

[REVIEW]**Sitting And Standing Balance Assessment Tools In Patients With Spinal Cord Injury: A Systematic Review.****Gaikwad Stuti N.¹, Harishchandre Maheshwari², Prof. Dr. Ganvir Suvarna (PhD)³**¹M.P.T. Student, ²Associate Professor, ³Professor and HOD

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ABSTRACT :

Background: The effectiveness of interventions depend on utility of a specific common set of clinical tools that has ability to assess important clinical outcomes.

Objective: To identify clinical assessment tools for assessing unsupported sitting and standing balance in SCI population.

Methods: PubMed access provided articles with key words “spinal cord injury,” and “balance assessment”. Studies describing measurement of balance in subjects with SCI, were included.

Results: After thorough screening 9 articles showed : 3 clinical scales assessed sitting balance and seated postural control, 1 clinical scale assessed standing function, 4 scale assessed functional mobility, static and dynamic walking balance; one scale assessed risk of fall during walking and 3 sensor based tools were identified.

Conclusion: It was observed that majority studies showed assessment of standing and walking balance; and both clinical performance based and sensor based tools were used for balance assessment.

Key words: balance assessment, spinal cord injury.

Introduction

Injury to the spinal cord can lead to changes which may be temporary or permanent in relation to its motor, sensory and autonomic functions.^[1] Damage to the spinal cord causes disability in this population and varies according to the extent of injury, the level of spinal cord at which the injury has occurred and to what length the nerve fibers have been damaged. Due to nerve fiber damage the sensory and motor nerve fiber destructions lead to disturbed efferent connections and impairments in the sensory system which alters or completely hampers the touch, pressure and warm sensations. This causes limb dysfunctions resulting in impaired balance during sitting, standing positions and walking.^[2] The functional status and quality of life is adversely affected due to the impairments in the spinal cord. This is primarily related to the level of vertebra involved and the extent of the lesion sustained by the spinal cord. These

patients when try maintaining a sitting position and functioning for daily activities in sitting posture can lead to increased risks of postural instability and falls. This may have deleterious outcomes on their ability to carry out various activities of daily living or their confidence while balancing, which may, in turn, disturb their participation in society and community.^[3] In the otherwise healthy population, the ability of sitting unsupported requires the coordinated use of the entire body, the legs, the trunk, the upper limbs, and the head, along with feedback from the sensory system.^[1] This motor activity essential for gross movements is therefore vital for population with SCI because they perform most of their functional activities from sitting position.^[4]

According to the literature, few of the instruments, tools and measures which have been used to examine the unsupported sitting balance in the SCI patients in the planned environment, such as force

