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Original Article

The sitting and rising test for assessing people with chronic stroke

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Abstract. [Purpose] To investigate the inter-rater and test-retest reliability of the sitting-rising test (SRT), the correlations of sitting-rising test scores with measures of strength, balance, community integration and quality of life, as well as the cut-off score which best discriminates people with chronic stroke from healthy older adults were investigated. [Subjects and Methods] Subjects with chronic stroke (n=30) and healthy older adults (n=30) were recruited. The study had a cross-sectional design, and was carried out in a university rehabilitation laboratory. Sitting-rising test performance was scored on two occasions. Other measurements included ankle dorsiflexor and plantarflexor strength, the Fugl-Meyer assessment, the Berg Balance Scale, the timed up and go test, the five times sit-to-stand test, the limits of stability test, and measures of quality of health and community integration. [Results] Sitting-rising test scores demonstrated good to excellent inter-rater and test-retest reliabilities (ICC=0.679 to 0.967). Sitting-rising test scores correlated significantly with ankle strength, but not with other test results. The sitting-rising test showed good sensitivity and specificity. A cut-off score of 7.8 best distinguished healthy older adults from stroke subjects. [Conclusions] The sitting-rising test is a reliable and sensitive test for assessing the quality of sitting and rising movements. Further studies with a larger sample are required to investigate the test's validity.

Key words: Outcomes, Stroke, Rehabilitation

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INTRODUCTION

Sitting and rising from the floor is a basic functional task which requires appropriate levels of muscle strength, joint coordination, balance and flexibility. After stroke, decreased muscle strength, impaired postural control and asymmetrical limb loading may cause functional decline, and affect activities such as rising from a sitting position[1)]. Previous studies have reported that people with stroke are two times more prone to falls than older adults in general[2)]. People with stroke often experience difficulty in rising from the floor after falling[3)], and morbidity may result from being unable to rise from the floor[4)]. Thus, the ability to get up from the floor is especially vital for patients with stroke.

The sitting-rising test (SRT) is a simple test which was developed to evaluate the ability to sit and rise from the floor[5, 6)]. The SRT objectively quantifies the number of supports (ie, hand or knee) needed and the presence or absence of stability in the actions[5)]. The maximum score is 10, and points are deducted for additional hand support or loss of balance. SRT scores

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have been shown to have high reliability in assessing healthy subjects[5, 6]. Therefore, the SRT is also a potentially useful test for assessing the ability of sitting and rising from the floor of people with chronic stroke.

Although the SRT may be useful for assessing chronic stroke patients, evidence for its reliability and validity in chronic stroke cases is still lacking. It is not known whether SRT can reflect the impairment, activity and participation levels of people with chronic stroke. Therefore, this study was designed to investigate the inter-rater and test-retest reliabilities of SRT scores, the correlation of SRT scores with measures of muscle strength, balance, functional mobility, community integration and quality of life, and the cut-off score which best differentiates healthy subjects from people with chronic stroke.

SUBJECTS AND METHODS

This study had a cross-sectional design. A sample size calculation showed that a total of 29 subjects could deliver 80% power of detecting an intra-class correlation coefficient (ICC) of 0.8 under the alternative hypothesis, and an ICC of 0.6 under the null hypothesis with 0.05 as the significance level.

Thirty people with chronic stroke (23 males, 7 females; mean age 61.7 years, SD 6.1 years; mean post-stroke duration 7.9 years, SD 3.1 years) were recruited from a local stroke self-help organization. The inclusion criteria were: a single stroke more than 12 months previously; a score of 7 or higher in the Abbreviated Mental Test (AMT); and a medical condition suitable for the research. Subjects with other neurological conditions such as spinal cord injury or Parkinson's disease, or other limiting disabilities such as arthritis or cataract were excluded.

Thirty healthy older adults (11 males, 19 females; mean age 64.2 years, SD 7.3 years) were recruited at a local community centre via a poster advertisement.

