ORIGINAL ARTICLE

Test-Retest Reliability of the Five-Times Sit-to-Stand Test in Sedentary Community-Dwelling Older Adults in Thailand

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Objective: To examine the test-retest, intra-rater, and inter-rater reliability of the five-times sit-to-stand test (FTSST) among sedentary community-dwelling older adults when administered by a licensed physical therapist and a trained village health volunteer (VHV).

Materials and Methods: The cross-sectional study included 34 sedentary community-dwelling older adults aged 60 years or older. The FTSST was administered in two sessions one week apart by an experienced physical therapist and a VHV. Test-retest, intra-rater, and inter-rater reliability were evaluated using intraclass correlation coefficients (ICC), standard error of measurement (SEM), and minimal detectable change (MDC).

Results: The FTSST showed excellent reliability across all assessments, with ICC values ranging from 0.920 to 0.958. SEM ranged from 0.409 to 0.554 seconds (4.00% to 5.43%) and MDC ranged from 1.133 to 1.537 seconds (11.10% to 15.05%). The agreement between the physical therapist and the VHV was high, indicating consistent test performance.

Conclusion: The FTSST shows good reliability in sedentary older adults, and that administration by trained VHV is feasible in community settings.

Keywords: Reliability; Sedentary behavior; Village health volunteer; Functional mobility; Older adults

The maintenance of lower extremity strength and functional mobility is essential for healthy aging. Declines in these functions are strongly associated with falls, frailty, loss of independence, institutionalization, and mortality among older adults[1,2]. The ability to rise from a seated position is a key functional task required for independent living and is commonly used as an indicator of lower limb strength, balance, and neuromuscular coordination[3,4]. This ability is frequently impaired in sedentary older adults who engage in prolonged periods of physical inactivity and limited weight-bearing activities, contributing to musculoskeletal deconditioning[5,6].

Sedentary behavior, defined as waking activities performed in a sitting, reclining, or lying posture with low energy expenditure, is an independent risk factor for multiple adverse health outcomes[7]. These include cardiovascular disease, metabolic disorders, functional decline, and increased mortality, independent of overall physical activity levels[8,9]. As populations age globally, early identification of functional limitations in sedentary older adults has become a public health priority, particularly in settings with limited access to rehabilitation and preventive services[10,11].

The five-times sit-to-stand test (FTSST) is a simple, time-based measure of lower limb strength and dynamic balance widely used in both clinical and community settings. The test requires minimal equipment and can be administered quickly, making it suitable for large-scale screening[12]. The FTSST has demonstrated good reliability and validity across a range of populations, including community-dwelling older adults and individuals with chronic health conditions[13]. Similar psychometric properties have been reported in individuals recovering from stroke or

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orthopedic surgery, further supporting its applicability across diverse clinical and community settings[9,14,15]. However, despite its established utility, the reliability of the FTSST has not been specifically validated in sedentary older adults, a subgroup likely to exhibit increased variability in motor performance due to physical deconditioning and reduced neuromuscular adaptability.

In many rural and resource-limited settings, access to licensed rehabilitation professionals remains limited. In Thailand, village health volunteers (VHVs) are a key component of the primary healthcare system, providing basic health monitoring, health education, and referral services within their communities[16]. Given their central role in delivering community-based healthcare, VHVs represent a potentially valuable resource for implementing scalable functional screening initiatives in underserved populations[17,18]. However, to ensure clinical utility and data reliability, it is necessary to determine whether VHVs can administer standardized functional assessments, such as the FTSST, with accuracy comparable to that of trained healthcare professionals.

Therefore, the present study aimed to examine the test-retest, intra-rater, and inter-rater reliability of the FTSST when administered to sedentary, community-dwelling older adults by both an experienced physical therapist and a trained VHV. The findings are intended to inform the feasibility of involving community health workers in functional mobility screening among aging populations, particularly in low-resource settings.

