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ORIGINAL ARTICLE

Development, validity and reliability of the 'Sitting Balance Measure' (SBM) in spinal cord injury

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Study design: This is a methodological research design.
Objectives: Spinal cord injury (SCI) may result in the inability to sit unsupported. This may lead to difficulty performing daily living activities. To make the subjects with SCI independent in their daily living to the maximum possible extent, therapists provide them balance training for which they may require to assess the sitting balance. This study aims to develop an objective measure 'Sitting Balance Measure' (SBM) for the assessment of sitting balance of the subjects with SCI, and to determine its content validity and internal consistency reliability.
Setting: This study was conducted in New Delhi, India.
Methods: The study was conducted in three phases, namely planning, construction and quantitative evaluation phase. Thirty-six items were generated through the review of literature and semistructured interviews. Qualitative and quantitative content validation through the expert opinion and the content validity ratio (CVR) method resulted in the 24-item scale, which was pilot-tested on a purposive sample of 30 subjects with SCI. Item analysis was conducted to determine internal consistency reliability.
Results: CVR method and qualitative review by the experts validated the content of SBM. The SBM has high internal consistency reliability (Cronbach's alpha = 0.96).
Conclusion: SBM is a valid scale for the assessment of sitting balance in subjects with SCI. Internal consistency reliability of SBM is high. This may be indicative of item redundancy, which necessitates the need for the second pilot test to refine the scale further.
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INTRODUCTION

Spinal cord injury (SCI) is an insult to the spinal cord resulting in a change, either temporary or permanent, in its normal motor, sensory or autonomic function.[1] As a result of paralysis and sensory loss, individuals with SCI have impaired sitting balance. The ability to maintain or attain sitting balance is believed to be necessary to perform functional activities such as dressing, transferring and eating in a seated position.[2] Good sitting balance and the ability to move within this posture are also critical prerequisite skills to standing.[3] Hence, to make the subjects with SCI independent in their daily living to the maximum possible extent, therapists spend a significant time providing balance training to those individuals who cannot sit unsupported. An individualized balance training program is designed depending on the abilities of the individuals with SCI to sit unsupported. To assess their sitting balance abilities, valid and reliable assessment measures are required.

There are a few existing measures to assess sitting balance of the subjects with SCI. The review of literature reveals that force plates and electromyography (EMG) surface electrodes are being used to measure changes in center of pressure, postural sway and muscle activation.[4] These measures provide precise and objective data, but they are not commonly used because of several reasons. First, force plates are expensive to purchase. Second, they require a separate and adequate space to be installed. Third, personnel operating these measures must be trained properly to collect and analyze data. As force plates and electromyograph are not available in all the clinical settings, the therapists measuring sitting balance generally use a subjective scoring of poor, fair, good and normal. However, this method of assessing sitting balance is subjective, and its validity and reliability has not been established. The available evidence shows that most of the standardized instruments for assessing balance have been developed for overall balance abilities of an individual and do not focus on sitting balance specifically, such as BBS (Berg Balance Scale), POMA (Performance-Oriented Mobility Assessment), CTSIB (Clinical Test of Sensory Interaction and Balance) and SOT (Sensory Organization Test). Hence, many items of these scales are not appropriate for those subjects with SCI who cannot stand and walk.

Some of the standardized scales that have been specifically developed for assessment of sitting balance are SBS (Sitting Balance Scale), FIST (Function in Sitting Test), SitBAT (Sitting Balance Assessment Tool), modified FRT (modified Functional Reach Test) and so on. Among these, only modified FRT has been proven to be reliable for SCI, whereas the rest of the scales have been targeted at other populations and their psychometric properties have not been established for subjects with SCI. Modified FRT covers only one aspect of task to encompass the sitting balance—that is, forward reach.

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In addition, it is not applicable for SCI subjects with limited range of motion, as it requires an individual to perform forward reach with 90 degrees of shoulder flexion.

Hence, because of the dearth of objective and comprehensive measures for the assessment of sitting balance, the aim of this study was to develop a measure for the assessment of sitting balance and to determine its validity and reliability in subjects with SCI.