All study protocols were approved by the ethics committee of the Hong Kong Polytechnic University and met the guidelines of the Declaration of Helsinki. Prior to the test, the purpose and procedures of the study were explained to all eligible subjects, and all gave their written consent to participation in the study.

Each subject with stroke was assessed by 2 independent assessors (assessor A and assessor B) for the analysis of the inter-rater reliability. The stroke subjects were also required to attend another assessment session 7 days after the first session (Day 1 and 2) for the determination of the test-retest reliability. Figure 1 illustrates the data collection procedures. The healthy older adults performed the SRT only once and their data was used to determine the cut off score.

Apart from the SRT, the subjects with stroke were also required to complete ankle plantarflexor (PF) and dorsiflexor (DF) muscle strength tests, the Fugl-Meyer assessment for the lower limbs (FMA-LL), the Berg Balance Scale (BBS) test, the timed up and go test (TUG), the five times sit-to-stand test (FTSTS), and the limits of stability test (LOS), as well as complete the community integration measure (CIM), and the short-form 12 health survey (SF-12). The testing order was randomized by drawing lots, and 2-minute rests were given between each test to reduce fatigue.

The SRT evaluates musculoskeletal fitness[6] and ability to sit and rise from the floor. It was conducted on a flat and non-slippery surface. To ensure a clear view, the assessors stood in front of the subjects to score. Prior to the test, the assessors gave the following instruction: "Without worrying about the speed of movement, try to sit and then to rise from the floor, using the minimum support that you believe is needed[6]."

The sitting and rising maneuvers have maximum scores of 5 points, respectively, with a maximum possible total of 10 points. The highest sitting and rising scores were added to obtain the total SRT score. One point was deducted for placing a hand, forearm, knee, or the side of the leg on the floor for support, or if the participant put his/her hand on the knee to facilitate rising or sitting. Half a point was deducted if the evaluator perceived partial loss of balance at any time during the maneuver. Crossing the legs during the test was allowed, but the participants were told not to use the side of feet for support. Each subject repeated the test twice in each session, once in front of each examiner[5, 6].

Ankle strength was measured using a hand-held dynamometer. In supine lying, the subjects were asked to press maximally on the dynamometer using their ankles in dorsiflexion and plantarflexion. Each ankle was assessed three times and the average value was calculated. Good to excellent reliability has been reported for this procedure (ICC=0.840–0.990)[7].

The FMA-LL was used to assess synergy, reflexes and coordination of the lower limbs[8]. The assessment consists of 17 items, which are scored on a 3-point ordinal scale (0=cannot perform, 1=can partially perform, 2=can fully perform), with a maximum score of 34 points. A high score indicates low severity of motor impairments. The FMA-LL has excellent inter-rater reliability for subjects with chronic stroke (ICC=0.93)[9, 10].

The BBS is a clinical measure of functional balance performance[5]. It consists of 14 subtests with a maximum score of 56[11]. It has high inter-rater and intra-rater reliabilities (ICC=0.98–0.99) for people with stroke[12].

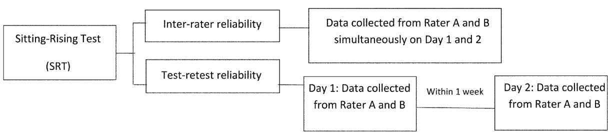

Fig. 1. Flow chart showing the data collection procedures

The FTSTS was used to quantify the functional muscle strength of the lower limbs. The time in seconds required to complete 5 full stands from a sitting position was recorded. The test has excellent reliability (ICC=0.970–0.999)[7].

The TUG test measures functional mobility[13]. Subjects rise from a chair and walk along a 3-metre path as fast as possible. The time needed to complete the test is recorded[13]. This test has excellent reliability for stroke patients (ICC= 0.96)[14]. The mean of 3 trials was use for the analysis in this study.

A SMART Balance Master® system was used to quantify the maximum distance that each subject could shift their center of gravity (COG) without losing balance. Reaction time (RT), movement velocity (MVL) and maximum excursion (MXE) were measured. RT refers to the time between the appearance of the movement signal and the first initiation of movement. MVL is the average speed of COG displacement from the first movement to attaining the target. MXE is the maximum displacement of the COG expressed as a percentage of the distance to the target. The LOS test has good test-retest reliability (ICC=0.78–0.91) for patients with stroke[15, 16].

