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Reliability of the Modified O'Sullivan Functional Balance Test in Person with Spinal Cord Injury

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Abstract

The modified O'Sullivan functional balance test is a short and easy scale that is commonly used in clinical practice, but this test lacks of standardized instructions that may affect its reliability. This study aimed to determine the reliability of the modified O'Sullivan functional balance (mOFB) test in persons with spinal cord injury. Various test instructions were given and VDO recorded in twelve chronic spinal cord injuries (lesion level C5-L5). Inter-rater and intra-rater reliability were determined by 5 physical therapists who have clinical experience ranging from 1 to 10 years. All raters scored the patient's performance from from observing the video twice, 7 days apart. Inter-rater and intra-rater were calculated by interclass correlation coefficient (ICC). The mOFB test showed excellent intrarater reliability (ICCs range from 0.93 (0.86-0.98) to 0.96 (0.92-0.99)), whereas interrater reliability ranged from poor to moderate (ICC range from 0.38 (0.12-0.69) to 0.53 (0.26-0.80). The different test instructions including posture alignment adjustment before testing, amount of resistance, and amount and direction of reaching led to decreased intra-rater reliability to poor and moderate. This study confirmed that a lack of a clear testing instructions and grading criteria decreased the reliability of the modified O'Sullivan functional balance test.

Introduction

For patients with spinal cord injury, wheelchair is the most important and most frequently used as their primary means of mobility (Post et al., 1997; Bergstrom & Samuelsson, 2006). Balance control in upright sitting on wheelchair is a necessary component in engaging the use of upper limbs in functional activities such as feeding, dressing, transferring (Gao et al., 2015), as well as preventing falls during wheelchair navigation over obstacles and up or down inclines (Sisto et al., 2009). Balance training in sitting, therefore, is very important to maximize opportunities for independent mobility, functional activities and preventing falls in patients with spinal cord injury. The successful of this training requires balance measurement tool that is reliable, valid and feasible to use in a clinical setting. Two main approaches of balance assessment consist of laboratory and functional assessments. The laboratory instrument such as force plate transducers and accelerometer

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provides objective and quantitative measurement without tester's bias but it is expensive and requires extensive training and testing. Clinical balance scale was developed to be used in clinical setting that does not require expensive equipment and is easy to use. The clinical balance scale assesses balance ability and its changes over time though ordinal scale that assesses a set of functional task which requires balance control during maintaining sitting posture or during doing activity (Horak, 1997).

A survey was conducted to gather information regarding types of balance measurement used amongst physical therapists working in the neurological area in Thailand. 130 respondents (86.09%) replied that they always or almost always measured balance by using clinical balance test (Chinsongkram et al., 2018). Among those, 16.56% used the standardized balance measures such as Berg Balance Scale (BBS), Time Up and Go (TUG) and Balance Evaluation Systems Test (BESTest), whereas 69.53% used the test that resembles O'Sullivan functional balance scale. The O'Sullivan functional balance (OFB) scale can be used to define both static and dynamic control in sitting and standing in elderly and patients with neurological disorders (O'Sullivan & Schmitz, 2007). The popularity of the OFB scale in Thailand may be due to it being short and easy to use; this test can be completed within 5 minutes (O'Sullivan & Schmitz, 2007). The OFB scale has been modified further by adding external resistance for disturbing static balance and weight shifting for disturbing dynamic balance and adjusted the grading criteria in accordance with the modified test. However, the modified O'Sullivan functional balance (mOFB) scale does not provide cleartest instructions, i.e., no clear test instruction of starting position, test command, amount of resistance and distance of weight shifting. When using this test without test instructions, a variety of testing procedures such as test commands or starting position may affect the reliability of this test. From literature review, psychometric properties of the mOFB scale had never been investigated in the population with spinal cord injury before. Therefore, it is necessary to examine the reliability that is the first step of psychometric properties study in the use of the mOFB scale in patients with spinal cord injury. The aim of this study was to determine the reliability in persons with spinal cord injury and determine the reliability of this test when use with different test instructions.