MATERIALS AND METHODS

This study was approved by Research Review Committee and Institutional Ethics Committee of Indian Spinal Injuries Centre, New Delhi, India. The study design followed was a methodological research design. The study was conducted in three phases, namely planning phase, construction phase and quantitative evaluation phase.[5]

Planning phase

The initial step (step 1) of the planning phase began by stating the purpose of the scale to be developed and the target group for whom the scale was intended. The purpose of the scale was to assess sitting balance, and the target group was the subjects with SCI. Step 2 involved review of the related literature followed by semistructured interviews. A thorough review of the literature was done to understand the various aspects of balance and the instruments that already exist for the assessment of balance. In addition, the scale to be developed was named as 'Sitting Balance Measure' (SBM) so that it clearly reflected its purpose. Subsequently, open-ended questions were formulated for one-to-one interviews in order to gain in-depth knowledge regarding the domain of sitting balance. Carefully structured, open-ended interviews with members of the target population and experts can increase the chance that items and other elements are representatives of and relevant to the facets of the construct.[6] Therefore, a total of 22 participants were interviewed. Among them, there were 12 subjects with SCI, 5 caretakers of subjects with SCI and 5 health-care professionals dealing with SCI clients (including one spine surgeon, two occupational therapists and two physical therapists). The open-ended comments of the semistructured interviews were interpreted.

Construction phase

The construction phase included steps 3 and 4. Step 3 comprised writing specific objectives of the scale, selecting item format and creating an initial draft of the scale. The specific objectives of the scale listed were to assess sitting balance in all the functional sitting positions, and during both static and dynamic tasks. The four content areas of the scale identified as a result of the formulation of these objectives were as follows: static short sitting balance, dynamic short sitting balance, static long sitting balance and dynamic long sitting balance. Items were generated to assess each specific content area on the basis of the review of related literature and the themes derived from the interviews. 'Static short sitting balance' and 'static long sitting balance' contained 4 items each, and 'dynamic short sitting balance' and 'dynamic long sitting balance' contained 14 items each. Hence, the initial draft of the scale consisted of 36 items. The scoring system developed for obtaining the score of each item was an ordinal scale. The score of each item ranged from 0 to 3. After these steps, the constructed scale was reviewed by three occupational therapy professionals. No changes were suggested, and thus face validity of the scale was established.

Step 4 involved content validation. The three stages in establishing content validity were as follows:[7]

1. Establishment of a panel of experts—Ten rehabilitation professionals (including five occupational therapists and five physical therapists) and ten subjects with SCI comprised the panel of experts.
2. Qualitative review of scale items—The experts were requested to provide their valuable feedback on the title of the scale, directions, content areas covered and response options/scoring of the items.
3. Quantitative review of scale items—The experts were asked to rate the appropriateness of each item of the scale as being:[8]

- Essential
- Useful but not essential, or
- Not necessary

The ratings of all the experts were entered into a Microsoft excel spreadsheet as per the following coding:

1 = essential, 2 = useful but not essential, 3 = not necessary.

The content validity ratio (CVR) was calculated for each item using the following formula:[9]

$$\mathrm{CVR} = \frac{n_e - (N/2)}{N/2}$$

where n_e is the number of panelists/experts indicating 'essential' and N is the total number of panelists/experts.

The calculated CVRs were then compared with the value required according to the Schipper's table.[9] Items with CVR values meeting the minimum value required were retained in the scale. After implementing the changes due to qualitative and quantitative reviews of the scale, the scale consisted of 24 items.

Quantitative evaluation phase

This phase comprised of steps 5 and 6. Step 5 involved pilot testing of the 24-item scale on a purposive sample of 30 subjects with SCI. Medically stable, both male and female, subjects with SCI (including traumatic and non-traumatic cases); subjects with all levels of injury of the spinal cord; subjects with age 18 years and above; and subjects having the ability to understand English were included in the pilot test. The exclusion criteria were subjects with spinal shock; associated head injury; any associated diagnosed psychiatric condition; or any other diagnosed condition that might affect balance. The equipment used in the pilot test was one chair without armrests, one hospital bed/plinth, a stopwatch, a measuring tape and a foot stool. The participants were asked to perform the items of the scale, and the score sheet was filled accordingly. Step 6 included the item analysis of the data collected in the pilot test.

