The Prediction of Muscle Strength, Physiological Indexes, Balance, and Walking Ability on Risk of Fall for Prefrail Older People

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Abstract

Aim: To explore the relationship of older adults' demographic information, physiological indices, and stages of frailty with their risks of falling.

Methods: In the cross-sectional study, a total of 221 older adults were surveyed.

Results: Results were observed in terms of the participants' physical performance, with significant differences being observed in the correlations of left-hand grip strength, (t = 5.05, p<.000), right-hand grip strength (t = 6.03, p<.000), and total grip strength (t = 5.70, p<.000), time up and go test (t = -6.25, p<.000), and 30-sec chair stand test (t = 7.19, p<.000) with the risks of falling. The stages of frailty (X^2 = 9.64, p<.002) were confirmed to be significantly associated with risks of falling. According to the logistic regression analysis results, long-term medication (OR = 0.12, 95%CI = 0.02-0.62, p < .01) and right-hand grip strength (OR = 0.86, 95%CI = 0.76-0.97, p < .01) are the main predictors of older adults' risks of falling. **Conclusions:** Older females with low education, history of falls, weaker grip strengths; taking longer to finish the TUG test; and standing fewer times during the 30-second chair stand test were at risk of fall. In prediction, older people using long-term medication were at lower risk of falling, and the greater the hand grip strength was, the lower the fall risk was. According to the research results, nursing personnel must develop care programs and improving older adults' risk of fall.

Keywords: community older adults; physical performance; stage of frailty; risk of falling

Introduction

Population aging is a worldwide crisis deserving attention. According to the World Health Organization (2016), an "aging society" comprises more than 7% people aged 65 years or older; for an "aged society", the corresponding ratio exceeds14%; and for a "hyper-aged society", the ratio exceeds 20%.The number of people aged 65 years or older worldwide is estimated to rapidly rise from 900 million to 3200 million from 2016 to 2100.

According to statistics from the Ministry of the Interior, R.O.C. (Taiwan),the ratio of adults aged 65 years or older in Taiwan reached10.6% by the end of 2009.This was estimated to rise to 14.7% in the next 10years and further to 37.5% in 2056 [1].

Research on frailty indicated the prevalence of frailty among older adults in the United States was 9.6%, and the prevalence of prefrailtywas47% [2]. In the U.K., the prevalence of frailty among older adults was 14% [3]; the corresponding prevalence in Europe was 2.6%, and the prevalence of prefrailty in Europe was 38.8% [4]. According to the study by Biritwum et al. [5], the ratio of adults aged 50 years or older in six countries—China, Ghana, India, Mexico, Russia, and South Africa Republic—accounted for 43% of the adults in this age group worldwide. Investigations showed the prevalence of frailty in older adults to be lowest in China (13.1%) and highest in India (55.5%). The result of the investigation by Yu et al. [6] on the frailty prevalence among older adults in rural areas and cities in Taiwan and Hong Kong demonstrated that frailty prevalence in rural areas in Taiwan was 38.10% and in Taiwanese cities was 33.06%. Frailty prevalence in Hong Kong was 16.57%.

According to research reports, the prevalence of falls among community-dwelling older adults was approximately 30% to 40%, and half of the older adults suffered from recurrent falls [7]. According to the research report of the "Taiwan Longitudinal Study in Aging" in Taiwan in 2015,the incidence of falls in the past year among community-dwelling older adults aged 65 years or older was 20.7%, and 37% of these adults fell recurrently [8]. In Taiwan, the mean annual hospitalization expense due to falls was between NT$90,000 to NT$130,000 per older adult. For older adults suffering from hipbone fractures due to falls, annual medical expense searched approximately NT$3,000,000,000 [8-9]. Research in the Asian region that has investigated community-dwelling older adults in Taiwan indicated that frailty prevalence among people aged65 years or older was approximately 14.1%, prefrailty prevalence was 53.7%, and the prevalence of both increased with age [10], meaning that frailty care and prevention are crucial. According to the Department of Health, Education, and Welfare of the United States, the estimated annual medical expense due to frailty was between US$11,800 andUS$26,200 million [11]; effective frailty prevention could reduce high medical costs. Therefore, assessing relevant risk factor searly on, before frailty or during prefrailty, helps to prevent future adverse health incidents such as falls.

Therefore, this study conducted investigations in communities to examine community-dwelling older adults' basic attributes, physical performance and frailty stages in relation to fall risk predictability. The results showed that it was possible to discover fall risk factors early enough to prevent or postpone the future occurrence of adverse health incidents among older adults, subsequently alleviating family care load and improving quality of life for older adults.

Aims

This study first analyzed the basic attributes, physical performance, frailty stages, and fall risks among community-dwelling older adults, and this was followed by an analysis of differences in basic attributes, physical performance, frailty stages, and fall risks. Last, the study explored participants' basic attributes, physical performance, and frailty stages in relation to the fall risk predictability.

