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Test-retest Reliability of a Novel Lateral Trunk Flexion Test in Healthy Men

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ABSTRACT

Background/Aim. Trunk lateral flexion is frequently assessed with many measurement tools at clinical setting. The aim of this study was to determine the test-retest reliability of a novel lateral trunk flexion test (LTFT).

Methods. Twelve young men and two raters participated in this study. The LTFT was measured by one rater three times on each side of each participant. Two weeks later, a different rater measured the LTFT in each participant a second time. Test-retest reliability was analyzed using the intra-class correlation coefficient (ICC) and coefficient of variation (CV). The minimum detectable change (MDC) was also calculated.

Results. Intra-rater reliability was excellent for both raters: ICC (1,3): right side, 0.90 and 0.94; left side, 0.94 and 0.91. The CVs of the first and second rater were 9.2% and 6.0% for the right side, and 5.8% and 6.9% for the left side. The inter-rater reliability, which verified the coincidence of the two raters, was also excellent: ICC (2,3) for the right side 0.96 and 0.98 for the left side. The MDC was 1.83 cm for the right side and 1.45 cm for the left side.

Conclusions. The LTFT showed excellent test-retest reliability. In the future, it will be necessary to examine the validity of LTFT and to verify the reliability and validity by conducting it on patients with diseases.

INTRODUCTION

Low back pain (LBP) is a major health problem and frequent cause of disability[1)]. Many of occupational and risk factors are associate with LBP in the working-age and old-age populations, as are neurological disease including stroke and Parkinson's disease. Individuals with LBP present with alterations or limitations of trunk mobility. A systematic review showed that reduced lateral trunk flexion range of motion, limited lumbar lordosis and restricted hamstring range of motion were significantly associated with the development of LBP[2)]. Decreased trunk mobility is also associated with arterial stiffening, making the measurement of trunk mobility a predictor of arterial stiffening[3)]. For the patients with neurological disease, stroke or Parkinson's disease, trunk function is one of the most important factors for activities of daily living, and comprises mobility, muscle strength, and coordination. Most stroke patients suffer from functional disorders of the extremities and trunk. Trunk function has been identified as an important early predictor of functional outcome after stroke[4,5)]. Furthermore, in patients with stroke hemiplegia, the trunk often takes on a posture lateral bend in the chronic phase due to an imbalance between the bilateral paraspinal muscles. Patients with Parkinson's disease present bradykinesia, tremor, postural instability and rigidity as the main motor manifestations[6]. Axial rigidity in particular can lead to functional impairment of gait, balance, and motor control[7]. Trunk mobility decreases at the early stage of Parkinson's disease[8].

Many researchers have developed assessment tools to evaluate the trunk function, including the Trunk control test[9] and Trunk Impairment Scale[10], which are clinical tools to assess stroke patients. These measurements evaluate trunk function by having the patient accomplish movement, but do not evaluate the muscle strength and mobility that affect the movement. Trunk muscle strength can be measured with dynamometry, which has well-established reliability and validity[11]. According to the Guide to Physical Therapist Practice, the examination of joint integrity and mobility is necessary in order to select appropriate physical therapy interventions[12]. Moreover, the assessment of mobility may assist clinicians in making diagnoses, measuring improvements in mobility, and determining limitations in functional activities of daily living[13]. Therefore, it is essential for clinicians to have reliable and valid instruments of measurement to objectively and accurately assess disease progression and outcomes. Measurement of range of motion (ROM) of the trunk may be accomplished through visual observation or use of a number of measurement instruments including motion analysis, goniometry, linear measures, and inclinometry. When therapist use goniometry to measure ROM of the trunk it requires the therapist to use both hands to locate an anatomical landmark and stabilize the patient's position. Thus, measurement of ROM of the trunk with goniometry increases the risk of errors due to inaccurate readings or incorrect placement. Disadvantages of inclinometry may include clinician unfamiliarity with measurement procedures. Procedural errors, such as misplacement of the inclinometer at a region distant to the landmark and failure to maintain constant pressure during movement, can lead to inaccurate readings[14].

