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ARTICLE

Test-retest reliability and validity of the Sitting Balance Measure-Korean in individuals with incomplete spinal cord injury

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STUDY DESIGN: Cross-cultural reliability and validity.
OBJECTIVES: To develop and validate the Korean version of the Sitting Balance Measure (SBM-K) in Korean persons with incomplete spinal cord injury (ISCI).
SETTING: Tertiary care center.
METHODS: Twenty-nine persons with ISCI were evaluated using SBM-K, which was validated using the kappa coefficient and intraclass coefficient (ICC). The correlation between SBM-K individual items and total score was analyzed using Spearman's correlation, and the internal consistency of test items was measured using Cronbach's alpha. Additionally, the standard error measurement (SEM) and minimal detectable change (MDC) were measured. For the clinical validity of SBM-K, the correlation of SBM-K with the modified Sitting Balance Scale (mSBS) and the Korean-Spinal Cord Independence Measure-III (KSCIM-III) was determined via Spearman's correlation. Linear regression was performed to determine whether SBM-K could predict KSCIM-III.
RESULTS: The weighted kappa score of the SBM-K individual items and ICC of SBM-K total score were 0.76–0.83 (good–very good) and 0.98 (0.95–0.99), respectively. The correlation between the SBM-K total score and individual items was notable ($r = 0.78$–0.98). Cronbach's alpha, SEM, and MDC of SBM-K were 0.98, 0.59, and 1.64, respectively. The clinical validity of SBM-K correlated with mSBS ($r = 0.88$) and KSCIM-III ($r = 0.65$–0.89). SBM-K accounted for 17–72% of the variance in predicting KSCIM-III.
CONCLUSIONS: SBM-K showed sufficient test-retest reliability, validity, and marginal measurement errors. SBM-K can serve as an optimal clinical assessment tool for Korean ISCI patients and may provide clinicians with reliable sitting balance assessment in Korean clinical settings.

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INTRODUCTION

Spinal cord injury is associated with impaired motor, sensory, and autonomic nervous system function, and it can be categorized based on the area and severity of the injury [1] which causes specific behavioral difficulties such as maintaining or controlling the sitting position without support. Sitting balance is essential to performing functional activities of daily living such as dressing, transferring and operating a wheelchair, changing position, and eating [2]. In addition, sitting balance ability and the ability to move from a sitting position must be acquired with the prior postural adjustment necessary for the sit-to-stand and standing movements [3]. Thus, restoring sitting balance ability is one of the most important treatment goals for individuals with spinal cord injury who cannot sit without support, and various treatments have been tried to improve their sitting balance ability [4].

Therapists must be able to accurately assess individuals with spinal cord injury according to the treatment plan and goals necessary for sitting balance assessment, and it is important to select assessment instruments with proven reliability and validity [5]. Generally, patients with spinal cord injury in the hospital are comprehensively assessed at the bedside. The Likert ranking scale (based on external help, observation, instruction, and independent performance) includes the following scores: impossible (0), poor (1), fair (2), good (3), very good (4), and normal (5). However, it is a subjective assessment instrument, its criteria are unclear, and it is very limited in accurately assessing individual sitting balance [6].

Currently, there are few instruments for assessing sitting balance in individuals with spinal cord injury in clinical trials, but relevant clinical studies have not been sufficient [5]. The Berg Balance Scale [7] and Performance-Oriented Mobility Assessment [8] used in clinical trials are designed to assess the overall balance ability of stroke patients, and only some sitting balance assessment items are included [4]. Most of the assessment scales in both balance assessment instruments are not appropriate because they have a floor effect for those with spinal cord injury who cannot stand and walk [5].

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Standardized scales developed for sitting balance assessment include the Sitting Balance Scale (SBS), Function In Sitting Test, Sitting Balance Assessment Tool, and Modified Functional Reach Test (mFRT). However, these sitting balance assessments are subjective, and their validity and reliability have not been established. Only mFRT of the above assessment instruments has proven reliability in spinal cord injury [9], but it reflects only one component of sitting balance i.e., forward reach. In addition, mFRT cannot be applied to individuals with spinal cord injury who have a limited range of motion or inability to reach forward with 90° of shoulder flexion.