Literature Review

Frailty

Frailty, a continuum of malfunction in physiological systems, is a complex and dynamic condition in which elements related to body, mind, and society interact. It is related to age but preventable and predictable by certain factors; therefore, aging does not necessarily cause frailty. Meanwhile, frailty is not related to any specific disease but increases comorbidities [10]. According to Fried et al. [12], frailty signified progressive physiological decline in several systems of the body, leading to the risks of adverse health outcomes such as physiological disability, loss of physiological reserve, and increased incidence of mortality, falls, disability, and hospitalization. The more commonly applied frailty assessment indexes are the five indicators of shrinking, low grip strength, exhaustion, slowness, and low activity levels proposed by Fried who established three frailty stages: nonfrail, prefrail, and frail [12].

Assessment Technique

Fried Phenotype of Frailty Derived from Cardiovascular Health Study (CHS)

Fried et al. [12] distinguished five major symptoms of frailty: 1.shrinking, 2.lowgrip strength, 3.exhaustion, 4.slowness, and 5.low physical activity level. The grip strength and 15-feet walking require physical performance tests. Individuals who meet three of the five criteria are identified as physiologically frail, those who meet one or two criteria are classified as physiologically prefrail, and those meet none of the five criteria are classified as physiologically nonfrail.

Study of Osteoporotic Fracture Index (SOF Index)

The criteria for frailty of Study of Osteoporotic Fracture (SOF) Index proposed by Ensrud et al. [13] comprised three indexes corresponding with the following questions:1.Have you experienced unintentional weight loss of ≥3 kg or 5%during the past year? 2.Can you do five chair stands without using your arms? 3. Do you feel full of energy? Respondents who answered “no” to one of the questions were deemed prefrail, and those who answered “no” to two or more questions were deemed frail.

The aforementioned literature showed that CHS index and SOF index were equally effective methods for assessing the risk predictability of negative care outcomes in community-dwelling older adults, such as recurrent falls, fractures, disability, hospitalization, and mortality. Both were applicable to community-dwelling older adults and amply discriminating. However, the CHS index was less applicable to the community context because it comprised more questions and required more complex tests (grip strength and walking speed tests) than the SOF index did [14].Osteoporotic fractures studied by Ensrud et al. [13] indicated that the relatively few questions and easy measurement method of the SOF Index made it as effective as the CHS Index in terms of risk predictability for negative care outcomes of community-dwelling older adults, including recurrent falls, disability, fractures, hospitalization, and mortality; the measurements were also easier to apply clinically thanks to the simple test procedures [15]. Therefore, the SOF Index was applied in this study.

Studies on Frailty and Falls

Research indicated that frail older adults are less resistant to pressure when experiencing stressful conditions such as injury, infection, anesthesia, surgery, and medication and that they experienced recurring adverse health conditions, including illness, falls, disability, hospitalization, stays in long-term care institutions, and mortality [10]. Lu et al. [16] conducted frailty assessments of 189 people aged 65 years or older using Fried indexes and cross-sectional research in outpatient clinics for chronic diseases. Among the 19% of the prefrail patients, falls over the preceding year, memory problems, dysphagia, fecal incontinence, pain, balance problems, and constipation were significantly more recurrent. Prefrailty-related predictors included five or more chronic diseases (OR = 3.99, 95%CI = 1.26–12.60), constipation (OR = 5.32, 95% CI = 1.99–14.38), falls over the preceding year (OR = 3.15,95% CI = 1.07–9.22), disability in action (OR = 14.03,95% CI = 3.75–52.56) and use of eight or more medicines for chronic diseases(OR = 4.19,95% CI = 1.13–15.54). Tseng [17] used a retrospective longitudinal study on 341institutionalized adults aged 65 years or older in which the proportion of prefrail study participants was53.7%, and the proportion of recurrent falls increased with frailty level. An analysis of the relationship of adverse health outcomes indicated that the chance of falls within two years in prefrail older adults with low walking speeds was 2.77 times that for healthy older adults (OR = 2.77, 95% CI = 1.20–6.41, p = 0.018). Furthermore, results from the observation by Cigolle et al [18] of 11,093 older adults aged 65 years or older in nursing homes indicated that the frailty prevalence was proportional to age. The study by Muir et al. [19] on 210 institutionalized prefrail older adults (70% men and30%women; mean age = 79.9years old, SD = 4.7) demonstrated that the fall risk for those with inferior balance was 1.5 to 1.6 times higher. The study by Gonzalez-Vaca et al. [20] on 331 institutionalized adults aged 65 years or older showed that 31.2% of the study participants were nonfrail and prefrail older adults; those who had fallen during the previous six months had significantly higher frailty levels in comparison with those who had not.

According to the aforementioned literature, older adults' physical performance for muscle strength, balance, and walking ability, for example, was closely related to the frequency of falls. Literature on falling was mostly set in institutions and outpatient departments of hospitals. Few research in Taiwan on prefrail community-dwelling older adults was based on objective measurements that involve investigating older adults' muscle strength, physical performance balance, and walking ability and how these factors influenced incidence of falls. Therefore, this study explored, through community investigation, prefrail community-dwelling older adults' basic attributes, physical performance and frailty stages in relation to fall risk predictability.

