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Characteristics of frailty phenotype in Chinese nursing home population and significance of motor function indicators in frailty assessment

Yizhao Wang, MS[a,b,*] ⓘ, Xin Yang, BS[b,c], Hao Liu, BS[b], Qingling Feng, BS[b], Yaqing Li, BS[b], Weijia Hou, BS[b], Xinlong Chen, BS[b], Liping Huang, MD, PhD[a], Jialing Wu, MD, PhD[d]

Abstract

The objectives of this study were to analyze the distribution characteristics of frailty phenotypes in older adults of Chinese nursing homes, and to compare some motor function characteristics of older adults in nursing homes between frailty and non-frailty, to determine which motor function and frailty are related. This cross-sectional study included 177 older adults living in nursing homes. Frailty was diagnosed by Fried's phenotype, and motor function assessment characteristics (including muscle tone, ROM, and balance) were also evaluated. Chi-square and logistic regression analyses were performed. Frailty prevalence was 53% in nursing homes in big Chinese cities (average age 82.0 ± 6.1). Low levels of physical activity (90.4% in frail elder), decreased handgrip strength (98.9% in frail elder) and slowed walking speed (100% in frail elder) were the 3 main components of the frailty phenotype of frail adults in nursing homes in China. It is worth noting that 74.7% of the non-frail elders also had reduced handgrip strength. Further analysis showed that balance ($P < .001$), muscle tone (upper, $P = .028$, lower, $P = .001$) and the range of motion ($P < .001$) were associated with frailty in older adults. The frailty of the elders in Chinese nursing homes was characterized by the decline of motor function. And surprisingly, both frail and non-frail elders were found to have poor strength. Frail nursing home seniors also have body muscle tone, range of motion and balance problems. The elderly of China should focus on strength, stretch and balance training to improve motor function, especially strength training, which is important for prevention frailty.

Abbreviations: FP = frailty phenotype, OR = odds ratios, ROM = range of motion.

Keywords: frailty, motor function, nursing home

1. Introduction

Life expectancy is getting longer and longer, especially in developed countries,[1] which will lead the world to face an aging problem. In China, the older adult population has grown to over 190 million, accounting for 13.5% of the total population in the end of 2020.[2] The rapid expansion of the aging population around the world has brought a concomitant rise in the number of older people with frailty. Frailty imposes a heavy burden on both society and the family. A study[3] found that frail women spend 3 times as much as healthy women on health care each year (annual cost $3781 robust vs $10755 frail). Nevertheless, frailty is not an inevitable part of the aging process, and many older people reach advanced ages without developing frailty.[4] However, many frail older people frequently do not identify themselves as frail.[5] In addition, frailty is a dynamic process that may gradually alleviate or worsen.[6] Frailty may increase the risk of falls and decrease the quality of life in the elderly. Therefore, early detection and appropriate interventions for frail older people are essential to prevent adverse outcomes and reduce health care costs.[7] Many studies have reviewed publications that captured the rate of frailty progression and established any associated risk or protective factors that affected this progression. Alcohol use,[8] cardiovascular risk,[9] diabetes[10] etc have been identified as risk factors of frailty. Higher education,[11] higher wealth,[12] being male[13]