The Sitting Balance Measure (SBM) was developed to assess sitting balance in individuals with spinal cord injury [5]. SBM is composed of static short sitting balance items (2), sits with back unsupported, sits with eyes closed, dynamic short sitting balance items (2), turns the head and trunk to the right and left, and looks behind and returns to the starting position, with a total of four items (4-point scale, 0–3 points) and a perfect score of 12. In addition, individual items of SBM have been developed to assess several factors related to different types of sitting balance. The face validity of SBM, correlation between individual items, and Cronbach's alpha for internal consistency reliability have been reported, and it is considered a reliable assessment tool for the objective and comprehensive assessment of sitting balance in individuals with spinal cord injury. However, Wadhwa et al. [5] conducted a pilot study necessary for the development of SBM, and the test-retest reliability and validity of the individual SBM items and total score were not reported.

SBM was developed in India by Wadhwa et al. [5], but there are cultural differences between India and Korea. However, the use of a common assessment tool between countries allows for comparisons between different population groups across linguistic and cultural barriers, enabling information exchange. To evaluate the sitting balance of individuals with incomplete spinal cord injury in Korea, SBM-Korean (SBM-K) was developed in accordance with the Korean contextual and cultural characteristics while maintaining the uniqueness of the original version of SBM. Therefore, this study aimed to examine the reliability and validity of SBM-K in individuals with incomplete spinal cord injury using the modified Sitting Balance Scale (mSBS) and Korean-Spinal Cord Independence Measure-III (KSCIM-III), which are used to evaluate sitting balance and functional level after spinal cord injury, respectively, before its clinical application in Korea.

METHODS

Participants

This study was conducted from October 2019 to June 2020 and included 29 individuals with incomplete spinal cord injury who were undergoing rehabilitation at the National Rehabilitation Hospital because of spinal cord injury. The study was approved by the National Rehabilitation Hospital Institutional Review Board (IRB File No. NRC-2019-05-032). All participants received explanations of the study protocol, and written informed consent was obtained. The criteria for the selection of study participants were based on the American Spinal Cord Injury Association Impairment Scale (ASIA E) Classification [10] for individuals with incomplete spinal cord injuries who were (1) able to sit unsupported for 10 s [4], (2) follow instructions, and (3) able to communicate. The exclusion criteria were as follows: (1) spinal cord injury that occurred within 3 months previously, (2) severe muscle strain on the limbs that could affect the sit unsupported test assessment items, and (3) pressure sores in the buttocks and heels, joint contractures, complications from spinal cord disease, musculoskeletal disorders, or external orthosis. The size of the sample is assumed to prove reliability at an intraclass coefficient of 0.90; thus, we used this value to verify the test-retest reliability (ICC = 0.90, $p < 0.05$). When individual participants were re-evaluated, the minimum number of samples required for 93% statistical power was 25 [11]. The minimum sample size to allow the detection of a significant difference between the measured variables was 20 [12]. Therefore, in this study, 30 participants were selected considering a 20% subject dropout rate.

Procedures

As the first step in the Korean translation process for SBM, the original SBM text was independently translated from English to Korean (forward translation) by two physical therapists and English translators with more than 14 years of clinical experience. The translated Korean versions were combined to form a consensus version by reconciling inconsistencies through a consensus meeting. The consensus version was reverse-translated back into English, and finally, the Korean version was completed by discussing the results through comparison and correction with a professor of physical therapy and a language expert. SBM-K was administered twice by a senior physical therapist with 14 years of experience, with assessments conducted in the same setting 1 week apart [13]. To reduce the memory effect on the rater, which could increase test-retest reliability, the examiner administered SBM-K to at least five individuals within a session and did not contact the individuals until their next assessments [14].

Assessment scale

Sitting Balance Measure-Korean (SBM-K). SBM was developed to assess sitting balance in individuals with spinal cord injury. The SBM-K is the Korean version of SBM. SBM is composed of static short sitting balance items (2), sits with back unsupported, sits with eyes closed, and dynamic short sitting balance items (2), turns the head and trunk to the right and left, and looks behind and returns to the starting position, with a total of four items (4-point scale, 0–3 points) and a perfect score of 12. The face validity of the SBM, correlation between individual items, and internal consistency reliability (Cronbach's alpha = 0.96) have been reported [5].

Modified Sitting Balance Scale (mSBS). mSBS consists of four items: (1) (poor), unable to maintain a static position; (2) (fair), able to maintain a static position but requiring assistance in all righting tasks; (3) (good), able to maintain a static position, but requiring the use of the hands for support when nudged; and (4) (normal), able to perform the test without physical assistance and without the use of the hands for support. The inter-rater reliability with a weighted kappa value of 0.69–0.96 has been reported for mSBS in individuals with spinal cord injury [4].