Method

Design

This study applied cross-sectional research design, purposive sampling, and structured questionnaires to collect and investigate basic attributes, physical performance, and frailty stages in relation to fall risk predictability for community-dwelling adults aged 65 years or older.

Research Participants

This study collected data on nonfrail and prefrail community-dwelling adults aged 65 years or older in northern Taiwan. Older adults fulfilling the following criteria were included in the study: (1) an age of 65 years or older without being banned from doing exercise, (2)clear consciousness and ability to communicate in Mandarin or Taiwanese,(3) nonfrail or prefrail status established through SOF Index screening, and (4) willingness to participate in the study and ability to complete questions independently or with assistance from researchers on site. The following criteria were used for exclusion:(1)inability to participate in the study due to serious visual and audio impairments, (2) balance problems and inability to participate in tests (for example, inability to sit, stand, or walk), and(3) with wrist fractures.

Sample Size

This study used G-Power 3.1software: α was set as 0.05, and Power was set as 0.9 with 95% of the confidence level and 5% of the confidence interval. Sample size was calculated, the total sample size was at least 221.

Research Method

Basic Attributes

The attributes included age, gender, marital status, living arrangements, education level, alcohol use history, history of falls, medical history, long-term medication, exercise status, and insomnia status.

physical performance

Body Mass Index

Overweight and obesity mean being abnormally or excessively fat and may lead to health risks. The main measurement is body mass index (BMI), which is obtained by the body weight(kg) divided by the square of the body height (m^2). The scores proposed by the WHO were used(18.5-25.0 kg/m^2: normal, 25.1–26.9 kg/m^2: overweight, ≥ 27 kg/m^2: obese). Chronic diseases such as cardiovascular diseases, diabetes, and cancer were caused by overweight and obesity [8]. BMI was also relevant to frailty, with abnormal weight (underweight or overweight)associated with higher risk for frailty [21].

Grip Strength

The grip strength test in this study referred to the senior fitness test developed by Rikli and Jones [22]. They developed and validated a functional fitness test for community-residing older adults. Participants used both hands in turn to grip the gripper twice, and the maximum value was recorded as the grip strength value. This tests muscles of the upper extremity by measuring the maximum muscle strength in static contraction with a digital dynamometer. The subject is asked to sit down with the elbow joints at an angle of 90° and with the knuckles gripping a digital dynamometer with the greatest possible force continuously for two seconds. The overall grip strength is the sum of the left and the right handgrip strengths; the measurement unit is kilograms. The intra class correlation coefficient (ICC) of the test was 0.81 [22], and the content validities for men and women were0.81 and 0.78, respectively [23]. The test–retest reliability between the left and right hands of 21 healthy older adults by Bohannon and Schaubert [24] using a Jamar dynamometer indicated no significant difference. Intraclass correlation coefficients for the left and right hands were 0.954 and 0.912, respectively

Timed "Up and Go "Test

The TUG test in this study referred to the senior physical performance test developed by Rikli and Jones [22]. The participant stands up from a seated position upon hearing the "go" command and walks to point 2.44 meters in the front of them before turning around and walking back to the front of the chair; the timer stops when the individual turns around and sits down. The test participant repeats the test twice, and the faster result is recorded. The shorter the respective time, the better the dynamic balance of the individual is considered to be [22].

According to Shumway-Cook et al. [25], when the community-dwelling older adults' cutoff point was 13.5 seconds, their sensitivity (87%) and specificity (87%) in terms of fall prediction were high. Several past studies have verified that the TUG test exhibited high intrarater reliability(ICC = 0.95–0.99) and interrater reliability (ICC = 0.56–0.98) [26,27]. Regarding validity, the results demonstrated that the TUG test was moderately to highly correlated with the Berg Balance Scale (BBS) (r = 0.47–0.74) in testing community-dwelling older adults[26,28].

30-Second Chair Stand Test

The test uses an armless chair with a fixed height (43–46 cm).The test participant sits in the middle of the chair without leaning on the chair back. During the test, the participant places each of their hands on the opposite shoulders, crossed at the wrists, while keeping the feet flat on the floor. The participants rise to a full standing position upon hearing “go” and then sit down again, thus completing a cycle. The number of times the participants able to complete in 30 seconds is recorded. The tools include a stopwatch and an armless chair. The test takers are given one chance, and the number of times is used as the measurement unit [22].

Jones et al. [29] divided 76community dwellers (34 men and42 women) into three age groups and compared the number of times participants of each group were able to stand in 30 seconds. The results indicated a favorable test–retest reliability for 30-second chair stands ($0.84<R< 0.92$, $p<.05$), and the number of times participants were able to stand decreased with age (F = 4.4, $p <0.01$); a correlation was observed between the number of times older adults were able to stand and leg muscle strength adjusted by weight (r = 0 .77, 95% CI = 0.64–0.85). This indicated that older adults’ leg muscle strength and endurance were significantly correlated to their activity levels as well as to future falls and hospitalization, which was also highly discriminating.