* Correspondence: Yizhao Wang, College of Exercise and Health Sciences, Tianjin University of Sport, No.16 Donghai Road, West Tuanbo New Town, Jinghai District, Tianjin 301671, China (e-mail: wang_yizhao@126.com).
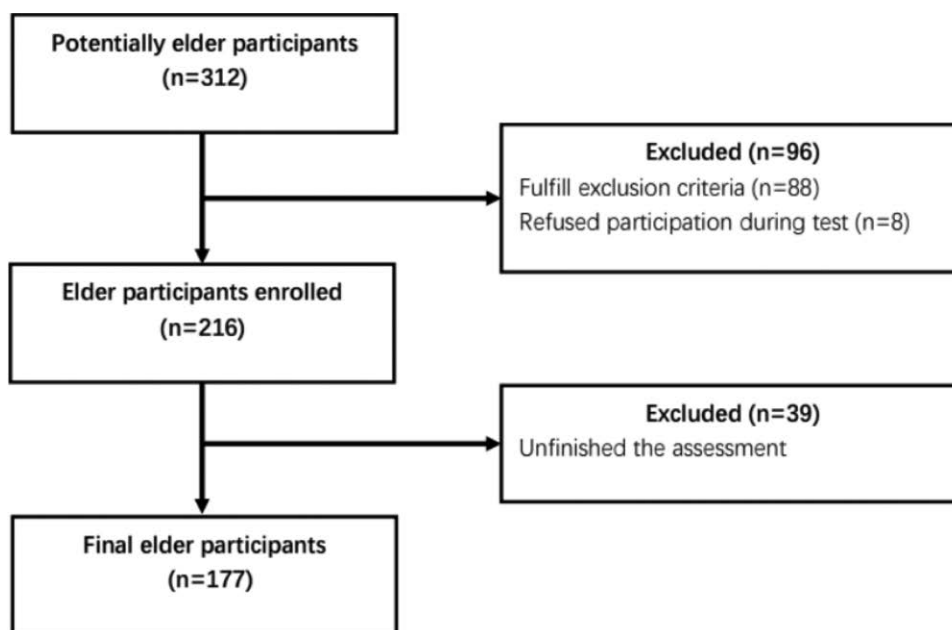
Figure 1. Flow chart of the study.

etc are considered protective factors. However, some of these factors, such as current illness, gender, and education level, are hard to change.

There is no gold standard tool of frailty measurement nowadays. Frailty index and frailty phenotype (FP) are 2 principal models of frailty. Frailty index is directly correlated with important clinical outcomes and has shown the capacity to predict outcomes of patients with ankle fractures.[14] The Fried's FP measurement, which have 5 phenotypes, was the most widely used screening tool. Three of phenotypes are directly related to motor function (slowness, weakness, and low physical activity), which are the ones that are subject to intervention. As noted above, some frailty influences, such as gender and education level, are relatively fixed. Motor function characteristics like strength and balance could be improved through rehabilitation intervention. That means early detection and correction of the motor function indicators associated with frailty can reduce the occurrence of frailty. From the European[15] and the American[16] studies, both subjective assessment (self-report fatigue) and objective assessment (unintentional weight loss, slowness, weakness, and low physical activity) were serious problems of frailty. However, the distribution of 5 components of FP in Chinese nursing institutions has not been reported. It is also unclear which motor functions are associated with frailty. It is an important reference for providing care and rehabilitation intervention to find out which motor function indicators are poor in the elder in China.

Hence, the objectives of this study were to analyze the difference between the 5 components of FP in older adults of Chinese nursing homes; to compare some motor function characteristics of older adults in nursing homes between frail and non-frail, to determine which motor function and frailty are related.

2. Methods

2.1. Study design and setting

A cross-sectional study was conducted on a sample of 177 older people from nursing homes living in the area of Tianjin of China in 2022. Tianjin is a big city with >13 million people. Older people were assessed by experienced physical therapists. The assessment included muscle tone, range of motion (ROM), balance and frailty. Before starting the data collection, we described

the project to each elder person and expressed respect for confidentiality and information privacy. Participants had the right not to participate in the study and to withdraw their consent at any time.

2.2. Sample inclusion and exclusion criteria

All participants were screened based on the inclusion and exclusion criteria before and during the face-to-face interview.

The inclusion criteria were: being over 60 years of age; ability to complete the assessments; ability to understand and follow instructions; and agreement of participation.

The exclusion criteria were: being under 60 years of age; very poor health and unable to finish the assessments; severe cognitive deficit or deafness that prevented interaction; refusing to participate in this study.

Figure 1 presented the selection flow chart. During the study period, a total of 312 elders from 4 different nursing homes in a big Chinese city were screened, among which 88 participants met the exclusion criteria, 8 people refused to participate during the test, and 39 elders did not finish the assessments. Hence, a total of 177 participants were included in the final analysis.