Korean-Spinal Cord Independence Measure-III (KSCIM-III). In this study, the Korean translation of SCIM-III (KSCIM-III) was used [15]. An assessment tool was developed by supplementing the SCIM developed by Catz et al. [16] for individuals with spinal cord injury. SCIM-III is the latest version comprising 19 items in three subscales: (1) self-care (six items, range 0–20), (2) respiration and sphincter management (four items, range 0–40), and (3) mobility (nine items, range 0–40). The inter-rater reliability of SCIM-III in spinal cord injury, including self-care (ICC = 0.98), respiration and sphincter management (ICC = 0.95), mobility room and toilet (ICC = 0.97), mobility indoors and outdoors (ICC = 0.98), total (ICC = 0.99), and the internal consistency (Cronbach's alpha coefficient 0.88) have been reported [17].

Data analysis

Statistical analysis was performed using SPSS 18.0. All data were tested for normality using the Shapiro–Wilk test, and frequency analysis was performed for the general characteristics of the participants. The test-retest reliability for each SBM-K item was used as the weighted kappa coefficient, and the test-retest reliability of the total SBM-K score was used as the ICC. An ICC of 0.90–1.00 was considered very good, 0.70–0.89 good, and 0.50–0.69 moderate. The weighted kappa coefficient of 0.81–1.00 was considered very good, 0.61–0.80 good, and 0.41–60 moderate [18]. The association between the individual items and the total SBM-K score was analyzed based on the Spearman correlation coefficient, and internal consistency reliability was obtained from the Cronbach's alpha coefficient of the test and retest.

The absolute reliability indices (standard error measurement, SEM) and the minimal detectable change (MDC) were calculated to determine whether the evaluation performance score responded stably in the confidence interval (95%) when the participants were repeatedly evaluated. If the SEM was less than 10% of the total average value, the MDC was less than 20% of the highest score, and the MDC% was less than 30%, the measurement error was considered to be small and the measurement was considered acceptable [19]. Furthermore, the difference in the mean of the two evaluation scores was analyzed using a t-test to determine whether there was a systematic error in the

SBM-K test-retest. In addition, the Bland–Altman method was used to investigate the pattern of inconsistency in the measured values [20]. This was indicated by a scatter plot to determine if there was a difference in the test-retest evaluation value, and the 95% limits of agreement were estimated. For the validity of SBM-K, the correlation of SBM-K with mSBS and the KSCIM-III self-care, mobility items, and total score was obtained using Spearman's correlation, and the correlation was considered weak ($r = 0.25–0.50$), good ($r = 0.51–0.75$), or very good ($r \geq 0.75$) [21]. Univariate linear regression was performed to evaluate the effect of SBM-K on the functional independence level (KSCIM-III). The significance level was set at $\alpha = 0.05$.

Table 1. Characteristics of the participants ($n = 29$).

Characteristic		***n* (%) or M ± SD (min–max)**
Sex (Male/Female)		20 (69%)/9 (31%)
Age (years)		41.14 ± 19.94 (21–75)
Injury level	C7	7 (24.1%)
(Motor)	C8	4 (13.8%)
	T2	2 (6.9%)
	T3	4 (13.8%)
	T4	1 (3.4%)
	T9	2 (6.9%)
	T10	1 (3.4%)
	T11	3 (10.3%)
	L1	4 (13.8%)
	L2	1 (3.4%)
Time since injury (months)		10.62 ± 5.08 (4–22)
ASIA grade	B	11 (37.9%)
	C	9 (31.0%)
	D	9 (31.0%)
mSBS (score)		2.97 ± 1.10 (1–4)
KSCIM-III	Self-care	9.62 ± 4.64 (2–20)
(score)	Respiration and sphincter management	28.72 ± 7.74 (15–39)
	Mobility-room and toilet	7.07 ± 2.67 (0–10)
	Mobility-indoors and outdoors	6.38 ± 5.19 (0–30)
	Total	51.52 ± 15.68

SD Standard deviation, *ASIA* American Spinal Cord Injury Association, *mSBS* modified Sitting Balance Score, *KSCIM-III* Korean-Spinal Cord Independence Measure-III.

