Arch AHS

ORIGINAL ARTICLE

Archives of Allied Health Sciences 2025; 37(3): 138-151.

The association between mobility limitations and physical performance measures in community-dwelling elderly: a cross-sectional study

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KEYWORDS
Postural balance; Geriatric Assessment; Muscle strength; Flexibility; Physiology; Aging

ABSTRACT

Effective management of mobility limitations in older adults requires two key components: early identification of at-risk individuals and the ability to target the most critical underlying physical deficits. While numerous clinical tests for balance and strength exist, there is a lack of clarity on which measure best serves both these screening and prescriptive purposes. This study aimed to (1) describe age-group differences, (2) examine bivariate associations between SPPB and flexibility/balance/strength measures, and (3) identify independent predictors and explained variance via stepwise multiple linear regression with age and sex as covariates. This cross-sectional study included 108 older adults (mean age 71.0 ± 5.0 years; 67 women, 41 men) with mobility limitations (SPPB score ≤ 9). Flexibility was measured with the sit-and-reach test; balance by the functional reach test (FRT), single-leg stance test (SLST), timed up and go test (TUGT), and y-balance test (YBT); and strength by handgrip dynamometry. Pearson correlations identified bivariate associations with SPPB score. Stepwise multiple regression was used to determine which measures were most strongly and independently associated with mobility limitation. Although no significant differences were observed between sexes, SPPB scores were significantly lower among the older age groups (75–84 and ≥85 years) compared with the youngest group (p-value < 0.01). The FRT demonstrated the strongest correlation with SPPB (r = 0.37–0.67, p-value < 0.01). In Model 1, FRT alone accounted for 48.3% of the variance in SPPB (β = 0.695, p-value < 0.01). When age was added in Model 2, the explained variance increased slightly to 49.3% ($\Delta R^2 = 0.01$; $\beta = 0.143$, p-value < 0.05). Functional reach emerged as a strong, independent predictor of mobility limitation, explaining nearly half the variance in SPPB score. Its simplicity and feasibility make it a valuable tool for routine geriatric screening to identify older adults at greatest risk of mobility decline. Age provides a modest but significant contribution. These findings support the incorporation of quick, practical balance assessments (FRT) in both community and clinical practice. The cross-sectional design limits causal inference, and findings may not be applicable to institutionalized populations.

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Received: 20 June 2025/ Revised: 21 September 2025/ Accepted: 14 November 2025

Introduction

The World Health Organization defines older adults as those aged 60 years and above. A significant concern arising from an aging population is the prevention of mobility impairment[1]. Approximately one-third to one-half of adults aged 65 and older report experiencing difficulty with ambulation or climbing stairs[2,3], which are common indicators of mobility capabilities[2,4]. Webber et al. (2010) defines mobility "as the ability to move oneself (either independently or by using assistive devices or transportation) within environments that expand from one's home to the neighborhood and to regions beyond"[5]. Mobility limitations correlate with heightened risks of falls, disability, hospitalization, and mortality risk as well as decreased quality of life[5,6], and poor psychosocial health[7]. The prevalence increases with age, affecting 35% of persons aged 70 and the majority of persons over 85 years[8]. Age-related declines in physical function[9], including flexibility, balance, and muscle strength[10], which contribute to mobility limitations[8,9].

Sex and age are critical factors that influence multiple domains of physical function. Women typically exhibit lower muscle strength and poorer balance than men, disparities attributed in part to hormonal changes, such as postmenopausal estrogen decline, and age-related differences in body composition[8, 11–12]. These physiological differences contribute to an earlier onset and higher frequency of mobility limitations in women. Furthermore, epidemiological studies confirm that women experience more falls and functional dependence, spending a greater proportion of their later life with mobility limitations compared to men of the same age. Concurrently, advancing age is strongly associated with progressive declines in flexibility, balance, and overall mobility, as increasing stiffness in muscles and connective tissues further restricts daily function [13, 14]. Thus, both sex and age are crucial determinants of mobility and independence in activities of daily living.