Statistical analyses

Descriptive statistics was used to describe the characteristics of the participants. Face validity was established through review of the scale by the occupational therapy professionals. Content validity of the SBM was established through calculation of CVR and content validity index.[9] Internal consistency reliability was determined by calculating Cronbach's coefficient alpha to provide information for item reduction. Item analysis using inter-item correlations was conducted by computing Pearson's correlation coefficient (r) for the items. All statistical calculations were performed with IBM Statistical Package for Social Sciences (SPSS) version 19 (SPSS South Asia Pvt. Ltd, Bangalore, India).

Statement of ethics

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

RESULTS

The results of each phase of the study are summarized separately.

Planning phase

During the planning phase, reviewing related literature and conducting semistructured interviews resulted in the generation of a pool of appropriate items for the initial draft of the scale.

Construction phase

To determine content validity of SBM, the items having a minimum CVR of 0.42 were retained, as the number of experts included in the

panel was 20.[9] Hence, 12 items with a CVR less than 0.42 were deleted from the initial 36-item scale, resulting in the 24-item scale. The items deleted were related to sitting with eyes open on a foam/pillow, sitting with eyes closed on a foam/pillow and scooting in anterior, posterior and lateral directions, both in short sitting and in long sitting positions. The item of 'sits with eyes open', in the content areas of both 'static short sitting balance' and 'static long sitting balance', was replaced by the two new items 'sits with back unsupported' in the same content areas based on the comments given by the experts on reviewing the scale qualitatively. On conducting the second round of content validity with this 24-item scale, CVR values of all the 24 items were more than 0.42, and thus all these items were retained. Content validity index was computed for the whole scale by calculating the mean of the CVR values of the retained items,[9] which was found to be 0.925.

Quantitative evaluation phase

The mean of the score for a sample ($N=30$) of 24 items of the scale ranged from 0.73 to 2.67 (Table 1). The descriptive statistics of items revealed a breadth of scores for all the items; that is, the scoring of the subjects covered the criteria set as minimum to the maximum score for most of the items.

Item analysis using inter-item correlations identifies those items that are too similar, and thus it was performed to suggest items that could be discarded to improve the scale's homogeneity. The inter-item correlation is the Pearson's correlation coefficient (r) computed for a pair of items.[10] The inter-item correlations ranged from 0.35 to 0.99 (Table 2). Significance level was kept at $P<0.05$. High inter-item correlations (>0.8) suggest that these are indeed repetitions of each

Table 1 Descriptive statistics (mean of scores and standard deviation of items for subjects, $N=30$)

Item number	*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Item 1	1	3	2.67	0.711
Item 2	0	3	1.93	1.311
Item 3	0	3	1.03	1.129
Item 4	0	3	1.03	1.129
Item 5	0	3	1.53	1.196
Item 6	0	3	0.80	1.095
Item 7	0	3	0.80	0.961
Item 8	0	3	0.83	1.020
Item 9	0	3	1.70	1.418
Item 10	0	3	1.23	1.223
Item 11	0	3	1.60	1.329
Item 12	0	3	1.57	1.305
Item 13	1	3	2.53	0.860
Item 14	0	3	1.97	1.299
Item 15	0	3	1.00	1.114
Item 16	0	3	1.03	1.159
Item 17	0	3	1.57	1.165
Item 18	0	3	1.50	1.358
Item 19	0	2	0.73	0.785
Item 20	0	2	0.77	0.774
Item 21	0	3	1.90	1.423
Item 22	0	3	1.57	1.357
Item 23	0	3	1.50	1.253
Item 24	0	3	1.53	1.306