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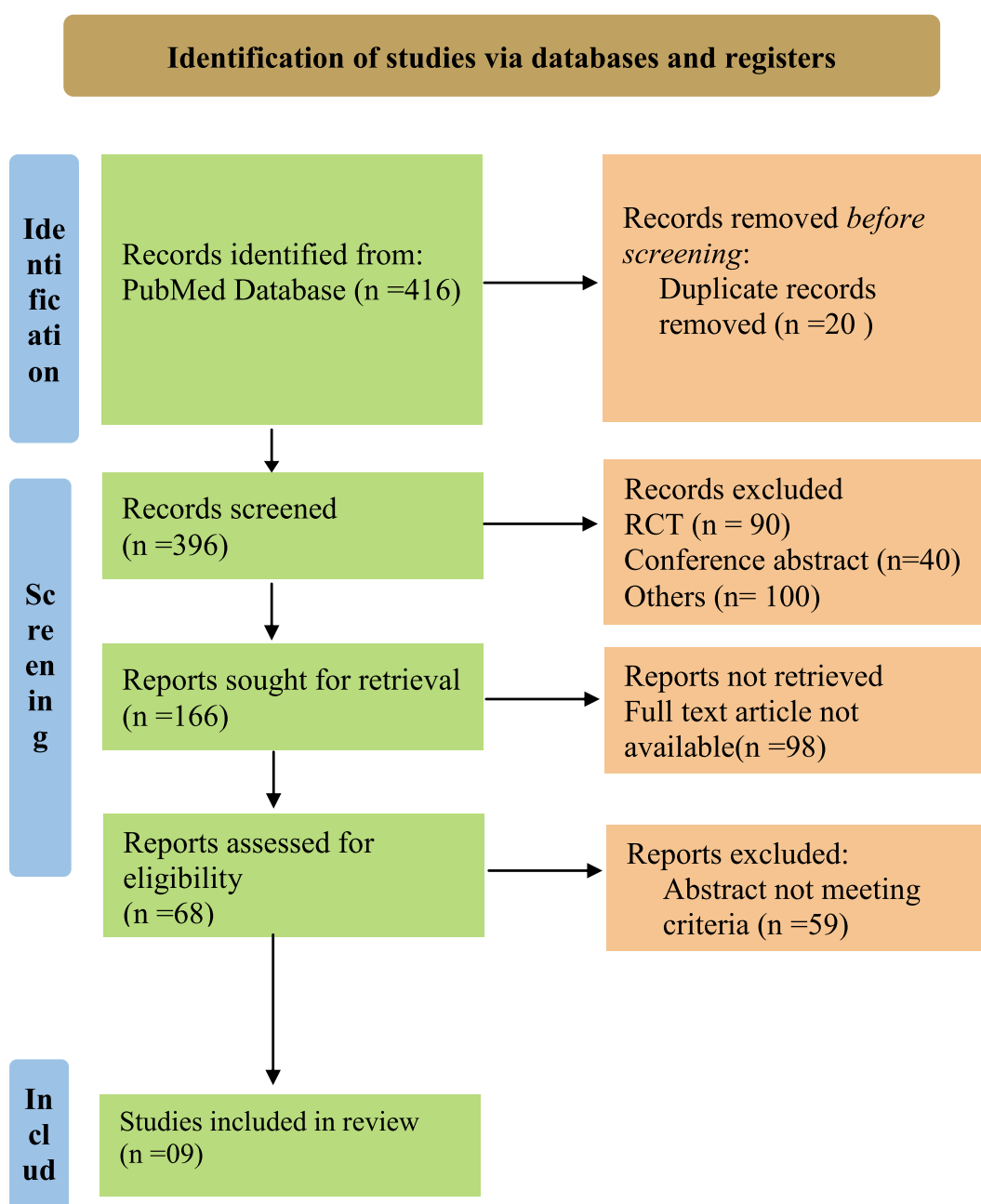


plate transducers, and limits of stability, and in clinical setups, such as the modified Functional Reach Test (mFRT). These tools or measures used in clinical settings are feasible to administer and can be taken quickly, but the assessment properties to guarantee their utility is less. Moreover, the instruments used in the clinical laboratories are expensive and sometimes inappropriate for use in planned set ups. Therefore there is need to study which of the equipments, tools can be used for the purpose of assessment which can be easily administered and taken within less time frames and must be appropriate to put into the application and analysis of the assessment properties.

Therefore, the prime objective of this systematic review was to help identify the clinical measurement tools with properties for assessing unsupported standing balance in the spinal cord injury population.^[4]

Methodology

Systematic search was undertaken in commonly used search engines (PubMed, Google Scholar for the period from January 2012 to January 2022. The search strategy comprised of the following terms: Balance assessment, Spinal Cord Injury, Sitting Balance.



Selection Criteria For Observation Studies:

Only observational studies published in English language evaluating Balance assessment in patients with spinal cord injury were included. The Exclusion criteria was Randomized control Trial (RCT), Tool Validation studies, Pilot studies.

Data Extraction:

The Data Analysis was done through various Electronic Data base searched by SG. The Title and Abstract of all the retrieved results were then screened for eligibility by SG& SG. The Screening process was aimed at narrowing down the volume of articles by rejecting the studies that are not relevant or appropriate according to previously stated criteria, Full text version of all relevant articles were evaluated by SG and SG.