Objective clinical tests commonly used to characterize physical function include measures of flexibility (Sit-and-Reach Test: SRT), balance (static: Single-Leg Stand Test (SLST); dynamic: Timed Up and Go Test (TUGT), Functional Reach Test (FRT), and Y-Balance Test (YBT), and muscle strength (handgrip dynamometry). Lower sit-and-reach performance reflects reduced hamstring and lumbar flexibility, which can alter gait mechanics and compromise balance[15]. The SLST assesses postural stability under static conditions [16], while the TUGT captures functional mobility and dynamic postural control[17]. The FRT and YBT provide insight into dynamic balance, reach control, and neuromuscular coordination [18-20]. Impairments on these tests are associated with increased fall risk and loss of independence. Handgrip strength is a well-established indicator of overall functional status and health outcomes[21]. Therefore, these assessments cover the major domains of physical function most relevant to understanding mobility limitation in community-dwelling older adults.

Although many studies have examined mobility in relation to a single domain—such as flexibility, balance, or strength—most have focused on outcomes like gait or endurance in older adults without mobility limitations[14]. Furthermore, few studies have compared the static and dynamic components of these functional domains within a single cohort. The identified gaps are significant, as epidemiological data indicate a higher prevalence of mobility limitations in women, with a decline in mobility associated with aging[22-23]. Nonetheless, limited research utilizes multivariate methods to assess the independent and relative contributions of flexibility, balance, and strength while adjusted for age and sex. Consequently, clinicians still lack clear evidence regarding which clinical tests explain unique variance in mobility status, necessitating prioritization for screening. Therefore, the aims of this study were (i) to describe age-group differences in participant characteristics (65–74, 75–84, ≥85 years); (ii) to examine bivariate associations between mobility limitation—indexed by the Short Physical Performance Battery (SPPB)—and objectively measured flexibility, static and dynamic balance, and muscle strength; and (iii) to determine the independent contributions of age, sex, and these physical components to variance in mobility limitation using stepwise multiple linear regression

Materials and methods

Study design and participants

This cross-sectional study was conducted between July 2022 and June 2023 in the northern areas of Thailand. A total of 276 individuals were initially screened for eligibility. *The sample size was determined based on a correlation analysis between the SPPB and balance ability in older adults. A two-tailed test with an alpha level (a) of 0.05, a power (1−β) of 0.80, and an anticipated moderate correlation coefficient (r = 0.26), based on previous literature, was used to calculate the required sample size[28]. Thus, the required sample size was 108 participants.*

Inclusion criteria were (1) age ≥ 65 years; (2) ability to ambulate independently for 10 m without an assistive device; (3) Short Physical Performance Battery (SPPB) score ≤ 9; (4) no acute cardiovascular, pulmonary, or renal conditions; (5) no prior diagnosis of Parkinson’s disease or neurological symptoms; and (7) no diagnosed psychiatric disorder and no use of sedative medications. The exclusion criteria included (1) substantial auditory or visual impairment; (2) lower-limb pain > 5 on the visual analogue scale; (3); and (4) inability to follow instructions. The study protocol was approved by the Human Research Ethics Committee at the University of Phayao review board, following the Declaration of Helsinki (protocol code: UP-HEC 1.3/035/64). Informed written consent was acquired from all participants following eligibility screening and before participation in any study procedures.

Data collection

Demographic data, disease history, medication use, and fall history were obtained via questionnaire. Fall history was classified as no falls, one fall, or ≥2 falls within the past 12 months[25]. Disease status was categorized into nine conditions: none, hypercholesterolemia, hypertension, diabetes, osteoarthritis, heart disease, low back pain, thyroid disease, and others. Medication use was classified into five categories. Physical examination included measurement of height (to the nearest 0.1 cm; TSCALE M301-200), weight (to the nearest 0.1 kg; TANITA UM-051), and calculation of body mass index (BMI, kg/m^2). Blood pressure (systolic and diastolic) was measured three times using a digital sphygmomanometer (Omron HEM-7156A), with 10-minute rest intervals between measurements; the average data of the three readings were recorded. Physical performance was evaluated using a battery of tests, including the SPPB, SRT, SLST, FRT, TUGT, YBT, and a handgrip strength test. To mitigate the effects of test order and fatigue, the sequence of these tests was randomized for each participant by drawing lots, and a sufficient rest period was provided between each test until the participant felt recovered. Detailed procedures for each test are described below