Participants and methods

Twelve participants with spinal cord injury were recruited from Pathum Thani of Thailand during October, 2017 to March, 2018. The sample size calculation by G*power version 3.1.9.2 was based on a power of 0.80 and alpha level of 0.05. An expect intraclass correlation coefficient of this study was 0.90. An intraclass correlation coefficient for null hypothesis was at 0.5 which represents poor reliability. The minimum sample size required was 12 therefore that is in line with the recommendation from guideline to determination of sample size requirements for estimating the value of intraclass correlation coefficient (Bujang & Baharum, 2017). Individuals were included in this study following criteria: diagnosis of spinal cord injury at 4th cervical spinal cord or below with stable medical conditions, age between 18-70 years, independent sitting and able to follow instructions to complete the assessment. Individuals were excluded from the study if they presented with other problem that is sufficient to disturb balance such as respiratory problem, bed ridden, postural hypotension, fracture and stroke. Interrater and intrarater reliability were determined by 5 physical therapists. Raters consisted of 1 lecturer in neurological physical therapy and 1 physical therapist with more than 5 years of neurological rehabilitation experience and 3 physical therapists with less than 5 years of neurological rehabilitation experience.

Outcome measurement in this study was the modified O'Sullivan functional balance (mOFB) scale. It consists of functional balance items in sitting and standing that focus on the ability to maintain a position and postural adjustments to voluntary movements such as head/trunk turning, picking up object off floor and weight shifting. This test has 4 items including; static balance in sitting, dynamic balance in sitting, static balance in standing and dynamic balance in standing. The static balance items are sequenced according to the level of difficulty from sitting or standing supported to unsupported and against external resistances in all directions. Likewise, the dynamic balance items progress from sitting or standing unsupported to minimal weight shifting and full range weight shifting in all directions. Due to lack of standardized test instructions, a starting position varies based on patients' performance such as ring sitting or long sitting in patients with quadriplegia and high sitting in patients with paraplegia. Testing time in each item ranges from 30 seconds to 120 seconds.

Amount of resistance in static balance test ranges from minimum to trigger isometric contraction of trunk muscle, to maximum of triggering trunk movement. The direction of apply external resistances or weight shifting was varied including anterior, posterior, left side, right side and add up and down direction for weight shifting test. (Chinsongkram et al., 2018) The distance of weight shifting in dynamic balance test ranges from reaching within arm range to reaching over arm range. Influence of the above-mentioned testing procedures in the mOFB scale (i.e., starting position, testing time, amount of resistance, direction of resistance and direction of weight shift) on the testing reliability were examined further in this study. Grading criteria of the mOFB test is scored on a 5-level ordinal scale from zero (unable to maintain balance) to normal (normal balance performance) as shown in Table 1. This test requires minimal testing equipment and short time (less than 5 minutes) for administering.

Table 1 Grading definition of the modified O'Sullivan functional balance test

Grade	Descriptors
	Static balance
Normal	Patient able to maintain steady balance without handhold support and maintain steady balance against the external resistance for disturb balance in all directions.
Good	Patient able to maintain steady balance without handhold support and maintain steady balance against the external resistance for disturb balance in some directions.
Fair	Patient able to maintain steady balance without handhold support but cannot maintain steady balance against the external resistance for disturb balance.
Poor	Patient requires handhold support and moderate to maximal assistance to maintain position.
Zero	Patient unable to maintain balance.
	Dynamic balance
Normal	Patient accepts maximal challenge and can shift weight easily within full range in all directions.
Good	Patient accepts moderate challenge and can shift weight within range in some directions.
Fair	Patient accepts minimal challenge; cannot maintain steady balance when weight shifting
Poor	Patient unable to accept challenge or move without loss of balance.
Zero	Patient unable to maintain balance.

This study was approved by the Human Research Protection Committee at Rangsit University, Thailand (number RSEC 33/2560). After signing the consent forms, participants completed demographic and clinical information including; age, weight, height, and level of spinal cord injury lesion, time since spinal cord injury, cognitive impairment and postural hypotension screening. The evaluation with the mOFB test was performed in a same setting and videotape recording was performed in the same view in all participants. Each participant performed the test in ring and high sitting with various testing instructions and testing procedures to examine the effect of varied instruction and procedure on the test reliability. The test instruction conditions including starting position in sitting, adjust postural alignment before test, testing time in static balance test, amount of resistance in static balance test, distance of weight shifting in dynamic balance test, and directions of apply external resistance or weight shifting. All participants received the same verbal instruction and were allowed to rest as needed during the test.

Video clip of each test condition were edited and randomized for patient's sequence in each test instruction and procedure before sent out to raters to prevent rater from remembering scores from previous test condition in the same patient. All raters scored the patient's balance grade from each video clip on 2 separate occasions. The second occasion was performed 7 days after the first occasion (Portney & Watkins, 2007; Shultz et al., 2013; Schlager et al., 2018). Intrarater reliability was assessed by comparing the score of occasion 1 and score of occasion 2 in each rater. Interrater reliability was determined by comparing the score from occasion 1 between 5 raters. Each rater scored video clip separately on the separate scoring sheets for each occasion and did not discuss scoring among participants and occasions.