Frailty Stages

The SOF Index of Ensrud et al. [13] indicated that its relatively few questions and ease of measurement made it as effective as the CHS Index in terms of risk predictability of negative care outcomes in community-dwelling older adults, including for recurrent falls, disability, fractures, hospitalization, and mortality; the measurement was also easier to apply clinically thanks to the simplicity of its test procedures [15,30]. Therefore, the SOF Index [13] was applied as the criteria for this study. It comprised three indexes corresponding with the following questions: 1. Have you experienced unintentional weight loss of ≥3 kg or 5% during the past year? 2. Can you do five chair stands without using your arms? 3. Do you feel full of energy? Respondents who answered "no" to one of the questions were deemed prefrail, and those who answered "no" to two or more questions were deemed frail.

Falls

This study used the BBS for measuring a person's dynamic balance abilities, which takes only15 to 20 minutes. It includes tests on 14daily tasks, with the score for each ranging from 0 to 4. The total score is56; test participants scoring45 or more are deemed to possess good balance ability and the ability to walk independently, whereas those scoring under 45 are deemed to be inferior in terms of physical balance and to be at risk of falls. According to Berg et al. [31] and Chou et al. [32], the Cronbach's alpha of this scale was 0.97–0.98 and 0.98, respectively. The ICC of the BBS was 0.93(95% CI: 0.87–0.96), demonstrating a relatively high internal consistency [33].

Research Ethics

The researchers first determined the principle investigator and submitted the project to the Research Ethics Committee of the National Taiwan University for review (case number obtained after approval: 201903ES021) prior to execution.

Data Analysis

This study used SPSS Statistics 21.0 software for Windows to organize and analyze the data. Status of basic attributes, physical performance, and fall risk were expressed as n (%) and Mean ± SD. Differences of the basic attributes, physical performance, and fall risk were analysed using chi-square test (X^2) and independent sample t test. Risk predictability of fall risk with basic attributes and physical performance was used by liner regression analysis.

Results

Basic Attributes, physical performance, Frailty Stages, and Fall Risk of Community-Dwelling Older Adults

The mean age of the study participants was 74.9 years old. The majority of the older adults enrolled were between 65 and 75years of age (52.9%), were women (146 women,66.1%), were married (167persons, 75.6%),and lived with family (191persons, 86.4%). The highest education level of the majority of participants was graduation from elementary school (121persons, 54.8%), and the next most common maximum education level was illiteracy (61persons, 27.6%). The majority of participants never drank alcohol (165persons, 74.7%). The number of those who had fallen was 49 (22.2%), with the majority having fallen only once. The majority of participants were not using long-term medication (185 persons, 83.7%), and the average number of medicines used on a long-term basis by these adults was 2.11, with hypertension representing the major disease being treated (n = 113；28.5 %). The majority of participants exercised “more than three days per week” (191 persons, 86.4%). The majority (59.7%) of participants were not insomniacs (Table 1).

The mean BMI of the study participants was 25.18kg/m^2. The majority was “overweight” (83 persons, 37.6%). The mean left-handgrip strength was 25.22kg (SD = 8.11), and the mean right-hand grip strength was 26.31kg (SD = 8.66). The mean overall grip strength reached 51.54kg (SD = 16.41).The mean for the TUG test was 8.12 seconds (SD = 3.04). In the 30-second chair stand test, the mean was 16.41 times (SD = 5.02). Of the 221 test participants, 76 were classified as prefrailty (34.4%) and 88 were at risk of falls (39.8%) (Table 1).

Table 1. Status of community-dwelling older adults in terms of basic attributes, physiological indices, frailty stages, and fall risk (N = 221).

Variable	N	(%)	Mean	SD
Age			74.95	6.81
Age group				
65–75 years	117	52.9		
75 years and above	104	47.1		
Sex				
Male	75	33.9		
Female	146	66.1		
Marital status				
Single	54	24.4		
Married	167	75.6		
Living status				
With family	191	86.4		
Solitary	30	13.6		
Educational level				
Illiterate	61	27.6		
Elementary school	121	54.8		
Junior high school and above	39	17.6		
Alcohol consumption history				
No	165	74.7		
Quit	21	9.5		
Yes	35	15.8		
Fall history				
No	172	77.8		
Yes	49	22.2		
1 time	38	17.2		
2 times	6	2.7		
3 times	5	2.3		
Chronic disease history				
Osteoarthritis	128	21.9		
Hypertension	117	20.0		
Diabetes	40	6.8		
Myocardial infarction	0	0		
Congestive heart	70	12.0		

failure				
Hyperlipidemia	90	15.4		
Stroke	12	2.1		
Kidney failure	1	0.2		
Mental disorder	15	2.6		
Glaucoma	13	2.2		
Cataract	99	16.9		
Long-term medication consumption				
Yes	36	16.3		
No	185	83.7		
Number of long-term medications			2.11	1.68
Exercise				
No	13	5.9		
< 2 days/week	17	7.7		
> 3 days/week	191	86.4		
Insomnia				
Yes	89	40.3		
No	132	59.7		
Physiological indices				
BMI			25.18	3.46
BMI grouping				
Normal	76	34.4		
Overweight	83	37.6		
Obese	62	28.1		
Grip strength				
Left hand			25.22	8.11
Right hand			26.31	8.66
Total grip strength			51.54	16.41
Timed Up and Go test			8.12	3.04
30-s chair stand test			16.41	5.02
Frailty stage				
None	145	65.6		
Pre-frailty	76	34.4		
Fall risk			46.10	6.28