Short physical performance battery

The SPPB quantifies lower-extremity physical performance and indicates mobility limitation, using three standardized subtests, and has excellent results in older populations ICC = 0.88–0.92[24]: a **three-stage balance test** (side-by-side, semi-tandem, and tandem stances held up to 10 s each); **gait speed** over 4 meters at their normal, comfortable pace while their time was recorded (a single trial is acceptable and has demonstrated reliability); and the five-times sit**-to-stand** (time to rise from a chair and sit down five times as quickly as possible). Each subtest is scored from **0** (unable) to **4** (best performance) according to published cut-points, yielding a **total score of 0–12** (higher scores indicate better function).

Sit-and-reach test

The SRT was used to assess hamstring flexibility and spinal range of motion during forward flexion, demonstrating acceptable reproducibility (ICC = 0.92)[15]. Participants sat barefoot on the floor with legs extended and heels positioned against a standardized sit-and-reach box (5×30.5 cm) equipped with a measuring ruler extending 15 cm beyond the box edge. With knees fully extended, participants placed their right hand over their left (fingertips aligned) and reached forward maximally along the measuring board without knee flexion. The score represented the furthest distance (cm) reached beyond the toes by the fingertips. Following two 10-second warm-up stretches, three trials were performed and averaged for analysis.

Single-leg stand test

For an SLST, participants stand on one foot with the knee of the other leg bent and not contacting the opposite leg. Single-leg balance results demonstrated acceptable intertrial reliability (ICC = 0.60-0.81)[16]. Participants were placed in the testing position and instructed to maintain balance for 30 seconds. During testing, if the raised leg touched the limb being tested or if movements such as hopping on one leg or using external support to assist with balance occurred, the participant was disqualified, and the researcher immediately stopped the test. The assessment was performed with both eyes open and closed, and the times from three trials were recorded and averaged to determine the mean value.

Functional reach test

The FRT assesses standing dynamic balance and demonstrates good test–retest reliability (ICC = 0.83–0.87)[18]. Participants stood near a wall without touching it. For the forward and backward directions, the participant extended the arm closest to the wall to 90° of shoulder flexion, and for the lateral directions, they abducted the arm to 90°, keeping the shoulder parallel to the measurement scale and the hand in a fist. Without moving their feet, they reached as far as possible, and the distance from the initial to the final position of the third metacarpal was measured in centimeters. Each participant completed three trials.

Timed up and go test

TUGT was used to assess functional mobility and fall risk. This test demonstrates excellent intertrial reliability, with a reported Intraclass Correlation Coefficient (ICC) of 0.96 [17]. For the procedure, a standard chair with a 43 cm seat height and armrests was used, and a cone was positioned 3 meters away. Participants were instructed to rise from the chair, walk to and around the cone, return to the chair, and sit down completely, all while walking at their normal, safe pace. On the command 'Go', a stopwatch was used to record the duration, starting as the participant's back lifted from the backrest and stopping as their buttocks made contact with the seat upon their return. Each participant completed three trials, and the average time in seconds was calculated for the final analysis.

Y balance test

The YBT assessed dynamic balance in three directions (anterior, posteromedial, and postero-lateral) positioned at 135° angles to each other. The test demonstrates intertrial reliability (ICC = 0.89–0.97)[26]. Participants stood on their preferred leg at the center of a Y-shaped grid with the great toe positioned at the line intersection. The non-stance leg reached maximally along each of the three directional lines while maintaining single-leg balance. Two practice trials per leg in each direction preceded testing. Trials were invalidated if the stance foot moved or the reaching leg failed to return to the starting position. Three trials were performed in each direction for both legs. Maximum reach distances were normalized to anatomical leg length, and YBT composite scores were calculated by dividing the sum of maximal reach distances in each direction by three times the leg length.

Grip strength test

Hand and forearm strength were assessed using a hand grip dynamometer (Takei Scientific Instruments Co. Ltd., Niigata, Japan). Test-retest reliability for measurements of grip strength was excellent for the dominant hand (ICC = 0.97; *p*-value = 0.001). Participants were instructed to stand with their arms extended straight down by their sides while the measurement was obtained with the dominant hand. Before the test, the grip device was adjusted to fit each participant's hand. The participants were then asked to squeeze the grip dynamometer using maximum force. Squeeze the dynamometer as hard as possible for 3-5 seconds[21]. Each participant was asked to perform this action twice with a one-minute interval between attempts. Their best performance was recorded.