The lateral trunk flexion test (LTFT) is a method to measure of ROM of lateral flexion of the trunk. In this test, the person stands with bare feet, feet hip width apart, knees straight with the weight borne evenly on the two legs, looking straight ahead, and arms hanging at the sides relaxed. Patients are instructed to lean over to the side as far as possible while keeping the fingers in contact with the leg. The distance from the middle finger to the floor, or to the edge of the head of the fibula, is measured in centimeters. To obtain an accurate measurement using this method, it is important to avoid compensatory movements that influence trunk flexion and rotation. However, these compensatory movements are difficult to control with only verbal command. One such method to control compensatory movements is to have the patients in standing position with feet positioned hip-width apart and the posterior aspect of the trunk maintaining contact with the wall[15]. However, reliability of this method has not been established.

The laser range meter is the simplest way to measure distance. Thanks to its laser precision technology and continuous measurement mode, it takes instant and reliable measurements that can include the distance between fingertip and floor in seconds. With just one button and a shape that enables measurement in any position, the laser makes measuring easier and faster than a tape measure.

The simplicity and reliability of LTFT to measure mobility of the trunk could be further improved with the use of newer technologies. This study aims to determine the test-retest reliability of a novel LTFT that involved participants maintaining the posterior aspect of the trunk while contacting a wall together with the use of the laser range meter.

MATERIALS AND METHODS

Participants. Twelve young men with the following demographics were recruited for this study: age, 19.9 ± 0.5yr; height, 1.7 ± 0.1m; weight, 62.1 ± 6.4kg; and body mass index, 21.1 ± 1.6kg/m^2. Inclusion criteria were: 1) age over18 years; 2) the ability to stand; 3) the absence of LBP or lower extremity pain. All participants had no knowledge of LTFT and this was their first time. All participants provided informed consent. This study was performed in accordance with the guidelines of the Declaration of Helsinki.

LTFT procedure. Participants were instructed to stand with feet positioned hip-width apart and to maintain contact between the posterior aspect of the trunk and the wall, while holding the laser range meter (Measurement accuracy ±3mm, ZAMO, Bosch, Germany) in the hand ipsilateral to the side being tested. The rater determined that the participant was in appropriate position and that the laser beam touched the floor just beside the foot. Participants were instructed to press the button to establish the start position, then asked to flex the trunk laterally as far as possible while maintaining their back on the wall, with the knee and arm fully extended and the contralateral foot touching the ground. For the second round, the rater again checked that the participant was in the appropriate posture and the laser beam in position before asking the participant to press the start button, flex the trunk laterally and measure the distance to the floor. The LTFT was performed three times on each side. For inter-rater reliability, two raters were assessed the LTFT. Raters were college students and had never measured LTFT. One rater (rater A) assessed the participants and initially, followed by a second assessment by the other (rater B) more than 2 weeks later because to avoid participants learning.

Participants were assessed for handedness using the Edinburgh Handedness Inventory[16] before administering the LTFT. Edinburgh Handedness Inventory is a 10-item questionnaire designed to assess handedness by self-reporting the preferred hand for carrying out common activities such as writing and drawing, and using utensils such as a toothbrush, knife, and spoon. They placed 1 or 2 check marks under "left" or "right", indicating strength of preference for each activity. A laterality quotient (LQ) was calculated as follows: LQ= (R - L) / (R + L) × 100. A score of 100 indicates complete right handedness while －100 indicates complete left handedness.

Statistical analysis. The data were analyzed by repeated measure two-way analysis of variance (trials × raters) for each side in order to verify whether there is no difference between measured values between trials and raters. Statistical significance was set at $p < 0.05$.

Intra- and inter-rater reliabilities were assessed with the intra-class correlation coefficient (ICC), coefficient of variation (CV), and 95% confidence interval (CI). ICC (1, 1) verifies the similarity in a set of values that are measured three times by a certain measurer and was used to confirm the intra-rater reliability. In ICC (2, 1), each participant was evaluated by each rater, and the reliability was calculated from the average of the measurements. The standard error of measurement (SEM) was calculated by the formula SEM = SD $\times\sqrt{1-ICC}$, where SD was the standard deviation. We also calculated minimum detectable change (MDC). MDC provides one index of responsiveness[17]. Clinically, a change in performance on a test may reflect an imprecise measurement. MDC represents a magnitude of change that reflects a true change in performance above and beyond any change accounted for by measurement error or random variability. MDC at the 95% confidence level (MDC_{95}) was determined by the formula $MDC_{95} = (1.96 \times \sqrt{2} \times SEM)$.