The CIM assesses integration into community life. The 10 items are scored using a five-point scale and summed, giving scores from 10 to 50. The CIM has been shown to have good internal consistency (Cronbach's alpha = 0.87)[17].

The SF-12 was used to assess health-related quality of life[18]. It has 12 items asking about physical and mental health. Subjects with better health obtain higher scores. The SF-12 has good test-retest reliability for both its physical (ICC=0.88) and mental (ICC=0.92) components[19].

Data analysis was performed using version 21 of the SPSS software. Descriptive statistics were compiled describing the characteristics of the stroke survivors and the controls. Pearson or Spearman correlation coefficients, depending on the normality of the data, were calculated to examine the significance of relationships between the SRT scores and the other outcome measures. Intra-class correlation coefficients, $ICC_{2,2}$ and $ICC_{3,2}$, were used to quantify the inter-rater reliability and test-retest reliability respectively. Model 2 ICC considers both the assessors and the subjects as random effects, while model 3 ICC considers only one of them as random[20].

Receiver operating characteristic (ROC) curves were plotted to determine the cut-off SRT score which best distinguished between the healthy controls and the subjects with chronic stroke. True-positive and false-positive probabilities are indicated by the sensitivity and specificity, respectively. A trade-off between 1 minus specificity and sensitivity is indicated by Youden's index, which was used to determine the optimal cut-off score. The area under the ROC curve (AUC) measures the accuracy of the cut-off score quantitatively based on the null hypothesis of AUC=0.5[20].

Table 1. Descriptive statistics of the subjects with stroke and healthy older adults

	Subjects with stroke (n=30)	Healthy older adults (n=30)
Gender, n (%)		
Male	23 (76.7)	11 (36.7)
Female	7 (23.3)	19 (63.3)
Age, years, mean (SD)	61.7 (6.1)	64.2 (7.3)
Height, cm, mean (SD)	165.5 (7.11)	161.3 (9.53)
Weight, kg, mean (SD)	68.3 (9.03)	58.0 (10.42)
BMI, kg/m^2, mean (SD)	24.9 (2.77)	22.3 (3.55)
Post stroke duration, years, mean (SD)	7.94 (3.06)	N/A
Affected side, n (%)		
Left	18 (60)	N/A
Right	12 (40)	
Nature of stroke, n (%)		
Ischemic	22 (73.3)	N/A
Hemorrhagic	8 (26.7)	
Number of falls in the past 6 months, mean (SD)	0.13 (0.35)	0.13 (0.43)
Mobility status, n (%)		
Unaided	18 (60)	30 (100)
Stick	12 (40)	0
AMT total score, mean (SD)	9.63 (0.62)	N/A
SRT score, mean (SD)		
Sitting score	3.32 (0.84)	4.4 (0.52)
Rising score	2.99 (0.95)	4.23 (0.68)
Total score	6.30 (1.66)	8.63 (1.09)

SD: standard deviation; BMI: Body mass index; AMT: Abbreviated Mental Test; SRT: sitting-rising test; N/A: not available

RESULTS

The descriptive statistics describing the characteristics of the subjects are presented in Table 1. The mean values for the outcome measures are presented in Table 2. Table 3 shows that the inter-rater reliability was excellent (ICC=0.872–0.967), and the test-retest reliability was good (ICC=0.679–0.863). The test-retest reliability for the rising score of rater A was slightly lower than that of rater B (ICC=0.679).