Statistical analysis

All analyses were conducted using the IBM Statistical Package for Social Sciences (SPSS, version 29.0, IBM Corp, Chicago, IL, USA) for the statistical analysis, and the data were presented as averages, standard deviations (SD), and the number (percentage) for categorical variables. To address objective 1 (describing group differences), characteristics were compared across age groups and by sex. An independent samples t-test was performed for continuous variables, while a chi-square test was applied for categorical variables, provided the data met the assumption of normality. For subgroups where data were not normally distributed, the appropriate non-parametric equivalents (Mann-Whitney U test and Kruskal-Wallis test) were employed. Pearson product-moment correlation coefficients were used to examine bivariate relationships between continuous variables. Stepwise multiple linear regression analysis was used to investigate multivariate relationships among predictors of mobility limitations. The potential covariates (univariate analysis, *p*-value < 0.1) were included for the multiple regression model[27]. Results were reported as unstandardized coefficients (B) along with the standard error (SE). The statistical significance level was set at *p*-value < 0.05.

Results

The study included 108 community-dwelling older adults with mobility limitations (67 females, 41 males) aged 65–86 years. The baseline characteristic, vital sign, number of diseases, number of medications, and history of falls exhibited no significant differences between males and females (*p*-value > 0.05). In comparison to the 65–74-year-old group, participants aged 75–84 years and >85 years exhibited significantly reduced weight, height, BMI, and leg length (*p*-value < 0.01). The majority of participants indicated no falls in the previous year, with polypharmacy (defined as the use of three or more medications) being most prevalent in the 65–74 age group (Table 1).

Table 2 indicates that there was no significant difference in total SPPB and TUGT between males and females, demonstrating comparable overall mobility performance. However, men demonstrated significantly greater upper limb strength and balance performance—specifically in the YBT—when compared to women (*p*-value < 0.01). Participants aged 75–84 years and over 85 years exhibited significantly lower SPPB scores, flexibility, balance performance, and muscle strength compared with the 65–74-year-old group (*p*-value < 0.05–0.01). Dynamic balance (FRT and YBT scores) decreased consistently with advancing age (Table 2).

Correlation analysis revealed that SPPB scores were moderately and positively correlated with static balance (SLST, *p*-value < 0.01), dynamic balance as measured by the FRT in all directions (r = 0.402–0.695, *p*-value < 0.01), and grip strength (*p*-value < 0.01). In contrast, a significant negative correlation was observed between SPPB and TUGT performance (r = −0.253, p-value < 0.01). No significant correlations were found between SPPB and age or gender (Table 3).

Table 1 Characteristics of sex and age-groups differences in elderly with mobility limitation (aged 65-86 years)