MATERIALS AND METHODS
Study design and participants

The present study employed a cross-sectional study. Thirty-four community-dwelling older adults aged 60 years and above were recruited from local villages in Phayao Province, Thailand. Inclusion criteria were 1) classified as sedentary, defined as engaging in less than 600 MET minutes of physical activity per week, assessed using the Global Physical Activity Questionnaire (GPAQ), version 2 (Thai version)[19], 2) ability to ambulate independently, without assistive devices, and 3) ability to comprehend and follow verbal instructions. Exclusion criteria were determined based on a comprehensive medical history review and included cardiopulmonary symptoms such as shortness of breath with minimal exertion, neurological conditions affecting balance or motor control, diabetes with

peripheral neuropathy, vestibular disorders, clinically significant lower-extremity musculoskeletal pain such as joint or muscle pain rated greater than 5 on the numerical rating scale[20] that could interfere with safe participation or valid test performance, acute musculoskeletal injury or a history of fracture within the previous year, active infection or a current diagnosis of cancer, recent episodes of dizziness or syncope, uncorrected visual impairment, and limb amputation. The required sample size was estimated using an online calculator for intraclass correlation coefficient (ICC) reliability studies (https://wnarifin. github.io/ssc/ssicc.html), based on an expected ICC of 0.81[21], a minimum acceptable ICC of 0.60, a significance level of 0.05, and a statistical power of 80%, resulting in a required sample size of 34 participants.

Raters and training

The FTSST was administered by two raters. The first was an experienced physical therapist with over five years of clinical experience in geriatric rehabilitation. The second rater was a VHV who completed a one-month preparatory training program prior to data collection. The training included theoretical instruction on the FTSST protocol, including standardized test positioning, verbal instructions, timing procedures, and termination criteria. Practical demonstrations were conducted by a licensed physical therapist, followed by supervised hands-on practice to ensure consistency and accuracy in test administration. In addition, the training emphasized basic health screening prior to test administration, including recognition of contraindications such as dizziness, excessive shortness of breath, severe lower-extremity pain, or balance instability. The VHV was instructed to postpone testing and refer participants to a physical therapist or healthcare provider if any safety concerns were identified. The VHV was also instructed to practice operating a stopwatch independently at home to reinforce timing accuracy and procedural familiarity.

Procedures

All participants completed the FTSST in two sessions conducted one week apart to assess test-retest reliability. In each session, participants performed one familiarization trial followed by two recorded trials. Each recorded trial was timed concurrently and recorded independently by two assessors, an experienced physical therapist and

a trained VHV, who were blinded to each other's measurements to minimize observer bias. The mean time of the two recorded trials was used for data analysis and expressed in seconds. Participants were allowed to rest in a seated position for one to two minutes between trials, as needed, to minimize fatigue[22].

Prior to each testing session, participant readiness was assessed collaboratively using a brief health screening, with clinical judgment and final decisions made by the physical therapist. The screening included self-reported symptoms such as dizziness, excessive fatigue, or shortness of breath, resting blood pressure, and general balance status. The trained VHV assisted by observing symptoms and adhering to the standardized protocol. Testing was postponed if acute symptoms or signs of instability were identified. A standardized safety protocol was applied throughout all assessments, and the physical therapist remained nearby to provide immediate assistance if required.

The FTSST was performed using a standard-height, armless chair of 43 to 46 cm. Participants were seated upright with the back in contact with the backrest, hips and knees flexed to approximately 90°, feet placed flat on the floor slightly behind the knees, and arms crossed over the chest. At the standardized verbal cue "Go", participants stood up and sat down five consecutive times as quickly and safely as possible without using the upper limbs. Timing commenced at the cue and stopped upon completion of the fifth stand, in accordance with established guidelines[4,23]. All assessments were conducted under standardized conditions using the same chair and timing device, by both raters, and at the same time of day, in the morning, to minimize procedural and diurnal variability.

Outcome measures

The primary measure was the total time recorded in seconds, required to complete the FTSST. Reliability of the test was assessed using three parameters, test-retest reliability, intra-rater reliability, and inter-rater reliability. Test-retest reliability evaluated the consistency of FTSST performance across two sessions administered by the same rater. Intra-rater reliability was assessed by comparing the test and retest scores obtained by each rater individually. Inter-rater reliability examined the agreement between the expert physical therapist and the VHV within the same session. These metrics provided a comprehensive evaluation of the reproducibility and consistency of the FTSST under both professional and community-based conditions.