Data Analysis:

The selected studies were analysed in terms of specific study design, no. of subjects included,

procedure performed, outcome measures used in the study, type of scales utilized and its specific components.

Analysis of study design helped to confirm specific type of observational study. Details of participants suggested the level of injury and duration of injury and the participants belonged to which ASIA grade. Procedure of each study revealed how the information about how the balance assessment with the help of various clinical tools and sensor based tools the data was collected. Outcome measures description included the purpose of use of each scale. Result of study produced a direction to understand the usefulness of each particular scale and how it supported the assessment of different components and till what extent it can be applied in the spinal cord injury patients and the relationship between the variables that were investigated in each study. Limitations and future scope compiled from each study may trigger the concept of new study among the readers.

Results :

Sr. No	Author	Participants	Scale	Components of Scale	Type of Scale
1.	Barthélemy D, et al. Prog Brain Res. 2015	25 SCI patients C-20,T-4,L-1	Berg Balance Scale (BBS)	Sitting to standing, standing unsupported, sitting with back unsupported, standing to sitting, transfers, standing unsupported (EC) etc	Clinical
2.	Unger J et al. Phys Ther. 2019 Apr 1	24 iSCI patients ASIA C or D	Mini-BESTest	Anticipatory, reactive postural control, sensory orientation,dynamic gait.	Clinical
			Community balance & Mobility scale	Unilateral stance, tandem walking, lateral foot scooting, walking and looking etc	Clinical
			ABC Scale	Walk around the house,walk up or down stairs, sweep the floor, step onto or off an escalator etc	Clinical
			Falls Efficacy Scale	Take a bath,walk around the house, get in and out of bed, grooming etc	Clinical

3.	Kapadia N et al. J Spinal Cord Med. 2014 Sep	27 SCI patients C2 to T12, ASIA C or D	TUG	Standing up, walking to the line on the floor, turning around and walking back to the chair and sitting down.	Clinical
4.	Ji Cheol Shin et al. Brain Sci. 2021	13 incomplete SCI Patients, C2 to T12, ASIA C or D	BBS	Sitting to standing, standing unsupported, sitting with back unsupported, standing to sitting, transfers, standing unsupported (EC) etc	Clinical
5.	Taesung In et al. NeuroRehabilitation. 2018	28 SCI patients Cervical iSCI	Postural sway length using force plate device	The force plate device measured the static and dynamic pressure of standing feet (1~120 N/cm ² , 2~5 Hz) by force sensors embedded on a plate (32×47 cm).	Sensor based system
6.	Williams AMM et al Scand J Med Sci Sports. 2020 Feb	14 SCI patients C4-T12, ASIA A,B & C	Elevated force plate (Bertec)	Static balance was assessed with eyes open (EO) and eyes closed (EC). Dynamic sitting balance was assessed by evaluating the participant's limits of stability (LOS) in the eight cardinal directions.	Sensor based system/tool
7.	Bergmann M et al. Medicina (Kaunas). 2019 Sep 21	5 SCI patients C5-C6, ASIA B/C	ConFormat Sensor model	Limits of stability (LOS; cm) were used to assess participants' dynamic sitting balance to see the able to move their COP in various directions.	Sensor based system/tool
8.	Rosanne B van Dijsseldonk et al. Front Neurol. 2018 Nov 20	15 SCI patients ASIA C or D	ABC scale	Walk around the house, walk up or down stairs, sweep the floor, step onto or off an escalator etc	Clinical
9.	Abou L et al. J Spinal Cord Med. 2022 Apr 7	59 SCI patients ASIA A or B	Function in sitting test(FIST)	Nudges, static sitting, sitting(lift foot),pick up object from behind, scooting etc.	Clinical

Discussion

The aim of this systematic review was to identify the clinical tools with assessment properties which can be used to measure the balance in unsupported sitting and standing positions in patients with SCI. Ten instruments were identified: 3 scales assess the sitting balance and seated postural control, 1 scale assesses the standing function, 4 scale assesses the functional mobility, static and dynamic walking balance, and one of the scales assess the risk of fall during walking. There were 3 sensor based tool among these which were used for assessment addressed by 3 studies.