Variable	Sex		Age groups		
	Female (n=67)	Male (n=41)	65-74 y (n=86)	75-84 y (n=19)	>85 y (n=3)
Age (year)†	71.07±4.90	70.90±5.22	68.98±2.82	77.95±2.52^{a**}	85.33±0.57^{a**b**}
Weight (kg)†	50.98±7.86	59.90±9.24	56.04±0.95	47.47±7.79^{a**}	50.13±11.58
Height (cm)†	151.70±7.97	162.12±6.52	157.13±8.43	149.74±8.49^{a**}	151.00±14.17
BMI (kg/m)^{2†}	22.13±2.84	22.67±3.02	22.67±2.94	21.12±2.69^{a*}	21.67±0.85
Leg length (cm)	68.27±3.58	72.95±2.93	70.71±3.79	67.38±3.82^{a**}	67.95±6.38
SBP (mmHg)†	131.90±19.39	133.15±17.66	131.84±17.33	135.74±23.60	126.33±26.63
DBP (mmHg)†	73.69±11.89	73.41±10.74	74.36±10.64	72.68±13.72	57.00±5.19^{a**}
Heart rate (beats/min)†	78.45±9.96	75.88±13.63	77.52±11.74	75.68±9.00	87.33±17.78
Oxygen saturation (%)†	98.24±0.97	98.27±0.89	98.21±0.95	98.42±0.83	98.33±1.15
Number of diseases n, (%)#					
No disease	15 (22.4)	14 (34.1)	22 (25.6)	5 (26.3)	2 (66.7)
Cholesterol	21 (31.1)	9 (22)	28 (32.6)	2 (10.5)	0 (0)
Hypertension	29 (43.3)	14 (34.1)	36 (41.9)	6 (31.6)	1 (33.3)
Diabetes mellitus	9 (13.4)	5 (12.2)	13 (15.1)	1 (5.3)	0 (0)
Osteoarthritis	7 (10.4)	3 (7.3)	6 (7)	3 (15.8)	1 (33.3)
Heart disease	3 (4.5)	4 (9.8)	4 (4.7)	2 (10.5)	1 (33.3)
Low back pain	2 (3)	1 (2.4)	3 (3.5)	0 (0)	0 (3)
Thyroid disease	2 (3)	1 (2.4)	3 (3.5)	0 (0)	0 (3)
Others	12 (17.9)	9 (22)	18 (20.9)	3 (15.8)	3 (100)
Number of medication n, (%)#					
0 type	24 (35.8)	16 (39)	32 (37.2)	6 (31.6)	2 (66.7)
1 type	15 (22.4)	7 (17.1)	18 (20.9)	4 (21.1)	0 (0)
2 type	13 (19.4)	8 (19.5)	18 (20.9)	3 (15.8)	0 (0)
3 type	6 (9)	4 (9.8)	8 (9.3)	2 (10.5)	0 (0)
≥4 type	9 (13.4)	6 (14.6)	10 (11.6)	4 (21.1)	1 (33.3)

Table 1 Characteristics of sex and age-groups differences in elderly with mobility limitation (aged 65-86 years) (Cont.)

Variable	Sex		Age groups		
	Female (n=67)	**Male (n=41)**	**65-74 y (n=86)**	**75-84 y (n=19)**	**>85 y (n=3)**
History of falls n, (%)#					
0 falls	59 (88.1)	39 (95.1)	78 (90.7)	17 (89.5)	3 (100)
1 fall	7 (4.9)	2 (10.4)	7 (8.1)	2 (10.5)	0 (0)
≥2 falls	1(1.5)	0 (0)	1 (1.2)	0 (0)	0 (0)

Note: † The data are presented as mean ± standard deviation (95% confidence interval). Comparisons among the three age groups were performed using the Mann-Whitney U test, while comparisons between male and female participants were conducted using the independent t-test. # The data are presented as the number (percent of total participants), and group comparisons were performed using the Chi-square test. [a] indicates a statistically significant difference compared to the 65-74 y group. [b] indicates a statistically significant difference compared to the 75-84 y group. * significant difference (p-value < 0.05), ** (p-value < 0.01).

Abbreviations: Y = years, Kg = kilogram, cm = centimeter, BMI = body mass index, SBP = systolic blood pressure, and DBP = diastolic blood pressure.

Table 2 Clinical balance assessment, upper limb muscle strength test, and flexibility test in elderly with mobility limitation group (n = 108)