Statistical analysis

Descriptive statistics were used to summarize participant characteristics and test performance outcomes. Relative reliability was assessed using ICC (2,3) with corresponding 95% confidence intervals (CIs). The strength of reliability was interpreted according to the classification proposed by Landis & Koch[24], as 0 for poor reliability, 0.01 to 0.20 for mild reliability, 0.21 to 0.40 for fair reliability, 0.41 to 0.60 for moderate reliability, 0.61 to 0.80 for substantial reliability, and 0.81 to 1.00 for very high or nearly perfect reliability. The standard error of measurement (SEM) was calculated using the formula: $SEM = SD \times \sqrt{(1 - ICC)}$. The minimal detectable change (MDC) at 95% confidence was calculated as $MDC = 1.96 \times \sqrt{2} \times SEM$. Both SEM and MDC were also expressed as percentages of the mean FTSST time (SEM%, MDC%) to aid interpretation across individuals. All statistical analyses were conducted using IBM SPSS Statistics, version 30.0 (IBM Corp., Armonk, NY, USA), with significance set at a p-value of less than 0.05.

RESULTS

Thirty-four sedentary community-dwelling older adults participated in the present study. The mean age of participants was 69.59±6.04 years, and the majority were female, with 27 female participants (79.41%). The average weight and height were 56.59±11.80 kg and 153.57±5.58 cm, respectively, with a mean body mass index (BMI) of 23.97±4.66 kg/m². The mean GPAQ score was 241.76±247.97 MET-minutes per week, indicating a low level of physical activity. Most participants were non-smokers at 88.24%, and 50% reported no underlying medical conditions (Table 1).

The FTSST performance was similar across raters and sessions. During the initial test session, the expert recorded a mean time of 10.36±2.04 seconds, while the VHV recorded 10.28±1.98 seconds. In the retest session, the expert recorded 10.26±2.03 seconds, and the VHV recorded 10.16±1.96 seconds (Table 2).

Table 3 shows the test-retest reliability of the FTSST conducted by both the expert physical therapist and the VHV. The results revealed excellent reliability for both raters. The ICC was 0.95 (95% CI 0.91 to 0.97) for the expert and 0.95 (95% CI 0.92 to 0.97) for the VHV. The SEM was 0.46 seconds and 0.45 seconds, corresponding to 4.48% and 4.38%, respectively. The MDC values were 1.27 seconds

Table 1. Participant characteristics (n=34)

Variable	
Age (years); mean±SD	69.59±6.04
Sex (female); n (%)	27 (79.41)
Weight (kg); mean±SD	56.59±11.80
Height (cm); mean±SD	153.57±5.58
BMI (kg/m^2); mean±SD	23.97±4.66
GPAQ score (MET-minutes/week); mean±SD	241.76±247.97
Smoking; n (%)	
No smoking	30 (88.24)
Former smoking	4 (11.76)
Underlying disease; n (%)	
None	17 (50.00)
Hypertension	9 (26.47)
Diabetes	1 (2.94)
Asthma	7 (20.59)

BMI=body mass index; GPAQ=Global Physical Activity Questionnaire; SD=standard deviation

Table 2. The five-times sit-to-stand test performance by rater and session

Session	Expert mean±SD	Village health volunteer mean±SD
Session 1 (seconds)	10.36±2.04	10.28±1.98
Session 2 (seconds)	10.26±2.03	10.16±1.96

SD=standard deviation

Table 3. Test-retest reliability of the five-times sit-to-stand test

Variable	ICC (95% CI)	SEM (seconds)	SEM (%)	MDC (seconds)	MDC (%)
Expert	0.95 (0.91 to 0.97)	0.46	4.48	1.27	12.41
VHV	0.95 (0.92 to 0.97)	0.45	4.38	1.25	12.13

VHV=village health volunteer; ICC=intraclass correlation coefficient; CI=confidence interval; SEM=standard error of measurement; MDC=minimal detectable change

(12.41%) and 1.25 seconds (12.13%) for the expert and VHV, respectively.