2.3. Frailty assessment

Fried's FP was defined as a clinical syndrome in which three or more of the following components were present[17]: unintentional weight loss (≥10 lbs in a prior year), poor endurance and energy (self-reported exhaustion), weakness (grip strength), slow walking speed (time to walk 15 feet), and low physical activity (based on the short version of the Minnesota Leisure Time Activity questionnaire).

2.4. Motor function assessment tools

1) Muscle tone: Modified Ashworth Scale[18] was used for grading muscle tone. 1/1 + grade means normal, and 2 to 5 grade means spasticity. The shoulder, elbow, and wrist represent the upper limbs; the hip, knee, and ankle represent the lower limbs. If one of them is grade 2 or higher, it is marked as spasticity.

2) ROM: The ROM[19] of the shoulder, elbow, wrist, hip, knee, and ankle joint were measured. If one of them is abnormal, it is recorded as limited upper/lower limb ROM.

3) Balance: The balance subscale of the Fugl–Meyer Assessment[20] was used for balance evaluation. 0 to 6 scores mean the subject is hard to stand up; 7 to 10 scores mean the subject is hard to stand up by one leg; 11 to 14 scores mean the subject has normal or nearly normal balance.

2.5. Statistical analysis

Kolmogorov–Smirnov tests were used to check continuous variables for normal distribution. For normally distributed variables, data were described as mean ± SD. For categorical variables, data were described as quantity and percentiles. Chi-squared test for general information and motor function characteristics when older people were divided into frail and non-frail. Logistic regression models were utilized to analyze the relationship between motor function and frailty. Results of Logistic regression models were presented as odds ratios (OR) and 95% confidence intervals. P value < .05 was considered statistically significant. All statistical analyses were carried out using Statistical Package for Social Sciences version 24.0 (SPSS Inc., Chicago, IL).

2.6. Patient and public involvement

There were no participants involved in the development of this study. Measurements results were provided to the participants, physical therapists and nursing home caregivers.

3. Results

3.1. Proportion of the frailty phenotypes

For frail elders, the most severe problems were slowness (100%), weakness (98.9%), and low physical activity (90.4%), with >90% of the frail elders having these problems (Table 1, Fig. 2 red line). Weakness was also the most common aspect in the non-frail elders; 74.7% non-frail elders had reduced handgrip strength (Table 1, Fig. 2 dash blue line).

3.2. General information and motor function characteristics in frailty

There was 53% frailty (94/177) in the research, and the average age was 82.0 ± 6.1 years for all nursing home elders. More than 60% of the elderly are in their 80s. The study sample included 101 females (57%) and 76 males (43%). There were no significant differences in frailty prevalence by gender and age.

Table 2 presented the results of motor function characteristics also. In the muscle tone assessment, only 3 (3.6%) and 2

(2.4%) non-frail elders were spasticity on the upper limb and the lower limb, respectively, but >10% (12.9% in upper limb and 17.4% in lower limb) in frail people; High percentage of non-frail elders (90.4% in upper limb and 86.7% in lower limb) had normal ROM, comparatively low proportion (63.4% in upper limb and 60.2% in lower limb) in frail elders; The balance assessment, 91.5% of non-frail people can stand up, one-third of them can stand by one leg. However, only 35.9% of frail elders can stand up, and just 1.1% of frail elders can stand with one leg.

In sum, there were significant differences between non-frail and frail elders in muscle tone, ROM and balance. Non-frail elders had significantly better motor function characteristics than frail elders.

3.3. Logistic regression model of frailty

Since this research was a cross-sectional study, the regression model was not designed to identify risk factors for frailty, but to estimate the risk of frailty for different motor functions (Table 3).

The effect of balance on frailty was statistically significant (P < .001). Older people who could stand but couldn't stand on one leg (7–10 scores) had twelve times the risk of frailty compared to those who could stand on one leg (11–14 scores) (OR = 12.499, P = .016). Older people who could not stand (0–6 scores) had 151 times the risk of frailty compared to those who could stand on one leg (11–14 scores) (OR = 151.519, P < .001).

Upper limb ROM was another key characteristic that has a relationship with frailty amongst the elderly (P = .010). Those with limited ROM in the upper limb were almost 3 times more likely to be frail than those with normal upper limb ROM (OR = 2.801, P = .038).

