ORIGINAL ARTICLE

5-Repetition Sit-to-Stand Test in Subjects With Chronic Stroke: Reliability and Validity

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ABSTRACT. Mong Y, Teo TW, Ng SS. 5-repetition sit-to-stand test in subjects with chronic stroke: reliability and validity. Arch Phys Med Rehabil 2010;91:407-13.

Objectives: To examine the (1) intrarater, interrater, and test-retest reliability of the 5-repetition sit-to-stand test (5-repetition STS test) scores, (2) correlation of 5-repetition STS test scores with lower-limb muscle strength and balance performance, and (3) cut-off scores among the 3 groups of subjects: the young, the healthy elderly, and subjects with stroke.

Design: Cross-sectional study.

Setting: University-based rehabilitation center.

Participants: A convenience sample of 36 subjects: 12 subjects with chronic stroke, 12 healthy elderly subjects, and 12 young subjects.

Interventions: Not applicable.

Main Outcome Measures: 5-Repetition STS test time scores; hand-held dynamometer measurements of hip flexors, and knee flexors and extensors; ankle dorsiflexors and plantarflexors muscle strength; Berg Balance Scale (BBS); and limits of stability (LOS) test using dynamic posturography.

Results: Excellent intrarater reliability of intraclass correlation coefficient (ICC) (range, .970–.976), interrater reliability (ICC=.999), and test-retest reliability (ICC range, .989–.999) were found. Five-repetition STS test scores were also found to be significantly associated with the muscle strength of affected and unaffected knee flexors ($\rho=-.753$ to $-.830$; $P<.00556$) of the subjects with stroke. No significant associations were found between 5-repetition STS test and BBS and LOS tests in subjects with stroke. Cut-off scores of 12 seconds were found to be discriminatory between healthy elderly and subjects with stroke at a sensitivity of 83% and specificity of 75%.

Conclusions: The 5-repetition STS test is a reliable measurement tool that correlates with knee flexors muscle strength but not balance ability in subjects with stroke.

Key Words: Muscle strength; Rehabilitation; Stroke.

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THE SIT-TO-STAND TEST was initially introduced as an outcome measurement for functional lower limb muscle strength.[1] The 5-repetition STS test was first used as a physical performance measure to detect the associations with prediction of mortality and disabilities in frail elderly[2] as well as to differentiate older adults (age range, 63–90y) with and without balance dysfunction.[3] It was also used as an outcome measure for evaluating effectiveness of intervention in subjects having total hip and knee arthroplasty[4] and vibration therapy[5] and for cross-sectional correlation studies in subjects with osteoarthritis[6,7] and vestibular dysfunction.[8] The 5-repetition STS test has also been introduced as an outcome measure in studies investigating strength training and functional performance in subjects with chronic stroke,[9,10] as well as cross-sectional studies evaluating the association of disabilities and falls in population with stroke.[11,12] Despite the common use of the 5-repetition STS test, test-retest reliability (ICC range, .890–.960) was established in healthy older adults[13,14] and elderly with osteoarthritis (ICC=.960)[7] but not in subjects with stroke.

Besides lower limb muscle strength, balance capacity of subjects could also affect sit-to-stand performance.[13,15] From a sitting position, more horizontal momentum was required to shift the posterior-located center of mass to rise to a standing position,[16] which demanded relatively good balance control.[17] Stroke-specific lower limb muscle weakness[18-20] and balance impairments[21-23] could lead to poor sitting to standing performance; however, the relationship between 5-repetition STS test scores and balance performance was unclear.

The objectives of the present study were (1) to investigate the intrarater, interrater, and test-retest reliability of the 5-repetition STS test in subjects with chronic stroke; (2) to investigate the relationship between the 5-repetition STS test and BBS, lower limb muscle strength, and the measurements of LOS in subjects with stroke; and (3) to determine the sensitivity of the 5-repetition STS test in distinguishing differences in mobility among subjects with stroke, healthy elderly, and young subjects.

METHODS

Participants

An ICC value of .957 for the 5-repetition STS test was previously shown in healthy subjects[14]; thus, the ICC value for subjects with stroke was hypothesized to be .930. Therefore, to detect an ICC value of .930 at a significance level of .050 for test-retest reliability, a sample size of 12 subjects was required to achieve 93% power of 2 observations a subject.

List of Abbreviations	
AUC	area under the receiver operating characteristic curve
BBS	Berg Balance Scale
COP	center of pressure
ICC	intraclass correlation coefficient
LOS	limits of stability
MVL	movement velocity
MXE	maximum excursion
5-repetition STS test	5-repetition sit-to-stand test
RT	reaction time

Convenience sampling was used to recruit 36 subjects, with 12 subjects in each of the 3 subjects groups: stroke, healthy elderly, and young. Young subjects were recruited to determine the cut-off score of the 5-repetition STS test. All subjects had to be able to stand up independently from a chair without hand support.

Subjects with stroke were included if they were at least 1-year poststroke, were older than 50 years, were medically stable, were able to ambulate more than 10m unassisted with or without a walking aid, and had an Abbreviated Mental Test[24] score of more than 7. Exclusion criteria were the presence of any cerebellar involvement or other conditions that might affect muscle strength, balance, mobility status, or ability to follow instructions.