Intra-rater reliability, evaluated during the retest session, demonstrated excellent agreement for both assessors. The licensed physical therapist achieved an ICC of 0.94 (95% CI 0.90 to 0.97), with a SEM of 0.49 seconds (4.75%) and an MDC of 1.36 seconds (13.00%). Similarly, the trained VHV demonstrated an ICC of 0.92 (95% CI 0.86 to 0.96), an SEM of 0.55 seconds (5.34%), and an MDC of 1.52 seconds (14.95%). Inter-rater reliability between the physical therapist and the VHV was likewise excellent, with an ICC of 0.96 (95% CI 0.93 to 0.98). The corresponding SEM and MDC values were 0.41 seconds (4.00%) and 1.13 seconds (11.0%), respectively (Table 4).

DISCUSSION

In the present study, the FTSST demonstrated high reliability for evaluating lower limb functional performance in sedentary, community-dwelling older adults. The close agreement between measurements obtained by a licensed physical therapist and a trained VHV suggests that the FTSST can be administered consistently across assessors with different professional backgrounds. These findings support the feasibility of using the FTSST in both clinical and community-based settings, particularly in contexts where access to professional rehabilitation services is limited.

The present study demonstrated excellent test-retest reliability of the FTSST, with an ICC of 0.95 (95% CI 0.91 to 0.97) for both the licensed physical therapist and the trained VHV. These findings are consistent with previous reports across diverse populations and clinical contexts. For example, Mong et al. reported ICC values ranging from 0.989 to 0.999 in individuals with chronic stroke, indicating very high temporal consistency[15]. Similarly, studies involving healthy older adults have shown ICC values between 0.89 and 0.96, supporting the stability of the FTSST in aging populations[3]. High reliability has also been reported in individuals with Parkinson's disease[25] and in community-dwelling older adults at high risk of falls, with ICC values ranging from 0.92 to 0.97[20]. These findings highlight the strong psychometric properties of the FTSST. Importantly, the present study extends existing evidence by demonstrating that the FTSST remains a stable and reliable assessment in sedentary older adults, a

Table 4. Intra- and inter-rater reliability of the five-times sit-to-stand test

Reliability	Rater pair	ICC (95% CI)	SEM (seconds)	SEM (%)	MDC (seconds)	MDC (%)
Intra-rater	Expert	0.94 (0.90 to 0.97)	0.49	4.75	1.36	13.00
Intra-rater	VHV	0.92 (0.86 to 0.96)	0.55	5.34	1.52	14.95
Inter-rater	Expert vs. VHV	0.96 (0.93 to 0.98)	0.41	4.00	1.13	11.00

VHV=village health volunteer; ICC=intraclass correlation coefficient; CI=confidence interval; SEM=standard error of measurement; MDC=minimal detectable change

subgroup that is often underrepresented in mobility research and may exhibit greater variability due to physical deconditioning and neuromuscular decline.

Intra-rater reliability in the present study was excellent, with an ICC of 0.94 for the physical therapist and 0.92 for the VHV. These findings are consistent with the previous studies reporting high intra-rater reliability of the FTSST across diverse populations. In community-dwelling older adults, ICC values ranging from 0.914 to 0.933 have been reported[26].

Similarly, very high intra-rater reliability has been observed in individuals with multiple sclerosis, including those performing the test remotely, with ICC values of 0.960 and 0.962[27]. Comparable reliability has also been reported in patients recently discharged from intensive care units, with an ICC of 0.95[28]. Collectively, these findings underscore the reproducibility of the FTSST when administered by a single trained assessor and support its applicability in both clinical practice and community-based screening contexts.

Inter-rater reliability between the licensed physical therapist and the trained VHV was excellent (ICC 0.96), indicating strong agreement between assessors with different professional backgrounds when standardized training procedures are used. This finding is consistent with previous studies reporting high inter-rater reliability of the FTSST across various populations, including individuals with multiple sclerosis and adult survivors of critical illness[27,28]. Slightly lower reliability has been reported in pediatric populations, such as children with cerebral palsy, likely due to greater variability in motor performance[29]. Moreover, a recent systematic review and meta-analysis involving 400 participants demonstrated strong overall inter-rater reliability for the FTSST (ICC 0.94)[13]. Together, these findings support the consistency of FTSST administration across raters following standardized training in both clinical and community-based contexts.

