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Reliability and validity of the sit-and-side reach test for assessing trunk function of stroke patients.

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The aims of the present study were to establish the test-retest reliability of the sit-and-side reach test (SSRT) and to determine the validity of the SSRT to assess trunk function of stroke patients. Study 1 consisted of repeating the SSRT to examine its test-retest reliability within session and interrater reliability. Study 2 consisted of measuring the SSRT and the Trunk Impairment Scale (TIS), the Trunk Control Test (TCT) and the Barthel Index (BI) to examine validity. Forty-four subjects with stroke (study 1, n = 23; study 2, n = 21) were recruited from inpatient rehabilitation hospital. Study 1, two raters independently measured SSRT. Study 2, SSRT was measured along with the TIS, the TCT and BI. The test-retest reliability within session and interrater reliability were excellent, with intraclass correlation coefficient of 0.97 and 0.94, respectively. Since distance reached on the SSRT correlated with the TIS (ρ=0.71,$p<0.001$), the TCT (ρ=0.6, p=0.003) and the BI (ρ=0.73, $p<0.001$), concurrent validity was acceptable. The SSRT is a reliable and useful clinical tool for assessing trunk function of stroke patients.

Key Words
Trunk function, stroke, sit-and-side reach test

Introduction

Stroke is the most common cause of disability or dependence in activities of daily living (ADL) among the elderly.[1)] Reducing the degree of dependence in ADL is often a central aim of rehabilitation programs and other related interventions for patients who have suffered a stroke. There is evidence that optimal management in stroke care results in reduced length of stay, reduced dependency, and earlier restoration of some aspects of physical function.[2)] However, care of stroke patients varies significantly between hospitals.[3)] A simple outcome measure that is sensitive to physical recovery profiles in stroke rehabilitation, is easy to use in various clinical environments, and which could be widely adopted, might provide an appropriate tool in the therapeutic setting for evaluating and optimizing physical outcome after stroke.

Trunk control is a crucial component to perform ADL.[4)] Trunk performance after stroke is evaluated in various ways. Methodological approaches used in previous studies included isokinetic muscle testing,[5,6)] manual dynamometry,[7,8)] electromyographic analysis,[9-11)] transcranial magnetic stimulation,[12)] computed tomography,[13)] and movement analysis.[14)] These approaches need to use expensive equipment to assess trunk per-

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formance. Clinical scales that have been used to evaluate trunk performance are necessary for the practice. Standardized clinical assessment tools are a prerequisite for scientific research and clinical practice. Clinical tools used to evaluate trunk performance have evolved over time. Originally, single items on an ordinal scale were used. Wade et al. presented a 3-point ordinal item, a lower score indicated a better performance.[15] However psychometric characteristics of this ordinal scale were not reported. The other scale for assessing trunk performance is the sitting balance scale. The sitting balance scale for hemiplegia evaluated normal sitting, sitting with the legs crossed, leaning sideways to both sides and leaning forwards.[16] Two- or 3-point ordinal scales were used to evaluate whether or not the patient can keep balance during different tasks, a higher score indicating a better performance. Quality of posture or movement is also scored for each task. Nieuwboer et al. examined the reliability of this instrument in 27 stroke patients at different stages of recovery. Four of the five items evaluating quality of movement had kappa values between 0.20 and 0.36, which were found insufficient to establish reliability.

There are several examples of scales where trunk performance is included as part of a total assessment. These include the Rivermead Motor Assessment,[17] the Motor Assessment Scale,[18] the Chedoke McMaster Stroke Assessment[19] and the Stroke Impairment Assessemnt Set.[20] These scales are easy to use in clinical setting. However these scales have some limits which is a ceiling effect or insufficient reliability.[21]

The Trunk Control Test (TCT) was the first specific clinical tool reported in the literature which evaluated motor performance of the trunk.[22] The test consists of four items which are assessed on 3-point ordinal scale. The scoring is as follows: 0, unable to perform movement without assistance; 12, able to perform movement but in an abnormal manner; 25, able to complete movement normally. The items are rolling from supine to the weak and strong side, sitting up from lying down and maintaining balance in the sitting position on the side of the bed. The total score for the TCT ranges from minimum 0 to maximum 100 points, a higher score indicating a better performance. The TCT became a well-established assessment tool, but at the same time several shortcomings were reported in the literature. The TCT does not take quality of movement into account.[22] Furthermore Bohannon found low correlation coefficients from 0.23 to 0.50 between TCT scores and trunk musculature measurements by means of a hand dynamometer.[8] The most limiting aspect of the TCT is its ceiling effect. Several studies have pointed out that during rehabilitation a high percentage of stroke patients obtained the maximal score.