4. Discussion

This study analyzed the proportion of 5 FPs in frail and non-frail elders. The frailty of the elders in China was characterized by the decline of motor function. In particular, muscle weakness was common among non-frail older people also. Moreover, the study described the motor function characteristics in Chinese nursing homes between frail and non-frail. The findings generally showed that the frail elder's motor functions, such as balance, muscle tone, and ROM, were worse than those of the non-frail elder in Chinese nursing homes. Chinese elders should focus on strength, stretch, balance, and walking training, to prevent frailty.

4.1. Frailty phenotypes analysis

This research clearly demonstrated the 5 FPs composition in nursing home frail and non-frail populations using radar figure. This study only represents the situation of the elderly in nursing homes in a large Chinese city, because the results may be different for different races and groups due to different

Table 1

Phenotype of frailty assessment.

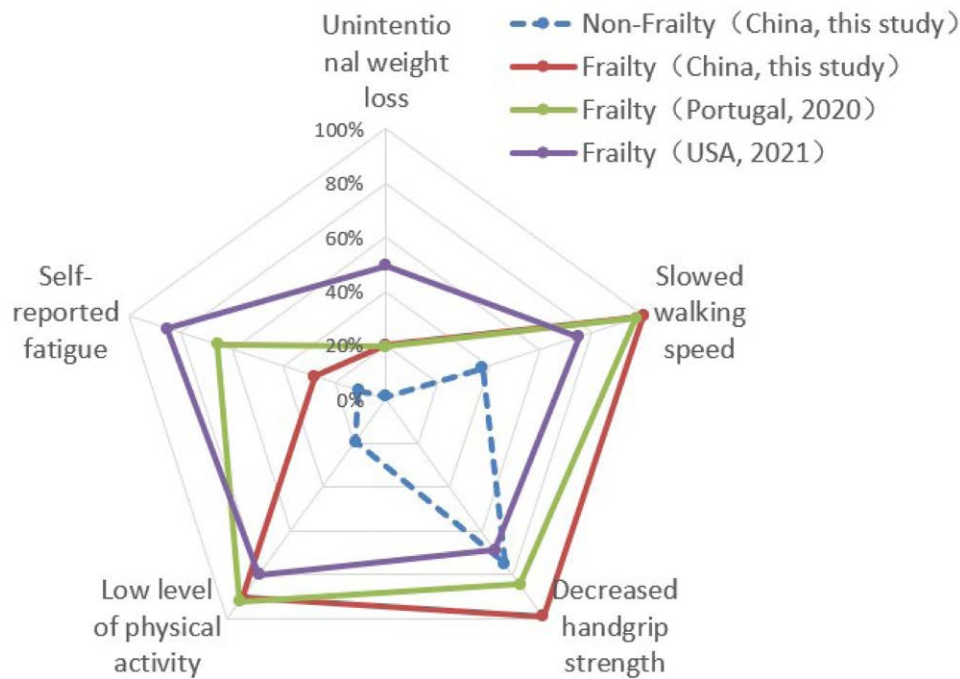|	Total (n = 177)	Non-frailty (n = 83)	Frailty (n = 94)
Unintentional weight loss	20 (11.3)	1 (1.20)	19 (20.20)
Slowed walking speed	125 (70.6)	31 (37.30)	94 (100)
Decreased handgrip strength	155 (87.6)	62 (74.70)	93 (98.90)
Low level of physical activity	101 (57.1)	16 (19.30)	85 (90.40)
Self-reported fatigue	35 (19.8)	9 (10.80)	26 (27.70)

Unit：number (%).

Figure 2. Analysis of the proportion of 5 frailty phenotypes by different study. Dash blue line represents non-Frail elders in this study; red line represents Frail elders in this study; green line represents Frail elders in an European study of 2020[15]; purple line represents Frail elders in an American study of 2021.[16]

Table 2

General information and motor function characteristics univariable analysis of frailty.