Yes	88	39.8
No	133	60.2

Analysis of the Differences in Older Adults' Basic Attributes, Physical Performance, Frailty Stages, and Fall Risks

In terms of basic attributes, the age (t = −7.42, p<.000), the gender (X^2 = 3.96, p<.04), the education level (X^2 = 32.28, p<.000), the fall history (X^2 = 8.95, p<.03), the use of long-term medication (X^2 = 14.79, p<.000), and the number of long-term medicines used (t = − .79, p<.000), and the number of at risk of falls and among the older adults not at risk were significantly different(p <.05). Regarding the physical performance significant differences (p <.05) were observed between the left hand grip strength (t = 5.05, p<.000), the right handgrip strength(t = 6.03, p<.000),the overall grip strength(t = 5.70, p<.000), the TUG test result (t = −6.25, p<.000), the TUG test result (t = 7.19, p<.000) of study participants at risk of falls compared with for study participants not at risk of falls. In terms of frailty stages, a significant difference (p <.05) was observed between the older adults at risk of falls and those not at risk (Table 2).

Table 2. Analysis of variance of the basic attributes, physiological indices, and fall risk of community-dwelling older adults with pre-frailty (N = 221).

Variable	Fall risk		X^2/t	p
	No (N = 133)	Yes (N = 88)		
Age[b]	72.47 ± 6.06	78.69 ± 6.17	-7.42	.000***
Age group[a]			45.82	.000***
65–75 years	95	22		
75 years and above	38	66		
Sex[a]			3.96	.04*
Male	52	23		
Female	81	65		
Marital status[a]			3.09	.07
Single	27	27		
Married	106	61		
Living status[a]			.17	.67

With family	116	75		
Solitary	17	13		
Educational level[a]			32.28	.000***
Illiterate	20	41		
Elementary school	79	42		
Above junior high school	34	5		
Alcohol consumption history[a]			1.24	.53
No	97	68		
Quit	12	9		
Yes	24	11		
Fall history[a]			8.95	.03*
No	105	67		
1 time	23	15		
2 times	5	1		
3 times	0	5		
Chronic disease history[a]			13.12	.15
Osteoarthritis	64	64		
Hypertension	64	53		
Diabetes	15	25		
Myocardial infarction				
Congestive heart failure	34	36		
Hyperlipidemia	51	39		
Stroke	6	6		
Kidney failure	1	0		
Mental disorder	9	6		
Glaucoma	9	4		
Cataract	52	47		
Long-term medication consumption[a]			14.79	.000***
Yes	101	84		
No	32	4		
Number of long-term medications[b]	1.75	2.65	-3.99	.000***

Exercise[a]			.17	.91
No	8	5		
< 2 days/week	11	6		
> 3 days/week	114	77		
Insomnia[a]			1.63	.20
Yes	49	40		
No	84	48		
BMI[b]	24.95 ± 3.32	25.51 ± 3.66	-1.17	.24
BMI grouping[a]			3.18	.20
Normal	46	30		
Overweight	55	28		
Obese	32	30		
Grip strength[b]				
Left hand	27.27 ± 8.34	22.13 ± 6.69	5.05	.000***
Right hand	28.83 ± 8.95	22.50 ± 6.61	6.03	.000***
Total grip strength	56.11 ± 16.92	44.64 ± 12.91	5.70	.000***
Timed Up and Go test[b]	7.07 ± 2.00	9.71 ± 3.61	-6.25	.000***
30-s chair stand test[b]	18.12 ± 5.02	13.84 ± 3.79	7.19	.000***
Frailty stage[a]			9.64	.002**
No	98	47		
Pre-frailty	35	41		

[a] is a categorical variable expressed as n (%) and analysed using a chi-square test (X2); [b] is a continuous variable expressed by Mean ± SD and tested using an independent sample t test

*p< .05，** p < .01，*** p < .001

Older Adults' Basic Attributes,physical performanc and Frailty Stages in Relation to Fall Risk Predictability

This study demonstrated significant differences between use of long-term medication (OR = 0.12, 95% CI = 0.02–0.62, p < .01) and right handgrip strength (OR = 0.86, 95% CI = 0.76–0.97, p < .01) for older adults at risk of falls compared with for older adults no at risk. A further analysis demonstrated that older adults not using long-term medication were at lower risk of falling than those using long-term medication were. Greater right handgrip strength was associated with lower risk of falling (Table 3).

Table 3. Fall risk predictability of community-dwelling older adults in basic attributes and physiological indices.

