible and maintaining the pressure until the recorded grip strength drops to 50 % of its maximum value [20]. Three measurements for each hand, alternating sides, were performed, and the best of the six grip strength measurements was used for statistical analysis. The grip work, or the total effort produced during this test, was calculated by the following formula: Grip work = (grip strength (kg) × 0.75) × fatigue resistance (min). It was measured using a hydraulic dynamometer.

Muscular isometric strength of 8 muscle groups Maximal isometric muscle strength of 8 different muscle groups (knee extensors and flexors, hip abductors and extensors, ankle flexors and extensors, elbow flexors and extensors) was measured according to the protocol defined by Buckinx [1]. Three consecutive maximal contractions of each muscle group were performed, and the highest performance was considered for the analysis.

Peak expiratory flow Peak expiratory flow rate is a person's maximum speed of expiration, as measured with a Mini-Wright's peak flow metre. Subjects were instructed to take a full breath in and then to exhale as fast as they could into the device. The measurement obtained is called peak flow and is expressed in litre/min.

Anamnestic data

Socio-demographic data A large number of variables were obtained from the subjects and completed using patient medical records: age, gender, anthropometric measurements such as weight to the nearest 0.1 kg and height to the nearest 0.1 cm, from which body mass index (BMI) was calculated, abdominal circumference to the nearest 0.1 cm, type of institution (nursing home, nursing home and care), technical assistance for walking, participation in physiotherapy sessions, alcohol consumption, smoking habits, drugs consumed, medical history, history of fractures and hospitalizations.

Cognitive status Cognitive skills were assessed with the Mini-Mental State Examination (MMSE), which consists of a 30-item questionnaire. A maximum score of 30 is attainable for a person without any neuropsychological impairments. Any score greater than or equal to 27 points indicates normal cognition. Below this cut-off, scores can indicate severe (≤9 points), moderate (10–18 points) or mild (19–24 points) cognitive impairment [21].

Nutritional status Nutritional status was assessed using the Mini Nutritional Assessment (MNA). This test comprises two parts: a screening part followed by an assessment part. If the score obtained for the screening section is 12 or more points out of the 14 total possible points, the subject is classified as well nourished and does not need to complete the assessment part. If the subject presents a screening score of 11 points or less, the assessment part has to be completed. The full evaluation is scored on 30 points. A score of 24 points or more indicates that the subject is well nourished, a score between 17 and 23.5 points indicates a risk of malnutrition, and a score lower than 17 points indicates malnutrition [22].

Level of physical activity Participant's leisure time activity was evaluated using the short version of the Minnesota Leisure Time Physical Activity Questionnaire. This questionnaire asks participants about the types, frequency and duration of their leisure time activity (average hours/day engaged in the following four categories: walking, doing aerobics or workouts, sports and household activities). The number of calories burned per day was calculated using the activity metabolic index, which enables the calories burned to be measured using the metabolic equivalent of tasks [23].

Body composition A validated multi-frequency bioelectrical impedance analyser, the InBody S10 Biospace device (Biospace Co, Ltd, Korea/Model JMW140), was used to assess the body composition of the subjects [24]. Electrodes are placed at 8 precise tactile points of the body to achieve a multi-segmental frequency analysis. A total of 30 impedance measurements are obtained using 6 different frequencies (1, 5, 50, 250, 500, 1000 kHz) at the 5 following segments of the body: right and left arms, trunk, and right and left legs.

Quality of life Quality of life was assessed using the following:

- The Short-Form 36 questionnaire (SF-36) is a 36-item questionnaire that measures quality of life (QoL) across

eight domains that are both physically and emotionally based. The eight domains that the SF-36 measures are as follows: physical functioning, role limitations due to physical health, role limitations due to emotional problems, energy/fatigue, emotional well-being, social functioning, pain and general health. In summary, an aggregate percentage score is produced for each of the eight domains that the SF-36 measures. The percentage scores range from 0 % (lowest or worst possible level of functioning) to 100 % (highest or best possible level of functioning) [25].

- The EuroQol 5-dimension (EQ-5D) documents the level of self-reported health problems according to 5 dimensions (mobility, self-care, usual activity, pain/discomfort and anxiety/depression). Each dimension comprises 3 levels: no problems, some problems and severe problems. The EQ-5D health states are then converted into a single summary index, providing a score ranging from 1 (perfect health) to 0 (death) [26, 27].
- The EQ visual analogue scale (EQ-VAS) records the respondent's self-rated health on a vertical, visual analogue scale with endpoints labelled "Best imaginable health state" (100) and "Worst imaginable health state" (0). This information can be used as a quantitative measure of health outcome as perceived by the individual respondent [26].