Variables	Non-frail (n = 83)	Frail (n = 94)	χ^2	P
Gender			0.516	.472
Male	38 (45.8)	38 (40.4)		
Female	45 (54.2)	56 (59.6)		
Age			1.221	.748
60–70 yr	3 (3.6)	4 (4.3)		
71–80 yr	25 (30.1)	26 (27.7)		
81–90 yr	51 (61.4)	62 (66.0)		
91–100 yr	4 (4.8)	2 (2.1)		
Upper limb muscle tone			4.854	.028
Normal	80 (96.4)	81 (87.1)		
Spasticity	3 (3.6)	12 (12.9)		
Lower limb muscle tone			10.613	.001
Normal	81 (97.6)	76 (82.6)		
Spasticity	2 (2.4)	16 (17.4)		
Upper limb ROM			17.494	<.001
Normal	75 (90.4)	59 (63.4)		
Limited	8 (9.6)	34 (36.6)		
Lower limb ROM			15.565	<.001
Normal	72 (86.7)	56 (60.2)		
Limited	11 (13.3)	37 (39.8)		
Fugl–Meyer balance scale			66.720	<.001
0–6 scores	7 (8.5)	59 (64.1)		
7–10 scores	50 (61.0)	32 (34.8)		
11–14 scores	25 (30.5)	1 (1.1)		

Unit：number (%).
ROM = range of motion.

lifestyles and habits. From Figure 2, slowness, weakness and low physical activity were the most serious issues for frailty elders. Especially weakness, >70% of the non-frail elders have a decline in strength. This may be because the elders in nursing homes were older and often accompanied by chronic diseases. Chinese elders prefer static activities, such as playing chess or watching TV, and less aerobic exercise or regular strength exercise. Strength can affect balance, which correlates with

walking speed and physical activity. This is highly consistent with our result and the radar figure. The results were consistent with previous recommendations also.[21] They should exercise 2 to 3 times a week, resistance and balance training for 20 minutes each. Balance training,[22] which is very important to prevent falls, include walking, one leg standing, etc.

We selected studies in Europe[15] and the United States[16] for comparison. The European research had 142 community

Table 3

Logistic regression of frailty.

Variables	B	Wald	OR	95%CI	P
Balance (11–14 scores)		37.687			<.001
Balance (7–10 scores)	2.526	5.769	12.499	1.592–98.419	.016
Balance (0–6 scores)	5.021	20.769	151.519	17.486–1312.906	<.001
Upper limb ROM	1.030	4.314	2.801	1.060–7.406	.038

OR = odds ratio, ROM = range of motion.

participants, mean age was 88 years. The results were highly similar to our study in that slowness, weakness and low physical activity were the most serious issues contributing to frailty in phenotypes analysis. However, self-report fatigue was much higher than in our study (65.7% vs 27.7%). The American study included 7439 community-dwelling elders, mean age was 75 years. It is interesting to note that self-report fatigue was the most obvious issue in frail elders (85.15%). In addition, almost half of the population (49.55%) had weight loss, significantly more than in other studies (20.2% in this study; 19.6% in the Europe study). The findings suggest that weight changes among older Americans should be of concern. Older people in Europe and the United States are more likely to experience fatigue on their own. Weight loss was rarely found in this study, indicating that Chinese elders in nursing homes maybe pay more attention to nutrition intake. Being sedentary and less active also led to a decrease in energy expenditure, which may be another reason for non-weight loss. The fact that Chinese elders feel less tired may be due to lifestyle changes in nursing homes. They do less housework than those who live on their own. And they have very little aerobic or endurance exercise. Therefore, the nursing home elderly in China should strengthen motor function training, like strength, stretch, balance and walking training to prevent or even reverse frailty. Of course, due to the different ages, region, and race, there will be different results, we need more relevant research.

4.2. Motor function characteristics and frailty

Sarcopenia is an age-related generalized skeletal muscle disorder. The main manifestation of sarcopenia is loss of strength and mass. The European consensus definition of sarcopenia is considered a key component of frailty. Loss of muscle mass will lead to weight loss, which is one of the Fried's FPs. The reduction in muscle size will reduce muscle strength include handgrip strength, which is the other one of Fried's FPs. From this study, we did not choose muscle strength in motor function assessment, because it's one of the FPs. However, from the phenotypes analysis, there is no doubt that both healthy elders and frail elders have muscle weakness. Hence, strength training in nursing homes is important and necessary for everyone. It is the foundation of balance and walking.