Independent variable	B	SE	p	OR	95%CI of OR
Age	.04	.05	.45	1.04	.93-1.16
65–75 years (75 years and above as *ref*)	-.66	.70	.34	.51	.12-2.03
Male (female as *ref*)	.30	.65	.64	1.35	.37-4.87
Educational level (Junior high school and above as *ref*)			.31		
Illiterate	.87	.76	.25	2.39	.53-10.67
Elementary school	.22	.66	.74	1.24	.33-4.58
Fall history (3 times as *ref*)			.16		
No	-19.63	16698.96	.99	.000	.000
1 time	-20.72	16698.96	.99	.000	.000
2 times	-20.89	16698.96	.99	.000	.000
Without long-term medications (with long-term medications as *ref*)	-2.08	.82	.01	.12	.02-.62
Number of long-term medications	.13	.12	.29	1.13	.89-1.45
Left hand grip strength	.06	.05	.27	1.06	.95-1.19
Right hand grip strength	-.14	.06	.01	.86	.76-.97
Timed Up and Go test	.12	.09	.21	1.12	.93- 1.37
30-s chair stand test	-.10	.05	.07	.90	.80- 1.01
No frailty (Pre-frailty as *ref*)	-.20	.40	.61	.81	.36-1.81

*p< .05，** p < .01，*** p < .001

Discussion

Community-Dwelling Older Adults' Basic Attributes, Physical Performance, FrailtyStages, and Fall Risk

The mean age was 74.9 years old, with women and married people comprising the majority. Among those using long-term medication, the average number of medicines used was 2.11, with hypertension constituting the major disease being treated. These findings were similar to those of a domestic study [34] on community-dwelling older adults regarding the correlation of health conditions and physical function with fall. Another related study was Chen [35] on the factors affecting community-dwelling older adults' fear of falling: The majority had fallen once. In addition, the results of this study resembled those of Ko [36], on the prevalence of and risk factors for falls among older adults in Taiwan, which found the medical history included bone and joint diseases, hypertension, and cataract. Other similar results came from Lin [37] on fall prevention and related factors for seniors in Taipei community care centers; the exercise status of the study participants was also "more than three days per week." Also, investigation by scholars on the cumulative incidence of falls and related factors for older adults in Shipai, Taipei, yielded a similar result: The majority was not insomniacs [38].

According to the World Health Organization (WHO), the BMI of reference for older adults must be normal between 18.5 and 25. In this study, the BMI groupings showed the majority to be close to overweight, and the respective result was close to that of Lee [39] on factors related to falls among community-dwelling older adults, which yielded a mean BMI 25.9. In this study, the mean time for the TUG test was 8.12 seconds, and the mean number of chair stands achieved in the 30-second chair stand test was 16.41.These values are superior to the results of tests by domestic scholars on community-dwelling older adults: The meantime for the TUG test was 10.86 seconds, where as the mean number of stands achieved in the 30-second chair stand test was 13.39 [41]. The TUG test by Chen [34] on community-dwelling older adults yielded a meantime of 12.48 seconds, and the mean number of stands achieved in a 30-second chair stand test was 10.89, both of which results were inferior to this study's. According to results of physical fitness tests conducted by scholars on community-dwelling older adults, the TUG and 30-secondschair stand test results for frail older adults were inferior to those for nonfrail and prefrail adults [42, 43].

Prefrail older adults accounted for 34.4% of our study's participants, a proportion close to those for prefrailty in related studies. Investigations on the five frailty indexes and adverse health outcomes in community-dwelling older adults by domestic scholars found prefrailty prevalence to be 32.3%, a result close to that of this study [17].The investigation by Wei [44] on the predictability of community-dwelling older adults' frailty and quality of life found the prefrailty prevalence to be 37.4%, which was also close to the result of this study. Domestic scholars' research on the prevalence of and factors related to prefrailty among older adults in Taiwan found the prefrailty prevalence to be30.6%, a result close to that of this study [45]. Also, the participants of this study were screened using the BBS. The result showed that 39.8%of the adults aged 65 years or older exhibited fall risks, and this resembled the results of other studies demonstrating that the incidence of falls increased with age, and the annual incidence of falls in community-dwelling adults aged 65 years or older was 28%–35%, whereas that of adults aged 75 years or older rose to 32%–42% [46].