The average range of number of participants recruited for assessment in respect to the reviewed articles were approximately around 15 to 20 participants for the studies.^[4] According to these articles researchers included the patients of cervical, thoracic and lumbar spinal levels. The cervical spinal cord level is observed to be the most level of injury in both developed and underdeveloped countries . Majority of the articles reported a lesser percentage of complete injury patients compared to the incomplete injury patients. According to one of the study on the types of disabilities caused by injury to the spinal cord, tetraplegia was identified to be more common than paraplegia in both developed countries and underdeveloped countries.^[5] The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) by the American Spinal Injury Association (ASIA) as a universal classification tool for spinal cord injuries examines the standardized sensory and motor assessment. Motor-complete injuries (America Spinal Injury Association Impairment Scale [AIS]-A or -B) were more common for SCI patients with traumatic injuries, while there were more motor incomplete injuries (AIS-C or-D) for SCI patients with Non traumatic injuries.^[5] For the reviewed studies ASIA Classification grades A, B and C patients were observed to be recruited.

Individuals with spinal cord injury (SCI) show major motor and sensory impairments below the site of injury which causes postural instability during sitting balance with no trunk support.^[5] These changes may adversely affect an individual's functionality and quality of life[1] So many of the functional activities, such as eating, dressing, and transfers, are performed in a sitting position in this population who have

paraplegia. Any disturbances in their ability to safely move the body's center of gravity toward stability may limit their wheelchair mobility and activities of daily living (ADLs). Hence, sitting balance is essential for functional independence for people who are unable to stand.^[1] These disabilities may restrict their the range of activities of daily living in SCI population.

According to the articles, all the clinical scales presented measurement properties assessment in a varying population of people with SCI (AIS A, B, C, and D) with cervical, thoracic and lumbar spinal levels involvement.^[4]

According to Datta et al the Berg Balance Scale was effective to discriminate patients with poor, moderate, and strong balance function for the population with motor incomplete SCI; however, its use varies with the functional status of the patient. According to an article an activity-based rehabilitation program induced recovery and response was studied with the help of Berg Balance Scale, as shown by the results of their longitudinal analysis in which there was effect seen in the first principal component which changed over the time to showing the recovery of the patient. Specifically, as patient's treatment was progressed, it lead to regaining of balance function. This showed that the simple items of the Berg Balance Scale gave contribution with less variability as performance of these items became consistently better.^[6]

The Timed Up And Go Test is a test which is used to assess patients' dynamic balance during a functional task. According to Christopher A et al in patients with SCI there was a strong correlation with BBS and the timed walking test. These outcome measures also study the same fundamental principles as the TUG such as balance and ambulation capabilities.^[7]

The Mini-Balance Evaluation Systems Test (mini-BESTest) assesses 4 balance control systems during standing and walking. The mini-BESTest is a valid measure of balance for individuals with iSCI [6]. This was the only clinical scale that includes an evaluation of the reactive postural control which is the mini-Balance Evaluation Systems Test (mini-BESTest); this measure was also found to be the most comprehensive balance scale previously used in the population with incomplete SCI (iSCI). The mini-BESTest assesses balance control in four aspects : anticipatory postural adjustments, reactive postural control,

sensory orientation, and dynamic gait. The studies by Jørgensen et al. and Roy et al. provided valuable insight into the psychometric characteristics of the mini-BESTest for the SCI population; however, the measure's test-retest reliability in the chronic SCI population has not been established; reliability is critical for clinical use. Moreover, the concurrent validity of the mini-BESTest has not been evaluated in any stage of recovery post-SCI, meaning mini-BESTest scores have not been shown to correlate with a "gold standard" measure of balance control.^[7]