All data analysis was performed using the SPSS version 26 (SPSS, Chicago, IL, USA).

RESULTS

All participants were right handed (Edinburgh Handedness Inventory: 83.3 ± 14.9). The results of the LTFT are shown in Table 1. The results of repeated measure two-way analysis of variance (3 trials × 2 raters) showed that no significant difference among the trials for each side: Right, $F = 1.92$, $p = 0.17$; Left, $F = 0.64$, $p = 0.54$.

For intra-rater reliability, we found that ICC (1,1) of the right side was ρ= 0.75 for rater A and ρ= 0.81 for rater B, while the left side was ρ= 0.83 and ρ= 0.75. Next calculated the formula ($\kappa = \frac{\rho 2(1-\rho 1)}{\rho 1(1-\rho 2)}$) to determine how many times the LTFT would need to be performed make the value "almost perfect". For the right side, the number of times required for raters A and B were 3 and 2, respectively, while for the left side they were 1.9 and 3 times, respectively. Therefore, we decided to use the average of three sets of measurements to verify the inter-rater reliability. When we used the average of three sets of measurements, ICC (1,3) of rater A and B were ρ= 0.90 and ρ= 0.94 for the right side and ρ= 0.94 and ρ= 0.91 for the left side (Table 2). The inter-rater reliability results are shown in Table 3.

DISCUSSION

The aim of this study was to determine the test-retest reliability of the LTFT featuring maintenance of contact between the participants's back and a wall, and use of the laser range meter. The intra-rater reliability of the LTFT was ICC 0.9–0.94, while inter-rater reliability was ICC 0.96 for the right side and ICC 0.98 for the left side. An ICC value of < 0.40 indicates poor reliability, 0.40–0.75 indicates fair to good reliability, and values > 0.75 reflect excellent reliability[18]. Another method to measure lateral trunk flexion mobility is the modified Moll lateral flexion test[19], which features a skin distraction technique originally described by Schober. Participants stand in a hands-behind-the-head position, then two marks are made on the skin in the frontal plane: the lower mark at the point where the front line crosses the iliac crest and the upper mark 20 cm cephalad. Participants are then asked to bend as far as possible without rotating the trunk. The distance between the upper and lower marks is then measured in centimeters. The extent of lateral trunk flexion is determined by subtracting 20 cm from that distance. The intra-rater reliability of the modified Moll lateral flexion test as measured with CVs was reported to be 8.9% for the right side and 9.5% for the left side[19]. The CVs of the LTFT in this study were shown to be 9.2% and 6.0% for the right side, and 5.8% and 6.9% for the left side, which were slightly better than those for the modified Moll lateral flexion test.

Table 1. Results of the LTFT in 12 male participants

Side	Trial	Rater	
		A	B
Right	1st	16.9 ± 1.1	17.7 ± 0.7
	2nd	16.8 ± 1.1	16.7 ± 0.7
	3rd	17.1 ± 0.9	16.5 ± 0.8
Left	1st	16.3 ± 0.8	16.3 ± 0.7
	2nd	15.9 ± 0.7	16.6 ± 0.8
	3rd	16.4 ± 0.8	16.5 ± 0.7

unit: cm
Value: mean ± SD

Table 2. Intra-rater reliability of the LTFT

Rater	Side	ICC(1,3)[95%CI]	CV(%)	SEM
A	Right	0.90[0.80–0.93]	9.2	1.08
	Left	0.94[0.94–0.99]	5.8	0.64
B	Right	0.94[0.87–0.98]	6.0	0.64
	Left	0.91[0.88–0.98]	6.9	0.75

ICC: intra-class correlation coefficient, CV: coefficient of variation, 95%CI: 95% confidence interval, SEM: standard error of measurement.