Difference Analysis of Community-Dwelling Older Adults' Basic Attributes,Physical Performance, FrailtyStages, and Fall Risks

This study indicated significant differences regarding basic attributes, age, age grouping, gender, education, fall history, use or nonuse of long-term medication, the number of medicines used on a long-term basis, and fall risk, demonstrating a significant correlation of the seven basic attributes with fall risk. Further analysis demonstrated that community-dwelling older adults with high fall risk were advanced in age (aged 75 or older), women, had achieved a maximum education level of elementary school graduation, had a history of falls, used medication on a long-term basis, and used a greater number of medicines on a long-term basis. The results of this study in relation to age and age grouping were close to those in Lin and Wang [47] on prevention of and risk factors for falls among community-dwelling older adults, in which age was found to be a risk factor for falls among older adults. Similarly, Kwan et al. [46] indicated that the incidence of falls increased with age and that the annual incidence of falls among community-dwelling adults aged 65 years or olderwas28%–35%, whereas the annual incidence rose to 32%–42% among those aged 75 years or older. Chang et al. [48] indicated that gender was a factor greatly affecting falls, and recurrent falls were particularly common among women, which agrees with the results of this study. However, other research [36] contradicted this study in suggesting that gender was not an important factor for falls. This was potentially because women accounted for 66%of this study's participants, and the women in the aforementioned study accounted for less than 50% of the participants. The results of this study suggested that lower education levels are associated with higher fall risks. Similar results came from research by domestic scholars [49] on community-dwelling older adults with chronic diseases and research by Yang et al. [50] on risk factors for falls among older adults in Taiwan: Both of these studies suggested that lower education levels were associated with a higher incidence of falls. Domestic scholars [51] also indicated the correlation between education level and falls through systematic literature review. The investigation by domestic scholars [47] on prevention of and risk factors for falls among community-dwelling older adults found, similarly, that prior falls were a personal attribute constituting a risk factor for falls among older adults. Another piece of research on literature [52] indicated that a history of falls was an intrinsic risk factor for falls among community-dwelling older adults. Another such result came from the literature research by Chen et al. [51] indicating that among biological risk factors causing older adults to fall at home, older adults with prior falls were at higher risk of falling than those with no prior falls. This study showed that study participants engaging in use of more medications and on a longer term basis exhibited higher risks of falls, a result reflected in several other studies. A systematic literature review by Kwan et al. [46] found use of multiple medications to be a major risk factor for falls among older adults in Asia. Another such result came from analysis by domestic scholars [51] of risk factors related to falls among older adults at home. This linked long-term medication use and use of more long-term medicines with higher risks of falling. Moreover, the research by domestic scholars [53] indicated that dosage change and multiple medications increased fall risks. The longitudinal study by Lin et al. [54] also found long-term medication to be a risk factor for falls.

This study demonstrated that the left and right handgrip strengths, the overall grip strength, and results of the TUG test and the 30-second chair stand test significantly affected fall risk, exhibiting a significant correlation of the five physical performances with fall risk. Further analysis indicated that individuals subject to such risks had weaker left hand, right hand, and overall grip strengths; took longer to finish the TUG test; and succeeded in standing fewer times during the30-second chair stand test. Lin et al. [40] tested community-dwelling older adults' physical performance and discovered the grip strength test to be a predictor of falls and adverse health conditions among very elderly persons. Other research [55, 56] has found grip strength to exhibit a significant positive correlation with fall risk, and a study by Chang et al. [57] on community-dwelling older adults' physical mobility found that declining mobility—grip strength, for example—was a factor that inevitably increased the incidence of falls. The results of this study agreed with those of several others, such as Chin et al. [41], that demonstrated inferior TUG test results to be a major factor affecting falls. In a study of relationships between frailty indexes and adverse health outcomes by Tseng [17], 341 community-dwelling adults aged 65 years or older in Greater Taipei, Linkou, and Taoyuan participated in the "Physical Fitness Tests in the Elderly" retrospective longitudinal study from 2007 to 2009: This showed the incidence of falls in two years to be 2.77 times higher among people who walked slowly than among those who walked at normal speeds (OR = 2.77, 95% CI = 1.20–6.41, $p = 0.018$), which reflected this study's results. A study by one domestic scholar [34] demonstrated that individuals with prior falls spent more seconds completing the TUG test than did those with no prior falls. Stenhagen et al [58] found that community-dwelling older adults with higher fall risks also exhibited inferior dynamic balance. This was reflected in the fact that the fall risk became 1.8 times higher with those walking in slower speeds. Inferior dynamic balance ability increased the incidence of falls: The study demonstrated that the fall risk for those who spent longer times completing the TUG test was 1.03–21.4 times greater than the risks for those who spent shorter times completing the test [59,60,25]. The aforementioned results were all close to those of this study. The results of this study demonstrated that participants at risk of falls completed fewer stands in the 30-second chair stand test, a result similar to that in Teng [61], indicating that the fall risk of those who achieved 7 or less stands in30-second chair stand test was 5.89 times greater than the risk for those who achieved fewer than 12 stands, and the fall risk for participants who achieved 8 to 11 stands was 2.86 times greater than the risk for those who achieved 12or more stands. The research of domestic scholars [41] demonstrated inferior 30-second chair stand test results to be a major factor affecting falls, corresponding with results from the study by [34] indicating that study participants with prior falls completed fewer stands in the same test. Base on the results of this study, Dent et al. [64] recommended that frailty should include a multi-component physical activity programme with a resistance-based training component and people with frailty should receive social support as needed to adherence to a comprehensive care plan.