Balance disorder is common in older adults and can lead to falls.[4,23] Actually, frailty and balance impairment can interact with each other. Frailty was indicated as a non-vestibular cause of balance disorder.[23] Frailty was also the result of imbalance. Elders suffered from balance disorder often move slowly or are afraid to walk. Slowness and a low level of physical activity will lead to frailty also. A recent study declares that frail and non-frail older women showed significantly different balance functions, such as stability limits, anticipatory postural adjustments, sensory orientation and stability in gait.[24] This is consistent with the results of this study. The risk of frailty was 151 times higher for low balance scores (0–6 scores) than for high scores (11–14 scores) from the Logistic regression of frailty. Furthermore, balance training is considered one of the most effective ways to reverse frailty.[21] It is worth noting that balance training should

be pay more attention to pre-frail elders, as they are paradoxically at higher risk for falls than frail individuals.[25] This is true because they spend more time on walking than frail elders and thus are at greater risk of falling.

From common sense, body muscle tone and joint ROM may affect walking speed and daily physical activity level, which are in the FPs. Our study confirms this idea. We found a significant difference in body muscle tone and ROM between frail elders and non-frail elders. However, we found only one article study about masticatory muscle tone and frailty, not body muscle tone. The study[26] analyzed the masticatory performance using surface electromyography, the result showed that high masticatory muscle tone predicts malnutrition and frailty. For ROM, a study[27] found that there was a correlation between shoulder ROM and Physical Performance Test, which is one of the assessment tools of frailty. In sum, both body muscle tone and ROM problems may affect motor performance. As the amount of physical activity gradually decreases, further lead to frailty. Body muscle tone and joints ROM problems suggest the importance of stretching training.

4.3. Strengths and limitations

This research had several strengths. First, we used radar maps to clearly show the 5 FPs between frail and non-frail older people in nursing homes. It found that weak strength was common in the non-frail elderly in Chinese big city nursing homes. We also compared the FPs distribution in other countries. Second, we described the motor function characteristics and compared the relationship between motor function characteristics and frailty. Previous studies on frailty factors often focused on relatively fixed aspect which difficult to change. There were some studies on sarcopenia and frailty, but little on the relationship between other motor function characteristics (such as ROM, muscle tone, balance, etc) and frailty. All these characteristics can be improved with rehabilitation interventions.

There were 2 limitations in our research also. First, this was a cross-sectional design study. It just reflects the relationship between motor function indicators and frailty. Further research is needed to determine cause and effect. Second, even participants from 4 different nursing homes, all of them were recruited from nursing homes only in the same big city of China. The results cannot be generalized to other areas, such as rural areas. Some participants were excluded from our study due to poor health conditions or severe cognitive deficits. Therefore, there is a selection bias in our study.

5. Conclusion

The frailty of the elders in Chinese nursing homes was characterized by the decline of motor function. And surprisingly, both frail and non-frail elders were found to have poor strength. Frail nursing home seniors also have body muscle tone, ROM and balance problems. The elderly of China should focus on strength, stretch and balance training to improve motor

function, especially strength training, which is important for prevention frailty.

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Author contributions

J.W. and Y.W. research project conception and design. Y.W., X.Y., H.L., Q.F., Y.L., W.H. and X.C. acquisition of data. Y.W. and X.Y. analysis and interpretation of data. Y.W. and L.H. manuscript preparation.
Conceptualization: Yizhao Wang, Jialing Wu.
Data curation: Yizhao Wang, Xin Yang, Hao Liu, Qingling Feng, Yaqing Li, Weijia Hou, Xinlong Chen.
Formal analysis: Yizhao Wang, Xin Yang.
Funding acquisition: Liping Huang, Jialing Wu.
Supervision: Liping Huang, Jialing Wu.
Writing – original draft: Yizhao Wang, Xin Yang.
Writing – review & editing: Liping Huang, Jialing Wu.

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