Table 2 Inter-item correlation matrix of items of SBM

	Item 1	*Item 2*	*Item 3*	*Item 4*	*Item 5*	*Item 6*	*Item 7*	*Item 8*	*Item 9*	*Item 10*	*Item 11*	*Item 12*	*Item 13*	*Item 14*	*Item 15*	*Item 16*	*Item 17*	*Item 18*	*Item 19*	*Item 20*	*Item 21*	*Item 22*	*Item 23*	*Item 24*
Item 1	1.000																							
Item 2	0.715	1.000																						
Item 3	0.444	0.677	1.000																					
Item 4	0.444	0.677	1.000	1.000																				
Item 5	0.622	0.815	0.753	0.753	1.000																			
Item 6	0.354	0.567	0.563	0.563	0.637	1.000																		
Item 7	0.404	0.564	0.705	0.705	0.726	0.779	1.000																	
Item 8	0.396	0.559	0.724	0.724	0.726	0.802	0.985	1.000																
Item 9	0.581	0.657	0.674	0.674	0.850	0.626	0.764	0.751	1.000															
Item 10	0.489	0.698	0.644	0.644	0.855	0.731	0.716	0.723	0.837	1.000														
Item 11	0.584	0.776	0.791	0.791	0.920	0.654	0.718	0.712	0.886	0.887	1.000													
Item 12	0.582	0.769	0.783	0.783	0.905	0.637	0.698	0.695	0.878	0.844	0.971	1.000												
Item 13	0.864	0.644	0.514	0.514	0.720	0.410	0.467	0.458	0.673	0.566	0.676	0.674	1.000											
Item 14	0.734	0.869	0.682	0.682	0.900	0.552	0.574	0.568	0.724	0.721	0.831	0.825	0.849	1.000										
Item 15	0.435	0.637	0.959	0.959	0.725	0.565	0.740	0.759	0.698	0.658	0.792	0.783	0.504	0.643	1.000									
Item 16	0.432	0.637	0.948	0.948	0.733	0.521	0.718	0.734	0.699	0.675	0.793	0.785	0.500	0.642	0.988	1.000								
Item 17	0.652	0.748	0.693	0.693	0.964	0.632	0.720	0.721	0.837	0.799	0.887	0.870	0.754	0.878	0.691	0.675	1.000							
Item 18	0.535	0.833	0.686	0.686	0.849	0.672	0.607	0.610	0.743	0.820	0.822	0.808	0.620	0.830	0.684	0.690	0.774	1.000						
Item 19	0.453	0.619	0.594	0.594	0.781	0.698	0.749	0.761	0.793	0.714	0.688	0.691	0.524	0.633	0.631	0.616	0.774	0.744	1.000					
Item 20	0.480	0.664	0.680	0.680	0.810	0.675	0.816	0.823	0.845	0.715	0.744	0.750	0.556	0.678	0.720	0.701	0.802	0.738	0.973	1.000				
Item 21	0.648	0.662	0.582	0.582	0.843	0.540	0.666	0.654	0.891	0.747	0.817	0.812	0.749	0.782	0.587	0.588	0.888	0.723	0.747	0.792	1.000			
Item 22	0.560	0.797	0.595	0.595	0.891	0.659	0.645	0.644	0.826	0.853	0.838	0.845	0.648	0.833	0.570	0.580	0.859	0.889	0.827	0.820	0.870	1.000		
Item 23	0.581	0.756	0.695	0.695	0.875	0.603	0.659	0.661	0.903	0.844	0.953	0.939	0.672	0.816	0.692	0.701	0.839	0.780	0.666	0.729	0.842	0.842	1.000	
Item 24	0.569	0.746	0.712	0.712	0.893	0.607	0.692	0.690	0.909	0.869	0.942	0.970	0.659	0.803	0.735	0.739	0.860	0.797	0.715	0.776	0.828	0.855	0.949	1.000

other (sometimes referred to as bloated specifics) and are in essence asking the same question.[11] Therefore, items with very high (>0.8) inter-item correlations were flagged for potential elimination, as these items were very closely correlated so as to result in redundancy.

For a given item, if more than 7 of the 23 inter-item correlations fell outside the optimal range, then that item was flagged for elimination. On the basis of this criterion, 10 items were suggested for elimination. The available literature concludes that the items should be retained if they are deemed to be theoretically important even if they do not meet the statistical criteria.[11] Hence, these items were considered in the light of clinical relevance and their theoretical importance. Among these 10 items, 2 items 'sits with eyes closed' and 'posterior external perturbations in sitting' were not eliminated, as these were considered to be clinically important. As SCI usually results in sensory and motor impairments, a subject with deficit in the sensation of proprioception might compensate with other senses such as vision in order to maintain sitting balance. Hence, it is important to assess sitting balance of a subject with SCI with eyes closed. The external perturbation provides a mechanism of assessing the reactive balance control of the subjects with SCI. Therefore, this item was also retained. Considering both the results of item analysis and the clinical relevance of each item, 8 items were deleted from the 24-item SBM, resulting in a total of 16 items (Appendix shows few items of the SBM). The Cronbach's alpha for this revised 16-item SBM was computed as 0.967, which indicates item redundancy,[12] and thus a second pilot test using this 16-item SBM is recommended in future studies.