Table 4 shows the correlations between SRT scores and the other outcome measures. Since all the variables were normally distributed, Pearson correlation coefficients were used. Among the stroke subjects, SRT rising scores correlated significantly with both DF and PF strength of the ankle on the affected side. The SRT total score also correlated significantly with ankle PF strength on the affected side. Both sitting and rising scores only demonstrated significant correlation with maximal velocity

Table 2. Mean values of all the outcome measures of the subjects with stroke

Outcome measure			
SRT score, mean (SD) (Full sitting score: 5; Full rising score: 5; Full total score: 10)	Sitting score	Rising score	Total score
Day 1 rater A	3.37 (0.87)	3.12 (0.90)	6.48 (1.71)
Day 1 rater B	3.35 (0.79)	2.82 (1.01)	6.17 (1.70)
Day 2 rater A	3.28 (0.87)	3.07 (0.92)	6.35 (1.58)
Day 2 rater B	3.27 (0.86)	2.95 (0.98)	6.22 (1.72)
Muscle strength of lower limb, kg, mean (SD)			
Ankle DF (affected side)		9.29 (4.74)	
Ankle PF (affected side)		9.87 (6.85)	
Ankle DF (unaffected side)		14.09 (3.64)	
Ankle PF (unaffected side)		13.80 (5.86)	
FMA-LL score, median (IQR) (full score: 34)		26.5 (6.25)	
BBS score, median (IQR) (full score: 56)		54 (2.25)	
TUG time, s, mean (SD)		15.80 (5.16)	
FTSTS time, s, mean (SD)		19.78 (6.78)	
LOS RT, s, mean (SD)			
Forward		1.32 (0.60)	
Backward		1.09 (0.65)	
Unaffected side		1.13 (0.45)	
Affected side		1.20 (0.71)	
LOS MVL, m/s, mean (SD)			
Forward		2.29 (1.42)	
Backward		2.63 (1.34)	
Unaffected side		4.16 (1.98)	
Affected side		3.85 (1.96)	
LOS MXE, %, mean (SD)			
Forward		58.17 (13.90)	
Backward		54.40 (17.76)	
Unaffected side		78.77 (12.50)	
Affected side		74.23 (16.63)	
CIM score, median (IQR) (full score: 50)		46 (10.25)	
SF-12 (PCS), median (IQR) (full score: 100)		43.5 (14)	
SF-12 (MCS), median (IQR) (full score: 100)		51 (18.25)	

SRT: Sitting-Rising Test; TUG: Timed Up and Go test; FTSTS: Five Times Sit-to-Stand test; BBS: Berg Balance Scale; FMA-LL: Fugl-Meyer Assessment (Lower extremity); LOS: limit of stability; RT: reaction time; MVL: movement velocity; MXE: maximal excursion; DF: dorsiflexion; PF: plantar flexion; CIM: Community Integration Measure; SF-12: The 12-Item Short Form Health Survey; PCS: physical component score; MCS: mental component score; SD: standard deviation; IQR: inter-quartile range

Table 3. Reliability of the SRT scores of the subjects with stroke

Reliability	Rater	Day	Score	ICC (95% CI)
Inter-rater reliability ICC (2,2)	A, B	1	Sitting	0.965 (0.926–0.983)
			Rising	0.932 (0.856–0.967)
			Total	0.967 (0.931–0.984)
		2	Sitting	0.967 (0.931–0.984)
			Rising	0.872 (0.730–0.939)
			Total	0.950 (0.895–0.976)
Test-retest reliability ICC (3,2)	A	1–2	Sitting	0.863 (0.713–0.935)
			Rising	0.679 (0.326–0.847)
			Total	0.846 (0.675–0.926)
	B		Sitting	0.837 (0.658–0.923)
			Rising	0.815 (0.610–0.912)
			Total	0.858 (0.702–0.933)

SRT: Sitting-Rising Test; ICC: intra-class correlation coefficient; 95% CI: 95% confidence interval; SD: standard deviation

Table 4. Correlations between the SRT scores and the other outcome measures (n=30)