RESULTS

Characteristics of the participants

Twenty-nine participants (20 men [69%], 9 women [31%]) participated in this study, and the average age was 41.14 years. Eleven, thirteen, and five participants had an injury at the level of C7–C8, T2–T11, and L1–L2, respectively, and the average time since injury was 10.62 months according to the ASIA classification; 11 people (37.9%) were stage B, and stage C and D each comprised 9 (31%) people. The average mSBS score was 2.97. The KSCIM-III scores were 9.62 for self-management, 29.72 for respiration and sphincter Management, 7.07 for room and toilet mobility, 6.38 for indoor/outdoor/on even surface mobility, and 51.52 for the total score (Table 1).

Test-retest reliability of individual SBM-K items

Among individual SBM-K items, the reliability of sits with back unsupported ($K = 0.83$) was very good, sits with eyes closed ($K = 0.77$) was good, and turns head and trunk to the right, looked behind, returned to the starting position ($K = 0.81$) was very good, and turns head and trunk to the left, looks behind, and returns to the starting position ($K = 0.76$) was good. The correlation of the SBM-K total score with individual items was $r = 0.78–0.98$, and the internal consistency of SBM-K test and retest items was high at 0.98 and 0.97, respectively (Table 2).

Test-retest reliability of the SBM-K total score

The test-retest reliability ICC of the SBM-K total score was 0.98 (95% CI, 0.95–0.99), indicating a high rate of agreement. SEM was 0.59 and was less than 10% (0.84) of the average score (8.48), while MDC was 1.64 and was less than 20% (2.4) of the highest score (12); percentage MDC was 19.3%, which is acceptable. There was no systematic error because of no significant difference in the mean value between the SBM-K test-retest ($p = 0.09$). In the Bland–Altman scatter plot, the limit of agreement ranged from −1.38 to 1.92, and the variation (error range) of the mean difference between test and retests was reliable (Table 3, Fig. 1).

Correlation of SBM-K with mSBS and KSCIM-III

The validity of SBM-K was confirmed to have a very high correlation with mSBS ($r = 0.88$) and with KSCIM-III: self-care ($r = 0.87$), respiration and sphincter management ($r = 0.65$), mobility room and toilet ($r = 0.77$), mobility indoors and outdoors ($r = 0.70$), and total score ($r = 0.89$) (Table 4).

Univariate linear regression analysis of the relationship between SBM-K and KSCIM-III

SBM-K was shown to be associated with KSCIM-III: self-care (65%), respiration and sphincter management (38%), mobile room and bathroom (54%), mobility indoors and outdoors (17%), and total score (72%) (see Supplementary Table S1).

Table 2. Test-retest reliability of SBM-K individual items ($n = 29$).

Item of SBM	**1st test**	**2nd test**	**Kappa**	**Interpretation**	**Agreement**	**Spearman coefficient**
	Mean ± SD (Min–Max)				**(%)**	**(*r*)**
Sits with back unsupported	2.59 ± 0.87 (0–3)	2.52 ± 0.87 (0–3)	0.83	Very good	93	0.79*
Sits with eyes closed	2.35 ± 1.01 (0–3)	2.21 ± 1.05 (0–3)	0.77	Good	86	0.78*
Turns head and trunk to the right, looks behind, and returns to the starting position	1.86 ± 1.22 (0–3)	1.79 ± 1.11 (0–3)	0.81	Very good	89	0.98*
Turns head and trunk to the left, looks behind, and returns to the starting position	1.86 ± 1.21 (0–3)	1.83 ± 1.07 (0–3)	0.76	Good	82	0.95*

SBM Sitting Balance Measure, *SD* standard deviation.
*$p < 0.01$.

Table 3. Test-retest reliability of the SBM-K total score ($n = 29$).

Measure	Mean (SD)		Mean difference	$ICC_{2,1}$	SEM	SRD	*P*	95% CI	
	Median (IQR)		(SD)	(95% CI)		(SRD%)		Lower	Upper
	Range								
	1st test	2nd test							
SBM-K	8.62 (4.14)	8.35 (3.81)	0.27	0.98	0.59	1.64	0.09		
total	10 (6.5–12)	10 (5.5–11.5)	0.84	(0.95–0.99)		−19.3		−0.044	0.596
Score (sum)	0–12	0–12							

SD standard deviation, *IQR* interquartile range, *ICC* intraclass correlation coefficient, *CI* confidence interval, *SEM* standard error of measurement, *SD* standard deviation of all the test-retest scores ×√(1-ICC), *MDC* minimal detectable change = 1.96 × SEM × √2, MDC% = (MDC/mean of measurements taken) × 100%. *P* value was based on the paired *t*-test, *SBM-K* Sitting Balance Measure-Korean.