The Trunk Impairment Scale (TIS) which was presented by Verheyden et al.[23] is available today. This scale comprises 17 items and evaluates static and dynamic sitting balance and trunk co-ordination. The items of the TIS are scored on 2-, 3- or 4-point ordinal scale. The total score ranges from minimum 0 to maximum 23 points, a higher score indicating a better performance. Test-retest and interrater measurement error, internal consistency, content, construct and concurrent validity were also established. In the TIS, quality of movement is taken into account by observing whether or not the task is performed with trick motions. Furthermore the TIS has no ceiling effect.[24] However the TIS is an ordinal scale, and lacks quantitative evaluation.

Another measurement is Sit-and-Reach test (SRT) that is measuring sitting balance. To achieve balance in sitting need trunk control to keep center of gravity in the base of support. Dean et al. reported that a forward-reach distance in sitting was positively associated with the magnitude of trunk and upper-arm segmental motion, as well as the active contribution of the lower limbs in healthy persons.[25,26] Therefore, reaching forward in sitting is a challenge to a person' s postural control; hence, it is suggested to be an indicator of sitting balance. Tsang et al. showed that the SRT was a significant predictor of mobility at discharge from a rehabilitation program.

Also they showed that the intrarater reliability of the SRT was marked by an excellent intraclass correlation coefficient(ICC) of .98.[27] Katz-Leurer et al. also showed significant reliability of sitting forward reach distance (ICC=.94) and side reach distance (ICC=.90).[28] When someone tries to reach side direction, trunk control is more needed than forward reach. However SRT was likely to used for measuring sitting balance in previous studies. We thought that sit-and-side reach distance temporarily evaluate trunk control function.

The purposes of our study were to standardize procedures of the sit-and-side reach test (SSRT), to establish its test-retest reliability within session and interrater reliability in patients with stroke and to investigate whether SSRT can evaluate the trunk function.

Methods

Two related studies were performed. Study 1 established the test-retest reliability within session and interrator reliability of the SSRT. Study 2 evaluated the concurrent validity of SSRT. Patients after a first stroke were recruited from the inpatient rehabilitation department.

Participants

Patients with stroke who were transferred to rehabilitation hospital were recruited for the studies. The inclusion criteria were (1) hemiparesis secondary to first stroke; (2) medically stable for rehabilitation; (3) ability to sit unsupported for 1 minute to allow performance of the SSRT. The exclusion criteria were (1) preexisting neurologic disorders, such as Parkinson's disease, which could cause motor deficits; (2) the nonparetic upper limb with shoulder abduction less than 110 °, which could affect performance on the SSRT. During the study, participants received the same medical and rehabilitation management as other patients. Interventions included physical therapy, occupational therapy and speech therapy.

Forty-four subjects with stroke (study 1, n = 23; study 2, n = 21) were recruited from inpatient rehabilitation hospital. Subjects were at sub-acute or chronic phase of stroke (weeks since onset; 37.2±23.4). This study was approved by the ethics committees of the hospital, and all participants provided signed informed consent.

Measures

Each participant was evaluated for the SSRT, trunk performance, ADL, motor function, muscle strength and gait function.

SSRT

The SSRT was modification of the Functional Reach Test which was developed by Duncan[29] and assesses limits of stability by measuring the maximum distance an individual can reach forward while standing in a fixed position. Performance on the SSRT was measured using slide bar which was set the level of the subject's acromial process of the nonparetic upper limb while he/she was sitting on an 40cm high plinth. The Subject was sit with feet positioned flat on the floor and abduct shoulder 90°. Then the subject was instructed to touch the tip of the slid bar with the tip of third finger of nonparetic hand and to push it as far as possible without trunk rotation and without leave the nonparetic foot from floor (Figure). Each subject practiced twice before performing the 3 test trials of the SSRT. The each value and mean value of the 3 test trials was used for analysis.

Trunk performance

The TCT and the TIS was measured by one of the two investigators. The SSRT, the TCT and the TIS were measured at same day. Investigators practiced to measure the TCT and the TIS, before study session was start.

ADL

ADL were measured with the Barthel Index (BI). The scoring range of the BI is between 0 to 100 points, a higher score indicating a greater independence in ADL.

Motor function

The severity of lower limb paresis was measured with the use of the Fugl-Meyer motor test (FM)[30]. Each item of the FM is graded on 3-point scale (from 0 to 2). The FM is known to be a reliable and valid measure of motor impairment for stroke patients.[31]

Muscle strength

Muscle strength of lower limb was measured on knee extension with the Hand Held Dynamometer. Each participant was sat on the chair with knee flexed 90°and measured at their isometric knee extension strength. Muscle strength was measured 2 times on each limb, and average value was used to further analysis.