Level of autonomy and dependence Subjects' functional limitations in activities of daily living (ADLs) were assessed by the Katz scale [28], which measures the independence of the subject in 6 basic and instrumental activities of daily living: bathing, dressing, toileting, transferring to and from a bed or chair, continence and feeding. A score ranging from 1 to 4 is attributed to each item depending on how independent the individual is when performing the activity. Higher scores indicate higher dependence in ADLs.

Fear of falling To assess the fear of falling (FOF), the Fall Efficacy Scale-International (FES-I) questionnaire was used. Individuals are asked to rate, on a four-point Likert scale, their concerns about the possibility of falling when performing 16 activities. The scores are summed to calculate a total score that ranges from 16 to 64 points, and a higher score indicates a greater FOF [29].

Statistical analysis

Quantitative variables that were normally distributed were expressed as the mean ± standard deviation (SD), and quantitative variables that were not normally distributed were reported as the median and percentiles (P25-P75). Shapiro–Wilk's test verified the normal distribution of all parameters. Qualitative variables were reported as absolute and relative frequencies (%). A global presentation of all subjects' baseline characteristics was performed, and frail subjects' characteristics were compared to those of robust subjects using a univariate analysis. ANOVA analysis was therefore used. Data were adjusted on age, sex and BMI using a multiple or regression analysis. The data analyses were performed using Statistica 12 software. The results were considered statistically significant when the two-tailed p values were <0.05.

Results

The SENIOR population

Subjects from 28 different nursing homes were included in this study (Fig. 1). In total, these nursing homes have 2675 beds (i.e. nursing home, nursing home and care). Out of these 2675 residents, 735 (27.5 %) met the selection criteria of the study. And 662 (90.0 %) of them agreed to participate in the study. Therefore, we included 24.7 % of the nursing home population.

A total of 662 subjects were therefore included in the SENIOR cohort (73.1 % women, mean age of 83.2 ± 8.99 years). The demographic and clinical characteristics of the subjects are shown in Table 1.

Prevalence of frailty

Of these 662 subjects, 166 (25.1 %) are frail, 396 (59.8 %) are pre-frail and 100 (15.1 %) are robust. Frailty is present in 71 women (27.3 %) and 35 men (19.2 %), pre-frailty in 286 women (59.6 %) and 110 men (60.4 %), whereas 56 women (11.7 %) and 33 men (18.1 %) are robust.

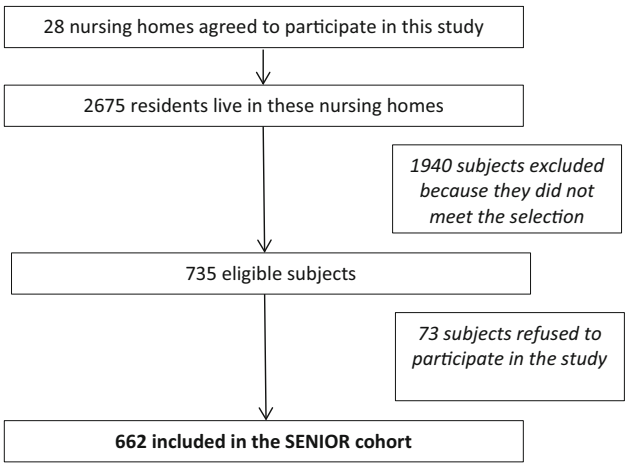

Fig. 1 Flowchart

Table 1 Baseline characteristics of the SENIOR cohort ($n = 662$)