Descriptive statistical analysis of demographic and baseline clinical characteristics of participants were conducted. For score distribution, the floor and ceiling effects were calculated as the percentage of sample scoring the minimum or maximum possible grade, respectively. Ceiling and floor effects of 20% or greater are considered significant. Interrater and intrarater were calculated by interclass correlation coefficient (ICC). ICC model 2, k was used for interrater reliability and model 3, k was used for intrarater reliability. ICC value of 0.80 and above indicates excellent reliability, 0.5-0.79 indicates moderate reliability and less than 0.5 indicates poor reliability (Portney & Watkins, 2007).

Results and discussion

Twelve chronic patients with spinal cord injury; 9 females and 3 males with the average age of 36.08 ±

7.46 years, participated in this study. The average time since onset spinal cord injury was 11.83 ± 9.40 years and level of spinal cord injury was ranged between C5 to L5 with above T1 level in 3 persons and below T1 level in 9 persons. The average of body mass index was 20.22 ± 1.51. Maximum functional independent in all participants were independent wheelchair activity.

The distribution of participants' score of the modified O'Sullivan functional balance scale in all testing conditions of static and dynamic balance test is displayed in Fig. 1. It can be seen that the distribution of scores from static sitting balance test covered the whole grade. The static sitting balance ability of most patients is in the grade fair (40.2%), good (36.5%) and poor (13%), respectively. In dynamic sitting balance, the balance ability of most patients is in the grade poor (40.4%), fair (31.4%) and good (15.7%), respectively. The analysis of the floor effect and ceiling effect demonstrated that there were 0-0.1% of participants receiving the lowest possible score (grade zero) and 2.2-2.8% of participants receiving the highest possible score (grade normal), suggesting there were no floor and ceiling effect of the modified O'Sullivan functional balance test in patients with chronic spinal cord injury.

The intrarater and interrater reliability of the the mOFB scale from 5 raters scoring, in appropriate test instructions are presented in Table 2. The appropriate test instructions including adjust postural alignment before test, testing time in static balance test is 60 seconds, minimum amount of resistance to trigger isometric contraction of trunk muscle, distance of weight shifting is reaching over arm range, and apply external resistance or weight shifting in all directions. The interrater reliability of the static sitting balance test was poor both in ring sitting and high sitting position. The ICCs of interrater reliability test in dynamic sitting balance was indicating moderate reliability in both ring sitting and high sitting position. In contrast, the intrarater reliability of the static sitting balance test and dynamic sitting balance test were excellent. Comparable reliability between ring sitting and high sitting condition suggested that sitting position had no effect on the testing reliability.

Table 2 Intraclass correlation coefficient and 95% confident interval of interrater reliability and intrarater reliability of the modified O'Sullivan functional balance test during proper conditions in patients with spinal cord injury

Compare	Interrater reliability ICC (95%CI)		Intrarater reliability ICC (95%CI)	
	Ring sitting	High sitting	Ring sitting	High sitting
Static balance	0.38 (0.12-0.69)*	0.40 (0.14-0.71)*	0.94 (0.88-0.98)*	0.93 (0.86-0.98)*
Dynamic balance	0.52 (0.19-0.80)*	0.53 (0.26-0.80)*	0.96 (0.91-0.99)*	0.94 (0.88-0.99)*

Remark: * Significant level of ICC at $p < 0.001$

The intrarater reliability of the mOFB scale in each rater, when scoring in different test instructions is shown in Table 3. Intrarater reliability of all raters decreased from excellent during the appropriate test instruction (Table 2) to poor and moderate when using varied instruction and procedures (Table 3). All test instruction factors led to deteriorating effect on intrarater reliability except the testing time factor.