Characteristics	Sex		Age groups		
	Female (n=67)	**Male (n=41)**	**65-74 y (n=86)**	**75-84 y (n=19)**	**>85 y (n=3)**
SPPB (score)	7.51±1.61	7.74±1.57	8.26±0.99	5.47±1.07 ^{b**}	4.00±0.00 $^{b**\ c*}$
SRT (cm)	8.02 ± 7.46	2.66 ± 5.93^{a**}	6.05 ± 7.27	6.51 ± 7.71	0.63 ± 8.60 ^{b*}
SLST (s)	10.33 ± 7.35	13.71 ± 7.26^{a*}	12.84 ± 7.29	7.28 ± 6.53^{b**}	3.91 ± 2.77^{b*}
FRT forward (cm)	18.57 ± 7.62	21.23 ± 8.43	20.53 ± 7.94	17.08 ± 6.78	8.33 ± 6.68^{b*}
FRT backward (cm)	12.47 ± 8.06	13.93 ± 6.48	13.75 ± 7.54	11.34 ± 6.55	2.92 ± 2.83$^{b*\ c*}$
FRT right side (cm)	12.97 ± 5.29	16.81 ± 5.29^{a**}	15.21 ± 5.90	12.04 ± 4.53^{b*}	7.10 ± 1.51^{b*}
FRT left side (cm)	12.70 ± 4.42	15.93 ± 4.43^{a**}	14.44 ± 4.86	11.86 ± 3.37^{b*}	12.21 ± 2.80
TUGT (s)	12.03 ± 3.09	12.07 ± 2.98	11.81 ± 2.88	12.68 ± 3.60	15.00 ± 2.28 ^{b*}
YBT anterior (cm)	30.41 ±10.88	37.73 ± 13.55^{a**}	35.11 ± 12.42	26.66 ± 8.66^{b*}	19.57 ± 13.71
YBT posteromedial (cm)	54.05 ± 9.98	60.62 ± 11.26^{a**}	57.95 ± 10.95	51.86 ± 8.19^{b*}	45.78 ± 14.27
YBT posterolateral (cm)	43.54 ±10.06	49.75±13.0^{a**}	47.38 ± 11.59	41.25 ± 8.72^{a**}	32.73 ± 16.35
Grip strength (kg)	16.10 ± 4.41	23.71 ± 6.99^{a**}	20.08 ± 6.67	15.01 ± 4.69^{b**}	13.05 ± 3.07 ^{b*}

Note: The data are presented by mean ± SD. Comparisons among the three age groups were performed using the Mann-Whitney U test, while comparisons between male and female participants were conducted using the independent t-test. ^{a} indicates a statistically significant difference compared to the female group. ^{b} indicates a statistically significant difference compared to the 65-74 y group. ^{c} indicates a statistically significant difference compared to the 75–84 y group * significant difference (*p*-value < 0.05), ** (*p*-value < 0.01).
Abbreviations: TUGT, Timed up and go test; SRT, Sit and reach test; SLST, Single leg stand test; FRT, Functional reach test; YBT, Y balance test; s, second; kg, kilogram; cm, centimeter.

Table 3 Correlation analysis between SPPB, static and dynamic balance ability, flexibility test and muscle strength participants (aged 65-86 years)

	SRT	SLST	FRT forward	FRT backward	FRT right side	FRT left side	TUGT	YBT postero-medial	YBT postero lateral	YBT anterior	Grip strength	SPPB
Age	-0.063	-0.277**	-0.246*	-0.232*	-0.320**	-0.142	0.308**	-0.276**	-0.267**	-0.317**	-0.329**	-0.037
Gender	0.354**	-0.220*	-0.162	-0.095	-0.179	-0.336**	-0.006	-0.293**	-0.261**	-0.288**	-0.559**	-0.083
BMI	-0.119	-0.111	0.078	0.032	0.223*	0.140	-0.039	-0.203*	-0.204*	-0.115	0.107	0.075
SPPB	0.129	0.326**	0.695**	0.402**	0.522**	0.527**	-0.253**	0.218*	0.158	0.283**	0.259**	1.000
SRT	1.000	0.132	0.215*	0.145	0.079	-0.029	-0.151	0.107	0.131	0.074	0.020	0.129
SLST		1.000	0.367**	0.325**	0.279**	0.281**	-0.199*	0.344**	0.429**	0.367**	0.251**	0.326**
FRT forward			1.000	0.600**	0.718**	0.648**	-0.274**	0.443**	0.316**	0.477**	0.365**	0.695**
FRT backward				1.000	0.549**	0.479**	-0.355**	0.397**	0.311**	0.434**	0.370**	0.402**
FRT right side					1.000	0.754**	-0.190*	0.273**	0.235*	0.389**	0.414**	0.552**
FRT left side						1.000	-0.075	0.289**	0.205*	0.352**	0.282**	0.527**
TUGT							1.000	-0.292**	-0.325**	-0.424**	-0.169	-0.253**
YBT- posteromedial								1.000	0.799**	0.809**	0.442**	0.218*
YBT- posterolateral									1.000	0.798**	0.354**	0.158
YBT- anterior										1.000	0.426**	0.283**
Grip strength											1.000	0.259**

Note: Correlations were analyzed using Pearson correlation coefficient. * Indicated significant differences (p-value < 0.05), ** (p-value < 0.01).