The present study demonstrated high absolute reliability of the FTSST, with low SEM values of 0.41 to 0.55 seconds (4.00% to 5.43% of the mean) and MDC values ranging from 1.13 to 1.54 seconds (11.10% to 15.05%), indicating the ability to detect meaningful changes in performance. These results are consistent with the previous findings in older adults, including a reported SEM of 0.9 seconds (6.3%) in older women[12] and 0.58 seconds (5.2%) in healthy adults[13]. Moreover, the observed MDC values align with thresholds proposed by Bohannon, at 1.5 to 2.3 seconds, for identifying true functional change in older populations[30].

The combination of high ICCs (0.94 to 0.96), low SEM, and acceptable SEM% values indicates excellent reliability and reproducibility of the FTSST across assessors. These findings are consistent with reports in clinical populations, including individuals with multiple sclerosis, with ICC of 0.96 and SEM of 1.4 seconds[27], while de Melo et al. found SEM values as low as 0.01 seconds and ICC of 0.95 in older adults at ICU discharge, reflecting minimal variability in same-day retesting[31]. These results support the psychometric robustness of the FTSST and its suitability for functional mobility assessment in sedentary older adults within community-based programs.

A key strength of the present study is its focus on sedentary older adults, a population often underrepresented in functional mobility research despite their heightened risk of sarcopenia, falls, and disability due to physical inactivity and neuromuscular deconditioning[32-34]. While prior studies have largely examined healthier or clinical populations, the present study findings indicate that the FTSST remains a highly reliable assessment even among individuals with low activity levels[13,35]. These results extend the applicability of the FTSST to broader public health settings, particularly for early screening initiatives aimed at supporting functional independence and aging in place[36].

The study also highlights the effective involvement of a trained VHV, whose assessment results were comparable to those of a licensed physical therapist. This supports existing evidence suggesting that community health workers, when properly trained and supervised, can reliably conduct standardized assessments[37,38]. In Thailand, VHVs are an integral part of the national primary healthcare infrastructure, and their engagement in mobility screening may provide a scalable and sustainable approach to reaching underserved older populations[39].

Limitations of the present study should be acknowledged. First, the small sample size and recruitment from a single province may limit the generalizability of the findings to broader older adult populations. Second, the cross-sectional design restricts conclusions regarding long-term reliability, responsiveness, and potential learning effects beyond the one-week test-retest interval. Third, participants were limited to sedentary, thus independently ambulatory, older adults. Therefore, the results

may not be applicable to more frail or highly active populations. Fourth, reliability was evaluated using a single trained VHV, which limits inference regarding variability across VHVs with differing levels of experience or training. In addition, manual stopwatch-based timing may be subject to minimal reaction time error, although this approach reflects real-world community practice. Participants were not formally blinded to prior test performance, which may have influenced effort during retesting. Finally, although testing conditions were standardized, environmental and psychosocial factors inherent to community settings were not formally measured or controlled. Future multicenter studies with larger samples, multiple VHVs, longer follow-up periods, and objective measurement systems are warranted.

Conclusion

The FTSST demonstrates high reliability in sedentary, community-dwelling older adults when administered by a trained VHV or a physical therapist. The FTSST may be suitable for use as a community-based functional screening tool to identify mobility limitations in older populations.

What is already known about this topic?

The FTSST is a simple and widely accepted tool for evaluating lower limb strength and balance in older adults. However, its reliability when performed by non-professional personnel such as VHVs in sedentary populations has not been well established, limiting its broader community application.

What does this study add?

This study confirms that with proper training, VHVs can administer the FTSST with excellent reliability in sedentary older adults. These findings highlight the test's potential for widespread use in community-based health monitoring, especially in resource-limited or rural settings.

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Authors' contributions

CK contributed to conceptualization, methodology, investigation, and writing-review & editing; AS contributed to conceptualization, methodology, investigation, supervision, data analysis, and writing-review & editing; BS contributed to investigation and writing-review & editing; PP and PA contributed to writing-original draft and writing-review & editing; TP contributed to investigation and writing-review & editing; and AI contributed to methodology, formal analysis, and investigation.

Ethics approval and consent to participate

The present study was approved by the Human Research Ethics Committee of the University of Phayao (approval code: HREC-UP-HSST 1.2/017/68).

Conflicts of interest

The authors declare no conflict of interest.

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