Gait function

Each participant was graded on the Functional Ambulation Category (FAC) to evaluate the level of dependency during walking. The grades range from 0 (requiring continuous support from two people) to 5 (being able to walk in- and outdoor with out supervision). Reliability for the FAC scores has been reported in the literature.[32]

Procedures

In study 1, two investigators who were physical therapists with more than 3 years of practice experience measured the SSRT about each subject. For test-retest reliability within session, the investigators independently measured the SSRT. For interrater reliability, one of the investigators measured the SSRT, the consecutive day the other investigator measured the SSRT again. Study 2 measured the SSRT, the TCT, the TIS and the BI at the same day.

Statistical Analysis

The test-retest reliability of the SSRT was studied using the intraclass correlation coefficient ($ICC_{1,1}$) and standard error of measurement (SEM). Within-session reliability tested the stability of value of the SSRT within a single testing session. Tests were repeated three times in one session. Intrarater reliability tested the stability of the values on two separate occasions and two different investigators. To compare the SSRT with the TIS, the TCT and the BI, Spearman's rank correlation coefficient were calculated. And also the SSRT was compared with FAC, FM score and muscle strength. P values of $<.05$ were considered to indicate statistical significance.

Results

Initially total 23 subjects were recruited in study 1. Investigator A measured the SSRT on 21 subjects (10 female, 11men) and B on 22 (9 female, 13men). Three subjects could not measure

Table 1: Characteristics of participants

	Study 1 (n=23)		Study 2 (n=21)	
	Mean ± SD	Range	Mean ± SD	Range
Age (y)	69.2 ± 16.5	26 - 91	70.5 ± 10.8	44 - 85
Gender				
Male	13		8	
Female	10		13	
Diagnosis				
Infarction	16		6	
Hemorrhage	7		15	
Paretic side				
L hemiplegia	15		10	
R hemiplegia	8		11	
Weeks since onset	46	12 - 108	26	4 - 75

the SSRT twice, because their schedule did not give time to measure. Therefore 20 subjects out of these 23 (9 female, 11men) were measured the SSRT by both investigators. Twenty-one subjects (13 female, 8 men) were recruited for study 2. (Table 1)

Test-retest reliability within session and interrater reliability

The SSRT had a good response stability. The ICC value for test-retest reliability within session of the SSRT were .97 (95%CI; .94 - .99) for investigator A and .97 (95%CI; .93 - .98) for B and SEM were 1.27 and 1.37, respectively. The results indicated that performance in the repeated trials of the SSRT was highly reproducible within the same session. On examining the interrater reliability, the ICC of the SSRT scores between 2 investigators was .94 (95%CI; .84 - .97) and SEM was 1.93. These results indicated excellent test-retest and interrater reliability for the SSRT. (Table 2)

Validity of SSRT

The correlation between the SSRT and the TIS, the TCT, the BI, FM score, muscle strength and FAC are showed in Table 3. Significant correlations ($P<.05$) were found between the TIS, the TCT, the BI, muscle strength and FAC. There was no significant correlation between the SSRT and FM score. There was a high correlation between the SSRT and the TIS ($\rho = .71$, $p=.0002$). A middle correlation was found between the SSRT and the TCT ($\rho = .60$, $p=.0035$). The SSRT and the BI showed a high correlation ($\rho = .73$, $p=.0001$). In muscle strength, there were a middle correlation between the SSRT and nonparetic and paretic lower limb strength, respectively ($r = .53$, $p=.012$; $r = .67$, $p=.0009$). Also the SSRT had a middle correlation with FAC ($\rho=.53$, $p=.012$). FM score of the lower limb did not correlate with the SSRT.

Discussion

In this study we investigate the test-retest reliability within session, interrater reliability and validity on the SSRT in people with stroke. The results showed that the SSRT is sufficient in psychometric properties for test-retest reliability within session, interrater reliability and concurrent validity. In the test-retest reliability within session, the results indicated that performance in the repeated trials of the SSRT was highly reproducible within the same session. Each subject is consistent, because guides are given and allowed 2 practice trials before test trials. We propose that 1 test trial of the SSRT would be adequate during clinical application to save time, because of the high consistency among test trials.

For interrater reliability, a 1-day interval was used because no significant change in sitting ability was to be expected within such a short period. The ICC for the SSRT was .94 in our study, which is considered excellent. Tsang et al. measured the sit-and-reach test that was reach to forward from sitting, and showed good intersession reliability (ICC = .79).[27] The reach direction makes the difference between the value of ICC in previous study and in this study. We choose the reach to nonparetic side direction because which

Table 2 : Test-Retest Reliability of the SSRT for within session reliability and interrater reliability

within session reliability						
	Trial 1	Trial 2	Trial 3	ICC	95%CI	SEM
investigator A	23.2±7.3	23.4±7.6	24.3±7.5	0.97	0.94 - 0.99	1.27
B	22.4±7.6	22.8±8.1	22.9±8.6	0.97	0.93 - 0.98	1.37
interrater reliability						
investigator A		investigator B		ICC	95%CI	SEM
23.4±7.6		22.8±8.3		0.94	0.84 - 0.97	1.93

Values are mean±SD
ICC ; Intraclass correlation coefficient
SEM ; Standard error of measurment

direction is more reflect trunk function to make postural adjustments than forward. The SRT is more affected by the function of lower extremities and foot position. According to the previous studies[33,34] that investigated weight-bearing on the feet in a sitting position during reach to forward, stroke subjects put weight on the nonparetic side during reach to compensate for trunk weakness.