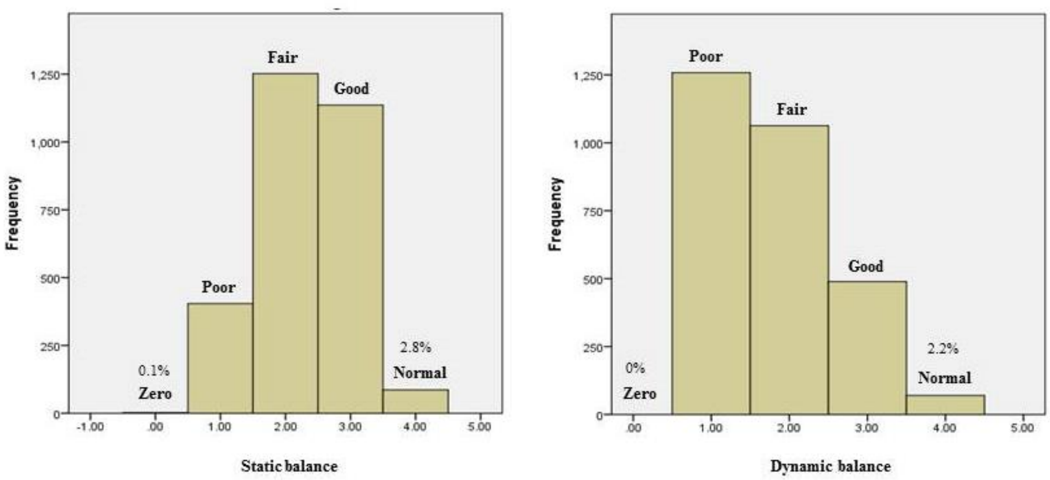

Fig. 1 Score distribution of the modified O'Sullivan functional balance scale in chronic patients with spinal cord injury during static balance test (left panel) and dynamic balance test (right panel)

Table 3 Intra-rater reliability of the modified O'Sullivan functional balance test in different testing instruction and procedures

Compare	Intrarater reliability; ICC (95%CI)			
	Posture alignment adjustment	Testing time	Amount of resistance and distance of weight shifting	Direction of resistance and weight shifting
Static balance	0.53 (0.45-0.61)*	0.95 (0.94-0.97)*	0.48 (0.44-0.56)*	0.55 (0.51-0.60)*
Dynamic balance	0.61 (0.53-0.68)*	0.95 (0.95-0.97)*	0.64 (0.60-0.69)*	0.63 (0.59-0.68)*

Remark: * Significant level of ICC at $p < 0.001$

This is the first study to determine whether the modified O'Sullivan functional balance (mOFB) scale is reliable for assessing balance impairments in patients with spinal cord injury. Although this study demonstrated that the mOFB scale lack of floor and ceiling effects, this scale may not be suitable for assessing balance in patients with chronic spinal cord injury with lesion between C5 to L5 due to its low rater reliability under certain testing conditions.

When using with clear and appropriate testing instruction and testing procedures, the mOFB scale showed excellent intrarater reliability but poor interrater reliability. The possible explanation of poor interrater reliability may be from diverse understanding of grading criteria. Interrater reliability in dynamic balance test tended to be higher than static balance due to the fact that dynamic balance test is more difficult and require higher balance control than static balance. Therefore, the sway that indicates balance impairment may be clearly noticeable, thus, most raters could reach agreement in scoring. From our results, it can be seen that the mOFB scale may not be preferable when being used by several assessors such as re-evaluation or case referral.

On the other hand, the intrarater reliability decreased significantly when the instruction and procedures were not controlled and varied. Several factors listed in this study (adjustment of posture, amount and direction of external resistance, distance of weight shifting) influenced the intrarater reliability of the mOFB scale, but not the testing duration which ranged from 30 seconds to 120 seconds, suggesting that varying of instructions and procedures could possibly affect the amount of observed sway. Therefore, the scores were different when graded by the same rater using the same grading definition. These findings emphasized the importance of having test instruction and procedures for testers for administering the mOFB scale with the same method. Our results are in line with the previous survey study that showed no consensus of test instruction and grading definition of the mOFB test in Thailand (Chinsongkram et al., 2018). Another study indicated that clear and consensus grades definitions and test instruction of the scale would improve reliability of this test (Iansek & Morris, 2013). An appropriate testing instructions and procedures that we used in this study could be used for developing clear and consensus test instruction of the mOFB scale including; (1) the assessor needs to adjust the postural alignment before starting the test to ensure that the patient sits up straight, (2) the proper testing time for static balance test is 60 seconds, (3) the amount of external resistance given to the patient should be minimum just enough to trigger isometric contraction of trunk muscle, (4) the distance of weight shifting needs to be farther by reaching over arm range, and (5) assessor should apply external resistance or instruct weight shifting in all directions. However, the reliability and validity of adjusted test must be studied for confirmation.

Conclusion

The mOFB scale is reliable for measuring balance in persons with chronic spinal cord injury when being used by same rater with an appropriate testing instructions and procedures. Both interrater and intrarater reliability of this scale reduce to moderate and poor when measuring without a clear testing instruction and grading criteria. The future studies are needed to verify if the criteria suggested in this study could improve rater reliability of the mOFB scale.

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