Characteristics	Mean ± SD	Median (P25-P75)	Number (%)
Age (years)	83.2 ± 8.99		
Sex (women)			480 (72.5)
Place of residence			
Nursing home			467 (70.5)
Nursing home and care			195 (29.5)
BMI (kg/m^2)	25.9 ± 5.52		
Waist circumference (cm)	110.7 ± 15.7		
Calf circumference (cm)	33.1 ± 4.25		
Arm circumference (cm)	28.1 ± 5.13		
Walking support			
None			291 (44.2)
Cane			117 (17.7)
Walking frame			195 (29.5)
Crutch			8 (1.22)
Wheelchair			34 (5.16)
Arm			7 (1.07)
Other			8 (1.22)
Drugs consumed (number)	10.4 ± 6.63		
Medical history (number)[a]		5 (3-8)	
MMSE (/30)	24.1 ± 4.52		
Minnesota (kcal/day)	853 ± 826		
MNA			
Normal nutritional status			439 (69.9)
Risk of malnutrition			175 (27.9)
Malnutrition			14 (2.20)
Body composition			
ALM/ht^2 (kg/m^2)			
Women	7.64 ± 1.08		
Men	9.44 ± 2.21		
Body fat (%)			
Women	28.3 ± 11.9		
Men	20.2 ± 8.71		
SF-36			
Physical functioning	0.53 ± 0.43		
Social role functioning	0.88 ± 0.21		
Physical role functioning	0.86 ± 0.33		
Vitality	0.47 ± 0.30		
Bodily pain	0.79 ± 0.42		
General health perception	0.65 ± 0.19		
Emotional role functioning	0.93 ± 0.24		
Mental heath	0.63 ± 0.21		
EQ-5D	0.57 ± 0.24		
EQ-VAS (%)	69.6 ± 17.4		
Katz score (6–24)	11.4 ± 4.55		
Fear of falling (/64)	31.8 ± 16.4		
Fried status			
Frail			166 (25.1)
Pre-frail			396 (59.8)
Robust			100 (15.1)

Table 1 continued

Characteristics	Mean ± SD	Median (P25-P75)	Number (%)
Tinetti test (/28)	22.4 ± 6.24		
TUG test (seconds)		19.9 (14.2-31.9)	
SPPB test (/12)	5.56 ± 3.23		
Gait speed (m/sec)	0.89 ± 4.25		
Grip strength (kg)	18.6 ± 10.9		
Grip work (kg)	24.9 ± 16.6		
IS: knee flexors (N)	85.7 ± 38.9		
IS: knee extensors (N)	101.6 ± 52.4		
IS: ankle flexors (N)	74.9 ± 56.7		
IS: ankle extensors (N)	87.9 ± 50.9		
IS: hip abductors (N)	69.9 ± 40.5		
IS: hip extensors (N)	74.9 ± 47.1		
IS: elbow flexors (N)	82.9 ± 40.6		
IS: elbow extensors (N)	63.2 ± 29.1		

IS isometric strength

[a] Medical history included general state of health, childhood diseases, immunizations (Tetanus–diphtheria, pertussis, measles, mumps, rubella, hepatitis A and B, influenza, varicella, polio), adult medical diseases, injuries and operations, allergies

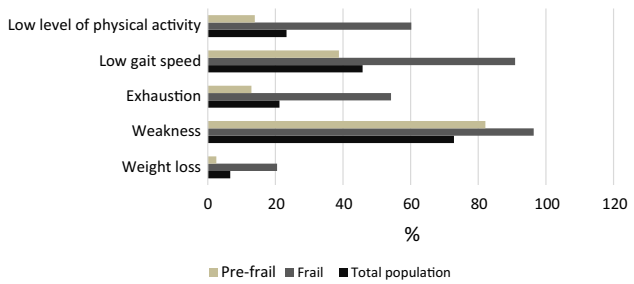

Fig. 2 Number of subjects with each component of frailty

Regarding Fried's five criteria, 44 subjects (6.61 %) present a loss of weight, 485 (72.8 %) weakness, 141 (21.2 %) exhaustion, 305 (45.8 %) a low gait speed and 155 (23.3 %) a low level of physical activity. The presence of these criteria is presented in Fig. 1 among frail and pre-frail subjects, as the robust subjects met no criteria (Fig. 2).

Physical and muscular performance according to frailty status

As expected, after adjusting for age and sex, all the collected data on strength and physical performance significantly differ between frail subjects, pre-frail subjects and robust subjects. Significant difference in body composition (body fat) is also observed between the groups (Table 2).

Quality of life according to frailty status

All domains of quality of life assessed by the SF-36 questionnaire, except for bodily pain, seem significantly different between frail, pre-frail and robust subjects after adjusting for sex, age and BMI. Quality of life assessed by the EQ-5D and EQ-VAS is also highly significantly different according to frailty status (Table 3).

Discussion

In the baseline evaluation of the SENIOR cohort, we assessed the prevalence of frailty among oriented and able to walk subjects and we compared the physical and muscular performances between frail, pre-frail and robust subjects using Fried's definition of frailty [2].