Abbreviations: BMI, body mass index; SPPB, Short Physical Performance Battery; TUGT, Timed up and go test; SRT, Sit and reach test; SLST, single legs stand test; FRT, Functional reaching test; YBT, Y-balance test.

Table 4 Multiple linear regression model predicting mobility limitation

Predictor	Unstandardized β	SE	Standardized Beta	R^2 change	95%CI
Model 1					
FRT forward	0.217	0.022	0.695**	0.483	0.174-0.260
Model 2					
FRT forward	0.228	0.022	0.730**	0.493	0.184-0.272
Age	0.071	0.036	0.143*		0.001-0.142

Note: * Indicates significant differences (*p*-value < 0.05), ** (*p*-value < 0.01).
Abbreviations: CI, Confidence Intervals represent the range for unstandardized; β, coefficients; FRT, functional reach test.

Based on Table 4, the multiple linear regression analysis (stepwise) was conducted to predict mobility limitation using FRT forward and age as predictor variables. In Model 1, FRT forward was a significant predictor of mobility limitation (β = 0.695, *p*-value < 0.01), explaining 48.3% of the variance (R^2 change = 0.483) in the outcome variable. The 95% confidence interval (CI) for the unstandardized coefficient ranged from 0.174 to 0.260. In Model 2, age was added as an additional predictor. Both FRT forward (β = 0.730, *p*-value < 0.01) and age (β = 0.143, *p*-value < 0.05) remained significant contributors to the model. The inclusion of age led to a slight improvement in model performance, increasing the R^2 change to 0.493, with the 95% CI for age ranging from 0.001 to 0.142, highlighting its additional impact on mobility decline.

Discussion

This study aimed to examine the relationship between mobility limitations and various parameters of physical function in older adults. This study found significant sex differences in physical function, with men exhibiting greater muscle strength and balance than women. Mobility limitation was moderately to strongly associated with balance and flexibility, with forward reach on the FRT emerging as the strongest predictor, explaining 48.3% of the variance. Adding age to the model increased the explained variance by 1%, highlighting the combined influence of balance performance and aging on mobility limitation in older adults.

In this study, significant differences in balance, flexibility, and muscle strength were observed across age groups and between sexes; however, SPPB and TUGT did not show significant differences. These findings are consistent with previous research demonstrating that balance and strength decline progressively with advancing age due to reductions in muscle mass, tendon stiffness, and neuromuscular coordination associated with sarcopenia and age-related sensory degradation[14,29]. Men generally outperform women in muscle strength and static balance tasks, which may be attributed to greater muscle mass, higher lower-limb strength, and superior postural control strategies[30]. Conversely, women exhibit higher flexibility due to differences in joint range, pelvic tilt, and connective tissue properties, which indicate sex-specific patterns of physical function decline in aging.

Several factors may explain no significant differences in SPPB and TUGT scores between groups. First, all participants in the present study were classified as having mobility limitations (SPPB ≤ 9), resulting in a restricted performance range and potential floor effects, thereby limiting the sensitivity of these global mobility measures to detect between-group variation. Second, both SPPB and TUGT are composite functional assessments that integrate multiple domains—including balance, gait, and strength—and may thus obscure domain-specific differences observed in isolated balance or strength tests. Similar findings have been reported by previous studies showing that global mobility scores may remain stable despite domain-specific impairments, as individuals compensate for deficits in one system (e.g., balance) with preserved function in another (e.g., strength or gait speed)[31,32]. Third, the relatively small sample size in the oldest age group (>85 years) may have reduced the statistical power to detect true group differences. Overall, these results suggest that while static balance and muscle strength decline more sharply and are sensitive indicators of age- and sex-related functional differences, global mobility tests such as SPPB and TUGT may lack sufficient granularity to distinguish these variations in populations already exhibiting mobility limitations.