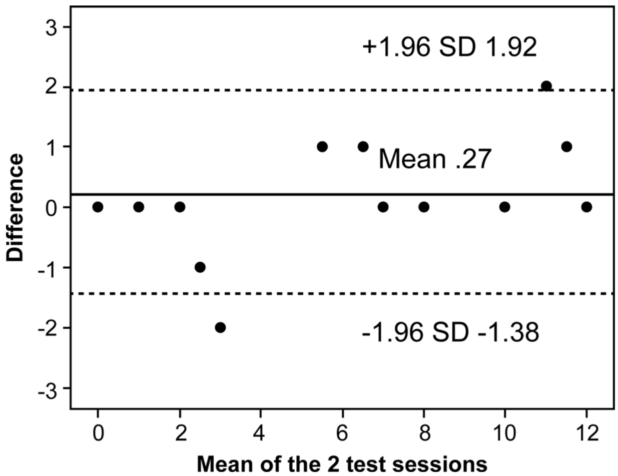

Fig. 1 Bland–Altman plot for the differences between measurements from the two test sessions against the mean of the two test sessions for each subject. The limit of agreement for the Sitting Balance Measure-Korean (SBM-K) ranged from −1.38 to 1.92. The solid line indicates the mean difference and the two dashed lines indicate the 95% limit of agreement (mean difference ± 1.96 × SD of the difference).

Table 4. Correlation of SBM-K with mSBS and KSCIM-III ($n = 29$).

Parameters	Correlation coefficient
mSBS	0.88*
KSCIM-III: Self-care	0.87*
KSCIM-III: Respiration and sphincter management	0.65*
KSCIM-III: Mobility-room and toilet	0.77*
KSCIM-III: Mobility-indoors and outdoors	0.70*
KSCIM-III: Total	0.89*

mSBS modified Sitting Balance Score, *KSCIM-III* Korean-Spinal Cord Independence Measure- III.
*$p < 0.01$

DISCUSSION

The assessment of sitting balance after spinal cord injury is an important part of planning treatment goals and the clinical management of patients [6]. In addition, the time required for evaluation should be short, and the evaluation should be simple and easy to interpret. In this study, we determined the reliability of the test-retest of individual SBM-K items and the total SBM-K scores. The correlation between the individual items and the total SBM-K scores was positive ($r = 0.78$–0.98), and the internal consistency reliability of the first test in SBM-K was 0.98, which was similar to the 0.96–98 reported by Wadhwa et al. [5]. The notable correlation between SBM-K individual items and total score means that the items are being evaluated for similar characteristics, and that the SBM-K individual items themselves fully reflect the sitting balance abilities of individuals with spinal cord injury. Agreement is considered good if the weighted kappa coefficient ≥0.70 (good), and reliability is considered good if Cronbach's alpha ≥0.80 [18]. The reliability of individual items and total SBM scores were not reported in previous studies. In our study, the weighted kappa coefficient for SBM-K individual items was found to be 0.76–0.83 (good, very good), and the tester had clear criteria for the correct definition and scoring of SBM evaluation items; thus, there was no significant difficulty in evaluating the participants. A general reliability survey analyzed three problems of error, influenced by correlation with tasks or variables, and structural problems in the tester's concordance and assessment tools [22]. In our study, the correlation between SBM-K individual items and total scores, the internal consistency reliability, and the weighted kappa coefficient of the test-retest for each item was confirmed to be high, which was sufficient to prove the reliability of SBM-K.

The ICC for SBM-K total score was 0.98, which showed a high concordance rate, and in a similar experimental study, it was reported that the concordance rate was higher than that of the mFRT total score which was 0.85–0.94 [23]. However, ICC provides relative reliability [24], and when participant evaluation is repeatedly conducted, the agreement rate is high; thus, the learning effect of reevaluation cannot be excluded [24, 25]. It is difficult for clinicians and researchers to determine whether the assessment score shows consistent reliability when repeated evaluations are applied to patients or if the actual score changes because of measurement errors. ICC shows the consistency of test scores during repeated measurements, but cannot determine the true score (observational score-error) of each individual, and the discrepancy between evaluations and the size of the measurement error are unknown [24, 25]. Random measurement errors that occur in the evaluation can be quantified by SEM and MDC, which are absolute reliability indices that evaluate the stability of the reaction [26, 27].