Outcome measures	Sitting score	Rising score	Total score
	Pearson's r	Pearson's r	Pearson's r
Muscle strength of lower limb			
Ankle DF affected side Ave	0.301	0.455*	0.392*
Ankle DF affected side Peak	0.278	0.449*	0.377*
Ankle PF affected side Ave	0.187	0.376*	0.289
Ankle PF affected side Peak	0.214	0.38*	0.308
FMA-LL	0.252	0.28	0.28
BBS Total	0.156	0.229	0.2
FTSTS Ave	0.249	0.013	0.133
TUG Ave	0.055	−0.129	−0.04
LOS forward			
RT	0.007	0.057	0.034
MVL	−0.108	−0.111	0.065
MXE	0.051	0.06	−0.094
LOS unaffected side			
RT	−0.157	−0.13	−0.384*
MVL	−0.416*	−0.404*	−0.049
MXE	−0.049	0.032	−0.008
LOS backward			
RT	0.128	0.138	0.138
MVL	−0.102	−0.071	−0.089
MXE	−0.204	0.001	−0.103
LOS affected side			
RT	0.105	−0.035	0.035
MVL	−0.094	−0.11	−0.106
MXE	0.012	0.079	0.047
CIM	−0.327	−0.303	−0.325
SF-12 (PCS)	−0.02	0.02	0.001
SF-12 (MCS)	−0.287	−0.28	−0.293

*Significant at the 5% level of confidence.
FMA-LL: Fugl-Meyer motor assessment for the lower limbs; FTSTS: Five Times Sit-To-Stand Test; BBS: Berg Balance Scale; TUG: Timed Up and Go Test; LOS: limit of stability; DF: dorsiflexion; PF: plantar flexion; RT: reaction time; MVL: movement velocity; MXE: maximal excursion; Ave: average; CIM: Community Integration Measure; SF-12: The 12-Item Short Form Health Survey; PCS: physical component score; MCS: mental component score

toward the unaffected side in the LOS test. However SRT scores did not correlate significantly with FMA-LL scores, BBS scores, FTSTS times, TUG times, other LOS measures, CIM scores or SF-12 scores.

A total SRT score of 7.8 was found to best differentiate healthy controls and subjects with stroke with high levels of stroke-specific impairments (both sensitivity and specificity 80.0%; AUC=0.89; $p \leq 0.0001$). A cut-off score of 3.9 for either component was also found to differentiate well between both groups (sitting score: sensitivity 90.0%, specificity 66.7%, AUC = 0.87, $p \leq 0.0001$); rising score: both sensitivity and specificity 80.0%, AUC=0.86, $p \leq 0.0001$).

DISCUSSION

Our subjects showed the expected decline in SRT score with age[9)]. According to a previous study, subjects 71 years old (± 7.0) normally have SRT scores of 0 to 3, while those 59 years old (± 6.3) typically score 8 to 10 points[6)]. The mean age of subjects was about 57 for scores lower than 7.5, and about 44 for scores below 9[6)]. Older adults are likely to use hand support to overcome problems such as muscle weakness and poor balance. This is expected, as physical function[21)], muscle strength[22, 23)], and postural stability[24)] decline with age. Adopting such compensatory techniques results in lower SRT scores.

The subjects with chronic stroke studied here had a mean age of 61.73 and a mean SRT score of 6.2. Subjects with a mean age of 61 had mean SRT scores of 7.5–8 in a previous study[6)]. The difference between these results presumably reflects the impaired motor control and balance of the chronic stroke subjects. Residual brain lesions affect the activation of motor neurons, reducing their mean discharge rate[25)]. The recruitment threshold and range would also be reduced. Poor balance and motor control may affect performance in the SRT[26)].

This is the first study to have examined the reliability of the SRT in assessing subjects with chronic stroke. The inter-rater and test-retest reliabilities were both high, indicating that the test is reliable for assessing the quality of movement in sitting and rising from the floor. This probably results from the test's simple, clear design which allows the assessor to follow the performance with ease. Also, all instructions and procedures were standardized. A week was given to minimize fatigue and learning effects and to ensure true performance. However, a slightly lower test-retest reliability was found for the rising score of rater A. Since the test-retest reliability for all the other conditions was high, it is likely that this was caused by a random error during the assessment.