All subjects recruited in the healthy elderly and young groups had to be more than 50 years of age or between 21 and 35 years old, respectively. Subjects having any conditions that might affect the assessment protocol, such as uncontrolled diabetes mellitus, were excluded from the study.

All subjects were required to sign written informed consent forms before the commencement of the experimentation. Ethic approval for this study was obtained from the ethics committee of the local institution.

Outcome Measurements

5-repetition sit-to-stand test. The 5-repetition STS test measured the time taken to complete 5 repetitions of the sit-to-stand maneuver. All sit-to-stand maneuvers were performed from a chair without an arm rest at 43cm in height and 47.5cm in depth. All trials were videotaped with a videotaping device. The first 2 trials were for familiarization purposes, and the average of the next 3 trials was used for analysis. A 1-minute rest was given between trials to prevent fatigue. Standardized instructions were given as follows: "By the count of 3, please stand up and sit down as quickly as possible for 5 times. Place your hands on your lap and do not use them throughout the procedure. Lean your back against the chair's backrest at the end of every repetition." The timing started once the subject's back left the backrest and stopped once the back touched the backrest.

Muscle strength of lower limb. Lower-limb muscle strength was tested with a hand-held dynamometer. Good to excellent reliability (ICC range, .840–.990)[25,26] was reported for lower-limb hand-held dynamometer strength measurements in subjects with neurologic conditions. Isometric muscle strength of hip flexors, knee flexors and extensors, and ankle plantarflexors and dorsiflexors were tested bilaterally with standardized testing positions and dynamometer placement (table 1). Make tests were performed on all muscle groups tested. Subjects were secured on a high chair with safety belts to standardize the assessment positions. The first 2 trials were for familiarization purposes, and the mean reading of the last 3 trials were used for analysis. One to 2 minutes of rest was given between trials to prevent muscle fatigue. Subjects were instructed to "Push against my resistance as hard as you can."

Clinical balance performance: Berg Balance Scale. The BBS was used to assess subjects' ability to maintain stability.[27] Excellent reliability of the BBS (ICC range, .980–.990)[28,29] was found in patients with acute[28] and chronic stroke.[29] The BBS involves 14 tasks; each has a score between 0 and 4, adding up to a total score of 56.

Laboratory balance performance: limits of stability test. LOS was assessed by dynamic posturography (Balance Master[a]), which measures the displacement of the COP during voluntary movement in a designated direction without instability.[30] A previous study demonstrated moderate reliability (ICC range, .840–.880) in subjects with chronic stroke.[29]

Table 1: Muscle Strength Testing Position and Dynamometer Placement

Muscle Group Tested	Testing Position	Dynamometer Placement
Hip flexors	High sitting Hip: 90° flexion Knee: 90° flexion Ankle: neutral	On anterior aspect of femur, 5cm proximal to superior border of patella
Knee flexors	High sitting Hip: 90° flexion Knee: 90° flexion Ankle: neutral	On posterior aspect of tibia, 5cm proximal from inferior tip of medial malleoli
Knee extensors	High sitting Hip: 90° flexion Knee: 90° flexion Ankle: neutral	On anterior aspect of tibia, 5cm proximal from inferior tip of medial malleoli
Ankle dorsiflexors	High sitting Hip: 90° flexion Knee: full extension Ankle: neutral	On ventral aspect of foot, across 1st to 5th metatarsophalangeal joints
Ankle plantarflexors	High sitting Hip: 90° flexion Knee: full extension Ankle: neutral	On dorsum aspect of foot, across 1st to 5th metatarsophalangeal joints

Three parameters of LOS were measured:
1. RT, measured in seconds, refers to the time between the appearance of the signal for movement and the initiation of the first movement.[30]
2. MVL, measured in degrees a second, is defined as the average speed of COP displacement during the first movement toward the given target.[30]
3. MXE, expressed as the percentage of the target distance being tested, refers to the maximal displacement of COP during the entire LOS testing for each target.[30]

Subjects were instructed to "Begin each trial with the cursor in the middle box. On hearing a 'Ding,' move the cursors as fast and as accurately as possible into the box where the circle appeared. Shift your body weight to control the position and direction of the cursors. Maintain your balance and keep your feet firmly on the platform throughout the assessment."

Procedures

Five trials of the 5-repetition STS test were measured simultaneously by the 2 examiners with 3 years of clinical experience. These trials were videotaped and shown to 3 physiotherapists with 3 to 7 years of clinical experience and 3 tertiary students without a medical or health care background. Procedures for data collection of intrarater, interrater, and test-retest reliability are illustrated in figure 1. The BBS, muscle strength, and dynamic posturography measurements of LOS were tested in random order by either examiner A or examiner B.

Statistical Analysis

Data analysis was done with SPSS version 17.0.[b] The Kolmogorov-Smirnov test and F test were used to assess the normal distribution and equal variance of the test score. Descriptive statistics were used for sociodemographic characteristics evaluation. Differences between the mean test score across the 3 groups were calculated by 1-way analysis of variance. ICC was used to calculate the degree of intrarater ($ICC_{3,1}$), interrater ($ICC_{3,2}$), and test-retest reliability ($ICC_{2,1}$). The relationship between the 5-repetition STS test score and