Since SEM refers to the size of the measurement error caused by chance variation during measurement, it provides information regarding the reliability of the participants' evaluation scores. MDC is an important indicator for clinical decision-making; it is used as a baseline for determining the effectiveness of interventions or predicting functional recovery [26]. In this study, the SEM of SBM-K was 0.59, which was less than 10% (0.84) of the SBM-K average score of 8.48 (test-retest average score), and MDC was 1.64, which was less than 20% (2.4) of the highest SBM-K score (12); MDC% was 19.3% (less than 30%), and the measurement error range was acceptable. In addition, the MDC score of the participants was not affected by measurement errors and chance variation, meaning that a sitting balance ability of 1.85 or more after treatment can be improved (or worsened) from the current SBM-K score of 8.48. Generally, highly reliable tests should have high ICC values and low SEM and MDC values [14], which was sufficiently demonstrated in our study. In addition, since there was no significant difference in the mean value between test-retest in SBM-K evaluation, it was confirmed that there was no systematic error ($p = 0.09$).

In our analysis, the Bland–Altman method was used to estimate the size of the rate of agreement between the test-retest of SBM-K. The limit of agreement of SBM-K was −1.38 to 1.92. Thus, there was no correlation between the mean value and the mean of the test-retest. The difference between the SBM-K test-retest and the evaluated result value exists within the 95% CI based on the 0 point; thus, it was normally distributed, and there was no systematic error, making it reliable. Therefore, SBM-K was demonstrated to be a sufficiently sensitive tool for evaluating the sitting balance ability of individuals with incomplete spinal cord injury.

SBM-K was confirmed to be highly correlated with mSBS ($r = 0.88$) and with KSCIM-III – self-care ($r = 0.88$), respiration and sphincter management ($r = 0.65$), mobile room and bathroom ($r = 0.77$), mobility indoors and outdoors ($r = 0.70$), and total score ($r = 0.89$). A similar experimental study reported a very notable correlation between the Trunk Control Test of people with spinal cord injury and the total score of KSCIM-III ($r = 0.87$) [6]. The correlation coefficient reflects the degree of correlation between the two variables and cannot explain the causal relationship between the explanatory and response variable. Our results showed that SBM-K was significantly associated with KSCIM-III self-care, respiration and sphincter management, mobile room and bathroom, mobility indoors and outdoors, and total points. In this context, the ability to maintain and control sitting balance and posture is an essential factor that precedes movements that enable independent activities of daily living, and it should be emphasized in the treatment process along with upper and lower extremity function training.

Regarding the limitations of this study, the average age, gender ratio, incidence and prevalence of the participants, diverse areas of spinal cord injury, proprioceptive sensation of the trunk and upper and lower extremities, spasticity, and the muscle strength of the trunk and limbs could not be fully controlled. Additionally, SBM primarily focuses on task performance rather than movement quality, and most of the individuals with thoracic spine injuries in this study had compensatory strategies (e.g., excessive anterior flexion of the trunk and use of latissimus dorsi, trapezius). Therefore, in future studies, based on the ASIA classification, trunk and limb muscle strength, proprioceptive sensation, plantar pressure, posture fluctuation, and center of gravity, a quantitative and systematic analysis of the correlation between the spinal cord injury areas and SBM needs to be performed.

CONCLUSION

The test-retest reliability of individual items and total scores of SBM-K was very high, and the validities of mSBS and KSCIM-III were significantly correlated. In addition, when SBM-K was repeatedly evaluated, the absolute reliability index, SEM, and the MDC score for distinguishing whether the evaluation performance responded stably in the confidence interval (95%) influenced the measurement error caused by chance variation. SBM-K was confirmed as a reliable method for evaluating the sitting balance of individuals with incomplete spinal cord injury in the clinical setting. Therefore, SBM can serve as an efficient clinical method for clinicians and researchers to assess sitting balance and monitor functional changes in those with incomplete spinal cord injury.

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COMPETING INTERESTS

The authors declare no competing interests.

ETHICS STATEMENT

The study was approved by the National Rehabilitation Hospital Institutional Review Board (IRB File No. NRC-2019-05-032). All participants received explanations of the study protocol, and written informed consent was obtained.

ADDITIONAL INFORMATION

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