The rising scores significantly correlated with the strength of the ankle dorsiflexors and plantarflexors ($r = 0.376$ and 0.455 respectively). When standing up, the ankle plantarflexors work concentrically while the dorsiflexors contract eccentrically[27)]. Excellent ankle strength is required to stand from sitting on the floor without using the hands and without swaying or losing balance[1)].

It is surprising that there was no significant correlation between the SRT scores and FMA scores, since the FMA assesses motor control of the lower limbs. A possible reason for the absence of correlation is that the SRT involves closed-chain actions with the feet on the ground, while the FMA involves open-chain actions in lying or sitting. Also, the SRT involves complex movements while the FMA uses simple movements only[28)].

It was rather unexpected that TUG times and FTSTS times did not correlate with the SRT scores, since both tests involve sitting and rising. A possible explanation for this is that the TUG and FTSTS tests use time as the performance measure while the SRT assesses the quality of movement. Furthermore, TUG times[29)] and FTSTS times[30)] correlate significantly with balance, while the SRT may not demand good balance.

It was also surprising that BBS scores did not correlate with SRT scores, because some of the tasks involved are similar. BBS item (1) is a sit-to-stand maneuver, and item (4) is sitting from standing. However, some of the BBS tasks take time into account, while SRT only measures the quality of movement. BBS also includes other items assessing balance in activities such as turning and reaching which would dilute any relationship. The lack of a significant correlation again suggests that perhaps subjects do not actually need good balance to achieve high SRT scores.

It was expected that there would be no significant correlation between SRT scores and the LOS results. The LOS test includes reaction time, speed and maximal excursion, none of which clearly relate to movement quality in rising from the floor. The two tests measure quite different actions.

The SRT scores did not correlate with either the SF-12 or CIM scores. This is not unexpected, as rising from the floor is not closely related to the whole picture of a person's quality of life or their community integration as measured by the SF-12 and CIM, respectively.

A test with high sensitivity and specificity has better discriminatory ability. This study is the first to have investigated the optimal cut-off score to distinguish healthy older adults from people with chronic stroke. A cut-off SRT total score of 7.8 was found to best differentiate the healthy subjects from subjects with more severe stroke-specific impairments. The AUC of 89.3% indicates the probability of correctly identifying subjects suffering from stroke-specific or related impairments using the SRT.

The SRT mainly examines the quality of movement and degree of using hand support in sitting and rising movements, but the other outcome measures chosen for examining correlations with SRT only examine factors potentially affecting mobility, such as muscle strength and balance. Speed is also often a chosen outcome measure, while the speed of completing the sitting-rising movement is not considered in the SRT. Speed may be a factor affecting the performance of daily activities by people with chronic stroke.

The sample size may have been insufficient to detect significant correlations between SRT scores and the other outcome measures. It was calculated based solely on the reliability assessment. The majority of the stroke subjects were males, which presumably created a gender bias. Gender may predict muscle strength[31)] and functional task performance[32)], and both would be expected to affect SRT performance. Furthermore, all the stroke subjects were recruited from a stroke self-help organization, which may have reduced the generalizability of the results. The stroke subjects generally had better mobility than the average stroke survivor, indicating that their SRT performance might also be untypical. Future studies should recruit a more diverse stroke group with a larger sample size and better gender balance to enable generalization of the results to the overall stroke population.

Finally, the cut-off score established was merely a distinction between healthy older adults and subjects with severe stroke-related impairments. It did not reflect the difference in SRT performance in relation to stroke severity, which would presumably be the test's clinical implication. These differences need further exploration. Intra-rater reliability was also not examined. Future studies are warranted to further expand the knowledge of how the SRT can best be applied in clinical practice.

The SRT is recommended for assessing people with chronic stroke in clinical practice as it is a simple and reliable test which assesses the ability to sit and rise from the floor. It has good inter-rater and test-retest reliability, as well as good sensitivity and specificity. A cut-off score of 7.8 can adequately differentiate healthy elderly subjects from those with more severe stroke-related impairments. SRT scores correlate significantly with ankle strength. Studies with larger sample sizes and subjects with different mobility levels are warranted to further define the test's applicability.

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