The results from the correlation analysis suggest that there is a high relationship between the SSRT and the TIS. This indicates that the SSRT can predict the trunk function as well as the TIS. The TIS comprises 17 items and evaluates static and dynamic sitting balance and trunk co-ordination. According to a study by Verheyden et al.,[35] a score of more than 20 on the TIS still indicated normal trunk function and independence in ADL. In our investigation, 23% of participants obtained a maximum score on the TIS and 41% obtained more than 20. This is from the difference of a phase of onset stroke. In this study, we investigated a chronic phase of onset stroke. And also there is a middle relationship with the TCT. The items of the TCT are rolling from supine in to each side, sitting up from supine and remaining in the sitting position. These are very low level activities, therefore in our investigation, 82% of participants obtained a maximum score. This showed that the TCT has a ceiling effect in the chronic stroke patients. It could be concluded that the TIS and the TCT are both measures of trunk performance applicable in the acute phase of stroke onset. In the chronic phase of stroke onset, the SSRT can predict other aspect of trunk function.

We also found a high relationship with the BI score and a middle relationship with FAC, nonparetic and paretic lower limb strength. However there was no relation with FM score. An explanation for the high relationship with the BI and middle with FAC is that sitting balance is essential for most functional activities, such as dressing, transferring and eating in a seated position. Accordingly, the first program after stroke in rehabilitation is to restore the posture. To restore sitting balance, the trunk function is important to maintain the center of gravity in base of support.

The SSRT requires patients who can follow simple instructions, are able to sit unsupported for 1 minute, and can actively abduct the nonparetic shoulder 100°. The patients are required only to perform a very simple side reaching action in a sitting position. In our study, all participants completed the test without a mistrial due to loss of balance. Therefore the SSRT is easy to measure trunk function in any clinical setting. Although the TIS is also easy to evaluate in any setting, it is an ordinal scale. Also the TCT can evaluate trunk function in any clinical setting, but it is an ordinal scale and has a ceiling effect in the phase of chronic stroke onset. In specially the SSRT more sensitive to measure trunk function than the TIS in a phase of chronic stroke. There has been no clinical useful quantitative evaluation tool for assessing trunk performance. The SSRT can be valuable for clinical use and clinical research as a scale for indicating changes in the rehabilitation process.

Study Limitations

The SSRT was developed to evaluate trunk function in a sitting position. Subjects with poor sitting balance who could not maintain sitting position with no support is not measured the SSRT.

In this study, excellent within session and interrater reliability, and concurrent validity of the SSRT were elucidated. However, it is necessary to examine other properties such as predictive validity of mobility level and responsiveness.

Conclusions

The SSRT is a reliable and useful clinical tool for assessing trunk function. We found that the performance of the SSRT had high within session and interrater reliability. Also we found that middle to high relationship with the TIS and the TCT, these are standard to evaluate the trunk function today. With this information, more sensitive assessment and rehabilitation program can be tailored to meet different needs of patients.

Table 3 : Relationships between the SSRT and TIS, TCT, BI, FAC, FM score and lower limb strength

Scale	correlation coefficient	P value
TIS	0.71*	<.001
TCT	0.6*	0.003
BI	0.73*	<.001
FAC	0.53*	0.012
FM score	0.38*	0.083
Muscle strength		
paretic	0.53**	0.012
nonparetic	0.67**	<.001

* ; Spearman ρ ** ; Pearson r

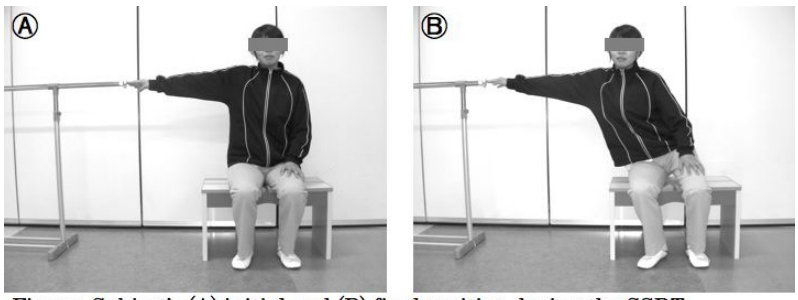

Figure. Subject's (A) initial and (B) final position during the SSRT.

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