Table 3. Inter-rater reliability of the LTFT

Side	ICC (2,3) [95%CI]	CV(%)	SEM(cm)	MDC_{95}(cm)
Right	0.96 [0.91-0.99]	10.3	0.66	1.83
Left	0.98 [0.95-0.99]	8.9	0.52	1.45

ICC: intra-class correlation coefficient, CV: coefficient of variation, 95%CI: 95% confidence interval, SEM: standard error of measurement, MDC_{95}; minimum detectable change at 95% confidence level.

From the results of Table 2, we reason that the LTFT had better CVs than the modified Moll lateral flexion test because the LTFT was performed with the participant's posterior aspect of the trunk maintaining contact with a wall, which helped to avoid compensatory movements. Moreover, the skin distraction method and modified Moll lateral flexion test require participants to remove their clothing and receive marking on the skin, creating the possibility for infection. Marking the skin on multiple people with one pen has been shown to carry the risk of cross-infection[20]. The LTFT is comparably safer and easier to use in the clinical setting.

With regard to inter-rater reliability, the results of ICC(2,3) demonstrated that the LTFT has the potential to be an excellent, reliable tool to evaluate trunk lateral flexion. Repeated measurements on healthy young men demonstrated high ICC(2,3) values at 95%CI: 0.96 (0.91–0.98) for the right side and 0.98 (0.95–0.99) for the left side. The CVs were 10.3% for the right side and 8.9% for the left side, which were better than the modified Moll lateral flexion test, which showed CVs for inter-rater reliability of 11.9% for the right side and 10.2% for the left side[21]. In this study, reproducibility was excellent, despite an > 2-week interval the first and second measurements. These results suggested that the LTFT has excellent inter-rater reliability.

Although both intra- and inter-rater reliabilities were excellent for the LTFT, the intra-rater reliability was much higher than the inter-rater reliability. These findings suggested that participant-related factors, such as day-to-day variation in motivation and effort, and rater-related factors such as measurement technique and intrinsic errors in measurements, were the principal variables affecting reproducibility. In the LTFT, the rater needs to monitor and correct the movements of the participant. Errors between raters may occur during monitoring and modification. However, the results of this study showed better reproducibility than that of the previous study. This reproducibility is important because it enables raters to compare their results confidently with those obtained by other investigators who use the same techniques.

MDC is an indicator of a patient's improvement in the LTFT. A change in the LTFL may be attributed to a measurement error or random human performance variation, as well as an actual change, whereas MDC represents a magnitude of change that reflects true change in performance. The MDC of the LTFT was 1.83 cm for the right side and 1.45 cm for the left side, so any change above these can be considered a true change. Clinically, knowing the MDC of whatever test is being used is important for recognizing meaningful changes in patients.

Trunk mobility is associated with postural instability. Postural instability and axial rigidity are frequent symptoms of Parkinson's disease. Artigas et al.[22] showed that scores of the Trunk Mobility Scale were worse in patients who had a history of falls. Trunk control is also important for stroke patients. Isho and Usuda[23] showed that trunk control was associated with mobility performance and gait. These studies indicated the importance of targeting trunk function not only in activities of daily living, but also as part of intensive rehabilitation treatment to regain better mobility and stable gait in patients early after stroke. Therefore, accurate and reliable methods of evaluation such as the LTFT are necessary and beneficial.

Limitation. Before these results can be generalized to other groups, however, at least two factors must be taken into account. First, we did not include participants with any disease, thus this lateral flexion test has not been proven to have disease-specific inter-rater reliability. Second, the small sample size limited the strength of this portion of the study. It will be necessary for a future study to verify the reliability of the LTFT by conducting the test on patients with stroke hemiplegia or Parkinson's disease.

CONCLUSION

We determined the test–retest reliability of the LTFT that involved maintaining contact the between the paticipants's back and a wall, and use of the laser range meter. The LTFT showed excellent test–retest reliability that exceeded that of previous studies. In this study, the reliability of healthy people was confirmed. In the future, it will be necessary to examine the validity of LTFT and to verify the reliability and validity by conducting it on patients with diseases.

CONFLICTS OF INTERREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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