DISCUSSION

This study has resulted in the development of a measure 'SBM' for assessment of sitting balance in subjects with SCI. SBM is a performance-based scale that includes 16 items being scored by the examiner on an ordinal scale of 0–3. A score of '0' indicates minimum balance ability and '3' indicates maximum balance ability. The equipment required for the administration of the SBM is one hospital bed/plinth, one chair without armrests, a measuring tape, a stopwatch and a foot stool. These equipments are generally easily available in any clinical setting, as against the force plates and electromyography surface electrodes.

SBM measures a number of components that are considered to be essential when measuring sitting balance. These include the ability to (1) control sitting balance statically during quiet sitting (steady state control), (2) move oneself in sitting while maintaining seated postural control (proactive control), and (3) maintain seated postural control during external perturbations (reactive control). Thus, the items of SBM have been designed to assess maximum components related to various aspects of sitting balance.

Clinical relevance

SBM can help the rehabilitation professionals and other clinicians in assessment of the sitting balance of SCI subjects objectively, and design their balance training program accordingly, as it gives a clear picture of the tasks in which the client loses balance or is having inadequate balance. The measurement of balance through administration of SBM may also help the clinician in prescribing the appropriate type of wheelchair and its seating system for the subjects with SCI.

Limitations of the study

The sample size for the pilot test was not statistically estimated, as the prevalence rate for the SCI population in India was not available owing to lack of any reliable database.

Future research

1. A pilot test of the 16-item SBM needs to be done in future studies.
2. Floor and ceiling effects need to be detected.
3. Test–retest reliability and sensitivity to change need to be determined in future studies.

CONCLUSION

The SBM provides a measure for rehabilitation professionals and other clinicians for documenting the sitting balance of the subjects with SCI objectively and comprehensively. The content validity of this newly developed measure of sitting balance is established, and its internal consistency reliability is estimated as Cronbach's alpha = 0.967.

DATA ARCHIVING

There was no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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APPENDIX

Few items of the SBM

Administration of items (items 1–8):

The subject should be seated in a chair without armrests. The back of the subject should be unsupported/not touching the back of the chair. The hips and knees should be flexed to 90 degrees or in sufficient flexion to permit short sitting position. The feet should be supported on floor/foot stool, as required.

Static short sitting balance

1. **Sits with back unsupported**

   Instructions: *Please sit up as straight as you can, using your upper extremities, if required.*

   Scoring:

   (3) Able to sit without the support of upper extremities
   (2) Able to sit with the support of one upper extremity

(1) Able to sit with the support of both upper extremities
(0) Unable to sit without support

2. **Sits with eyes closed**
Instructions: *Please sit up as straight as you can, without using upper extremities for support, for 30 seconds.*
Scoring:
(3) Able to sit for 30 seconds
(2) Able to sit for ⩾15 seconds and less than 30 seconds
(1) Able to sit for less than 15 seconds
(0) Unable to sit without support

Dynamic short sitting balance

3. **Turns head and trunk to the right, looks behind and returns to the starting position**
Instructions: *Please turn around to your right, look behind and then return to the starting position, without using your upper extremities for support.*
Scoring:
(3) Able to turn completely and return to the starting position
(2) Able to turn more than the midrange and return to the starting position
(1) Able to turn less than or equal to midrange and return to the starting position
(0) Loses balance when trying to turn head and trunk/unable to turn head and trunk

4. **Turns head and trunk to the left, looks behind and returns to the starting position**
Instructions: *Please turn around to your left, look behind, and then return to the starting position, without using your upper extremities for support.*
Scoring:
(3) Able to turn completely and return to the starting position
(2) Able to turn more than the midrange and return to the starting position
(1) Able to turn less than or equal to the midrange and return to the starting position
(0) Loses balance when trying to turn head and trunk/unable to turn head and trunk