Significant differences were observed in this study for fall risks among older adults at different frailty stages. Further analysis indicated that 30% of the nonfrail older adults were at risk of falls, whereas 50% of the prefrail older adults were at risk, demonstrating a higher proportion of risk in prefrail older adults than in nonfrail ones, a result corresponding with several other ’studies’. For example, Lu et al. [16] used Fried frailty indexes and cross-sectional research on189 adults aged 65 years or older in domestic outpatient clinics for chronic diseases and found frailty prediction to be a relevant factor for falls in the preceding year. Similar results came from the study by Tseng [17]of relationships between frailty indexes and adverse health outcomes for 341 community-dwelling adults aged 65 years or older in Greater Taipei, Linkou, and Taoyuan who participated in the "Physical Fitness Tests in the Elderly" retrospective longitudinal study from 2007 to 2009.This study demonstrated that the incidence of falls increased with the frailty level: A statistically significant difference ($p = .035$) was observed between the nonfrail group's fall rate(24.6%) and the prefrail group's rate(25.7%) [62-63]. The investigation by domestic scholar [45] on the prefrailty prevalence among older adults in Taiwan and related factors observed a significant positive correlation between falling history and prefrailty and showed that older adults with prior falls were at higher risk of falling than those without prior falls (OR = 1.80, 95%CI = 1.37–2.36, $p<0.0001$).These results reflected this study's.

Older Adults' Basic Attributes, Physical Performance and Frailty Stages in Relation to Risk Predictability

This study indicated that community-dwelling older adults with long-term medication exhibited lower fall risks. Regarding long-term medication in risk predictability, the study demonstrated such adults with long-term medication had lower fall risk. These results were different to those of several other studies. Hung et al. [53], Lin et al. [54], and Chen et al. [51] demonstrated that dosage changes and multiple medications often increased older adults' fall risks at home. Systematic literature review by other scholars [46] retrospectively assessed older Asian adults' fall risk factors. Our results showed that participants with long-term medication were subject to low fall risks. The possible reason is that the blood pressure and physical conditions of the older people are more stable due to long-term medication; therefore the risk of falling is reduced.

This study demonstrated that greater grip strength among community-dwelling older adults was associated with lower fall risks. The result resembled that of Wang et al. [62] on the connection between factors related to falls among older adults and bone strength, which indicated that grip strength predicted older adults' physical statuses and fall risks. Wang [63],on how adding vitamin D and calcium to the diet affected fall incidence of older women, yielded similar results, demonstrating that fall risk in older adults could be predicted using grip strength. Lin et al. [40] on the physical performance of community-dwelling older adults showed that future falls and adverse health conditions in older adults could be predicted through grip strength tests. Similarly, significant positive correlations between grip strength and fall risk have been observed in other studies [55, 56]. Chang et al. [57] on community older adults' physical mobility showed that the decline in such physical mobility, such as for grip strength, was a certain cause of falls, and their findings corresponded with this study's.

Limitations

This study had several limitations. First, in relation to the method, the results through cross-sectional research design could represent physical performance of community-dwelling older adults during a short period only. This indicated only the correlation between the variables and falls and neglected to investigate how factors such as physical performance and frailty stages in these adults affected falls at various times and in various periods. This limited the inferential levels of the research results. Second, the applied purposive sampling meant that the research results would apply to only a limited range of individuals. Despite the aforementioned limitations, this study had the advantage of being the first comparative study to address basic attributes, physical performance and frailty stages in relation to fall risk in community-dwelling older adults in Taiwan. Therefore, the results permit the assessment of frailty and fall risk in the risk group and the development of appropriate care interventions for preventing future falls.

Conclusion

This study investigated the basic attributes, physical performance and frailty stages in relation to fall risk in community-dwelling older adults. Older females with low education, history of falls, weaker overall grip strengths; taking longer to finish the TUG test; and standing fewer times during the30-second chair stand test were at risk of fall. According to the research results, nursing personnel must develop care programs and improving older adults' risk of fall. In prediction, older people using long-term medication were at lower risk of falling, and the greater the hand grip strength was, the lower the fall risk was. Therefore, comprehensive care plans including multi-component physical activity programme were necessary.

Declarations

Competing interests

The authors of this manuscript declare no competing financial interests related to this work. Meanwhile, the authors declare that they have no competing interests.

Authors' contributions

SFC made substantial contributions to research conception. She also designed the draft of the research process and submitted the manuscript as corresponding author. YCL made substantial contributions to analysis and interpretation of data. She developed and executed the interprofessional training. CYK had been involved in the development of the intervention and the study protocol. He also supported the study design to avoid the confounding factor. SFC had been involved in revising manuscript critically for important intellectual content. She modified the manuscript format, discussed reviewer opinions, and clarified the professional name. All authors read and approved the final manuscript.

Availability of data and materials

The datasets used and analysed during the current study available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study passed the review and ethical approval by the Behavioral and Social Sciences Research Ethics Office of National Taiwan University (IRB-Reference Code:

201903ES021) in Taiwan. All methods were performed in accordance with the relevant guidelines and regulations. All the written consent was obtained from participants. The research data were solely used for research purposes and strictly kept confidential.

Consent for publication

Not applicable.

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