We found a prevalence of frailty of 25.1 %, which is lower than the prevalences observed in other European cohort studies performed in the nursing home setting. For example, a Polish study showed a prevalence of frailty of 34.9 % [30]. This higher value is probably due to the selection criteria of the study population. Indeed, the Polish studied population included 55.8 % of subjects with cognitive impairment, which was an exclusion criterion of the SENIOR cohort. Moreover, the operational definition used for the diagnosis of frailty in the Polish study was the Canadian Clinical Frailty Scale, whereas we used Fried's definition, and it is proved that the prevalence of frailty varies according to the definition used [31]. Another study showed a prevalence of frailty, based on the Cardiovascular Health Study frailty criteria, of 48 % in a population of Canadian nursing home residents [32]. The FINAL study of Gonzalez-Vaca also showed a higher prevalence of frailty than in our cohort, with a value of 68.8 % [33] in

Table 2 Physical and muscular performance according to frailty status

Characteristics	*N*	Frail	*N*	Pre-frail	*N*	Robust	*p* value
Tinetti test (/28 points)	155	17.1 ± 6.99	387	24.2 ± 5.10	94	26.6 ± 2.65	0.001
Timed Up and Go test (sec)	156	32.4 (22.2−44.4)	390	24.1 (14.4−28.0)	96	14.1 (10.4−16.8)	<0.0001
SPPB test (/12 points)	160	2.85 ± 2.18	394	5.96 ± 2.94	96	8.51 ± 2.31	0.001
Gait speed (m/sec)	140	0.44 ± 0.18	381	0.75 ± 0.33	95	1.04 ± 0.37	0.001
ALM/ht^2 (kg/m^2)	51	7.96 ± 1.26	160	8.06 ± 1.40	36	8.35 ± 1.25	0.50
Body fat (%)	51	28. ± 11.9	160	25.1 ± 11.9	36	23.3 ± 10.8	0.04
Grip strength (kg)	166	14.1 ± 6.68	396	18.1 ± 9.23	99	27.9 ± 16.6	<0.0001
IS: knee flexors (N)	112	68.1 ± 36.2	270	88.4 ± 35.8	54	108.9 ± 44.0	<0.0001
IS: knee extensors (N)	112	79.9 ± 41.1	270	103.6 ± 52.5	54	136.4 ± 52.3	<0.0001
IS: ankle flexors (N)	112	64.1 ± 88.6	270	74.3 ± 34.5	54	100.2 ± 54.6	0.0004
IS: ankle extensors (N)	112	70.3 ± 32.1	270	90.2 ± 55.7	54	113.7 ± 45.5	<0.0001
IS: hip abductors (N)	112	45.5 ± 35.9	270	73.1 ± 36.1	54	104.6 ± 39.9	<0.0001
IS: hip extensors (N)	112	45.1 ± 38.2	270	78.3 ± 43.9	54	111.7 ± 46.0	<0.0001
Isometric strength: elbow flexors (N)	112	72.4 ± 32.5	270	90.7 ± 38.3	54	116.2 ± 49.8	<0.0001
Isometric strength: elbow extensors(N)	112	52.6 ± 23.2	270	63.9 ± 27.6	54	81.5 ± 36.8	<0.0001

Table 3 Quality of life according to frailty status

Characteristics	*N*	Frail	*N*	Pre-frail	N	Robust	*p* value
SF-36 physical functioning	165	0.25 ± 0.22	394	0.59 ± 0.26	89	0.73 ± 0.23	0.003
SF-36 social role functioning	165	0.80 ± 0.26	394	0.91 ± 0.18	89	0.94 ± 0.15	<0.001
SF-36 physical role functioning	165	0.70 ± 0.44	394	0.91 ± 0.26	89	0.93 ± 0.25	<0.001
SF-36 vitality	165	0.39 ± 0.20	394	0.50 ± 0.34	89	0.56 ± 0.18	<0.001
SF-36 bodily pain	165	0.60 ± 0.32	394	0.74 ± 0.28	89	1.32 ± 4.69	0.14
SF-36 general health perception	165	0.58 ± 0.20	394	0.66 ± 0.18	89	0.72 ± 0.17	<0.001
SF-36 emotional role functioning	165	0.84 ± 0.36	394	0.96 ± 0.19	89	0.95 ± 0.21	<0.001
SF-36 mental health	165	0.56 ± 0.22	394	0.64 ± 0.21	89	0.69 ± 0.20	<0.001
EQ-5D	166	0.26 ± 0.36	396	0.59 ± 0.22	89	0.69 ± 0.39	<0.001
EQ-VAS	166	065 ± 0.18	396	0.70 ± 0.16	89	0.75 ± 0.16	<0.001