The present study found that SPPB scores were significantly and positively correlated with SLST and all directions of the FRT, with the strongest association observed in the forward reach direction. This finding suggests that forward reaching ability, a measure of dynamic balance and postural control, is a key determinant of overall mobility performance in older adults with mobility limitations. The importance of forward reach is consistent with previous studies reporting that reduced anterior reaching distance is associated with impaired balance, limited functional mobility, and increased fall risk in older adults[33]. Moreover, the observed positive association between SLST and SPPB supports evidence that single-leg stance performance reflects the integration of sensory, neuromuscular, and balance control systems that are critical for safe ambulation and functional independence[34]. Conversely, the negative correlation between SPPB and TUGT performance aligns with prior research showing that prolonged TUGT completion time is indicative of slower gait speed, poorer mobility, and higher disability risk[35]. Collectively, these findings emphasize that specific dynamic balance measures, particularly forward reach may serve as sensitive indicators of mobility performance and could be prioritized in geriatric screening and intervention programs.

In the multiple linear regression analysis, forward reach distance on the FRT emerged as the strongest predictor of mobility, accounting for 48.3% of the variance (ß = 0.695, *p*-value < 0.01). This result aligns with previous evidence that dynamic balance measured by the FRT, is a critical determinant of functional mobility in older adults. Rosa et al. (2019) reported normative values of 26.6 cm for community-dwelling older adults and emphasized the FRT's strong association with fall risk, underscoring its clinical relevance[36]. The addition of age in Model 2 increased the explained variance only marginally to 49.3%, with age demonstrating a smaller yet statistically significant effect (ß = 0.143, *p*-value < 0.05), consistent with findings by Trombetti et al. (2016) linking advancing age to mobility decline[37]. Similarly, Duncan et al. (1990) demonstrated that the FRT effectively measures limits of stability during functional tasks, while Springer et al. (2007) confirmed its reliability and predictive validity for falls in older populations[33,34]. Conversely, some studies, such as Thomas and Lane (2005), have reported weaker or non-significant associations between FRT and mobility outcomes, particularly in cohorts with high baseline functional capacity, suggesting that its predictive value may be reduced in more active populations[38]. The comparatively larger effect size of FRT relative to age in the present study indicates that functional performance measures may offer more immediate and actionable insights into mobility status than chronological age alone. Moreover, the narrow 95% confidence intervals for both predictors (FRT: 0.184-0.272; Age: 0.001–0.142) reflect the precision and stability of these estimates, reinforcing the value of incorporating the FRT as a central component in mobility assessment and targeted interventions for older adults.

A key strength of this study is its comprehensive assessment of balance, strength, flexibility, and mobility, along with sex- and age-based comparisons that provide valuable insights into factors influencing functional capacity in older adults. However, certain limitations should be noted. The cross-sectional design precludes causal inferences regarding the observed associations. Potential confounding factors, such as habitual physical activity, nutrition, and lifestyle behaviors, were not fully controlled. In addition, the oldest age group (>85 years) was underrepresented, limiting statistical power and the generalizability of findings for this segment.

Conclusion

This study identified significant sex- and age-related differences in physical performance among older adults. Forward reach performance on the FRT was the strongest predictor of mobility limitation, with age providing an additional but smaller contribution. These findings highlight the FRT as a practical and effective tool for detecting mobility limitations and emphasize the need for targeted strategies to maintain functional capacity in older populations.

Take home messages

The FRT is a quick, practical balance measure that strongly predicts mobility limitation in older adults. Incorporating FRT into routine screening may help identify individuals at high risk of mobility decline, supporting early intervention to preserve independence and prevent falls.

Conflict of interest statement

The authors declare no conflict of interest.

Acknowledgements

The authors sincerely thank the bachelor students and physiotherapists for their assistance in data collection, as well as all participants for their valuable contribution. We also extend our gratitude to the University of Phayao for its support. Special thanks are extended to Asst. Prof. Ajchamon Thammachai for her valuable guidance and consultation in statistical analysis.

Author contributions

Chonticha Kaewjoho: Conceptualization, Methodology, Writing review and editing, Formal analysis, Investigation, Data curation, and Writing original draft preparation.

Narongsak Khamnon: Validation, Software, Resources, Visualization.

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All authors have read and agreed to the published version of the manuscript.

Data availability

Data available on request due to privacy/ethical restrictions.

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