Spanish nursing home residents using Fried's definition of frailty. This greater prevalence of frailty compared to our study is also probably due to the selection criteria of the population, as 77.9 % of the Spanish subjects had an MMSE score below 24. The results of these different studies are difficult to compare to ours because it is known that the prevalence of frailty varies, not only according to the definition used for the diagnostic, but also according to country [34]. Thus, it is important to obtain valid data for each country and for each population. To our knowledge, this is the first Belgian study assessing the prevalence of frailty in nursing home residents.

The prevalence of pre-frailty in the SENIOR cohort was 59.8 %. In the literature, few studies exist in the nursing home setting. Nevertheless, according to a recent analysis performed on community-dwelling older people from 10 countries, the prevalence of pre-frailty is 37.4 % (ranging from 30.4 to 44.9 % according to the country). A Belgian study showed a prevalence of pre-frailty in community-dwelling older people of 47.9 % [35]. The prevalence of our result is higher because nursing home residents are generally older and more dependent than community-dwelling older people.

Regarding each of Fried's five criteria, in our study, weakness was the most common deficit present in nursing home residents as reported by 72.8 % of the subjects. This is consistent with the data presented by Freiheit, which showed a higher prevalence of weakness (88.9 %) compared to Fried's four other criteria [32]. This finding seems to indicate a potential link between frailty and sarcopenia.

In our study, frail subjects had lower physical and muscular performances than robust subjects. This is quite expected because low muscle strength (i.e. grip strength)

and low gait speed are components of frailty, and this finding is consistent with other studies. For instance, Batista showed that lower levels of lower limb muscle strength were associated with advanced age and greater presence of signs of frailty [36]. Given the various effects of frailty on physical health, the quality of life of the subjects affected by this syndrome is very likely to be decreased. Indeed, a recent study reported a reduced quality of life among frail elderly people living in the community [37]. However, few studies have reported data concerning the quality of life of frail institutionalized subjects.

This study has a number of strengths. This is an original study conducted in a large number of nursing home residents and it includes a large number of demographic and clinical characteristics. Therefore, the SENIOR cohort may offer robust longitudinal evaluations of frailty. Moreover, the diagnosis of frailty is based on Fried's definition, which is the most widely used tool to assess frailty in the literature. The use of this definition will enable us to compare our data with the existing data. Finally, in addition to conventional data on muscle strength (i.e. grip strength), we collected the isometric muscle strength of 8 muscle groups. This may provide interesting data on physical function. Indeed, our results highlight that frail subjects have a lower isometric strength compared to non-frail subjects and this is particularly true with regard to the hip strength. This finding offers complementary research perspectives, especially in longitudinal studies, in order to determine whether a low hip strength could be a good predictor of frailty.

Our study, unfortunately, has limited external validity because of the non-representativeness of the sample. Indeed, the sample was mainly composed of volunteer, oriented and able to walk nursing home residents, and thus, the frailest subjects have probably been excluded from this study. This limits the extrapolation of our results to all nursing home residents. We should also note that large number of tests and questionnaires might be tiring for elderly people, and thus, this may have led, in our study, to an underestimation of the results (i.e. test of strength for example). To limit this bias and make comparisons possible, tests were always carried out in the same order in all subjects.

Finally the cross-sectional design of our study enables the establishment of some associations between frailty and physical components but not the identification of cause–effect relationships. Longitudinal studies are necessary to determine these types of relationships and are also needed to validate Fried's criteria (i.e. as predictive criteria for adverse health outcomes).

In conclusion, frailty is a major public health problem because it concerns a large number of elderly subjects, even in nursing homes. Frailty seems to be associated with a substantial number of physical and muscular performance indicators. Longitudinal studies are necessary to confirm these data, to establish a cause–effect relationship and to identify the most predictive components of physical frailty for adverse outcomes in nursing homes. Follow-up data of the SENIOR cohort could be helpful to fill this gap in the literature.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Human and Animal Rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants for whom identifying information is included in this article.

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