The Community Balance and Mobility Scale (CBMS) measures high-level, ambulatory balance and is a valid measure for iSCI. The CB&M addresses several of the shortcomings which is seen in available balance measures used in patients with SCI. First, it does not seem to show a ceiling effect like the Berg balance scale. This suggests that it may be a useful balance measure for higher-functioning individuals with SCI. Second, the majority of tasks on the CB&M involve walking activities, such as running, hopping and negotiating stairs. First, the CB&M might be appropriate only for individuals with high functionality in SCI patients (that is, there might be a floor effect). Indeed, the CB&M requires performing the tasks with no walking aid which are challenging for ambulatory activities. This requirement significantly restricts the application of the scale to the wide range of SCI population. Secondly, few of the items on the CB&M did not show discrepancy among their sample of high-functioning individuals with SCI, which questions the usefulness of these components in the scale.^[8,10]

The Activities-specific Balance Confidence (ABC) scale asks participants to rate their confidence in performing 16 standing and walking tasks without losing their balance (0% = no confidence, 100% = complete confidence). The ABC scale is a valid and reliable measure of balance confidence in community-dwelling, ambulatory individuals with chronic iSCI. It is an appropriate measure for clinicians and researchers to use with this sub-group of SCI. Few studies suggest that future work should be focusing on the responses and interpretation of ABC scale scores in the SCI individuals. According to previous articles, studies showed limitation in respect to the generalization of the utility of the scale to the population of low functioning spinal cord injury individuals.^[8,11]

The Falls Efficacy Scale International (FES-I) measures participants' concern about falling during functional activities, and although its psychometric properties have not been evaluated in the SCI population, it has been used in previous research in people with iSCI. Reactive balance control becomes important for the prevention of falls in SCI patients. The Higher scores on the BBS shows better balance abilities which were seen to be significantly associated with lower scores on the FES-I implying less risk of fall. This correlation suggests that these patients having good ability to balance tend to show less fear of fall.^[8,12]

Analysis of Postural imbalance based on postural sway length (PSL, cm) was done with the help of a force plate device (PDM Force Plate, Zebris, Germany). The force plate device measures the static and dynamic pressure of standing feet by force sensors embedded on a plate. This parameter has shown to be valuable as an assessment for posture balance.^[13]

The other sensor based tool which was the elevated force plate (Bertec) assessed both the static and dynamic balance evaluating the ability to sit still and move in different directions respectively. These data were subsequently used to calculate the root mean square distance (RDIST) and velocity (RVEL) from the COP trajectory to examine over all postural stability and the amount of postural activity during the static seated balance tasks.^[14]

The last sensor based tool, that is a CONFORM at sensor model 5530 (Tekscan, Inc., South Boston, USA) body pressure measurement system assessed Limits of stability (LOS; cm) assessing participants' dynamic sitting balance. LOS can measure the maximum distance that a participant is able to move their COP in various directions while remaining stable and without changing the configuration of the base of support (BOS). Multidirectional LOS has been used to describe dynamic sitting balance in individuals with SCI.^[15]

There are several advantages of the assessment instruments over the clinical instruments. First, data from the wearable sensor are continuous normative scales without floor and ceiling effects. This contrasts with coarse ordinal scales used by clinical instruments, which make it suitable for detecting subtle but clinically meaningful changes in sitting balance function due to therapies or the progression

of pathologies. Second, time-domain and frequency-domain measurements from the sensor can quantify sitting balance impairments and identify postural regulatory strategies, which can be used to develop biomarkers with high sensitivity and specificity. Third, the assessment using the wearable sensor can be rapidly administered, which is usually completed within a few minutes. Finally, the wearable sensor is an easy-to-use and lowcost device that interfaces with data storage, which enables remote patient monitoring.

Conclusion

In this review, we analyzed clinical instruments available to assess both the sitting balance along with the standing balance in subjects with SCI. The sitting balance assessment devices included the Elevated force plate (Bertec), Con Format Sensor model, which shows that majorly sensor based measurement of sitting balance were observed in spinal cord injury patients for cervical and thoracic levels of injury measuring unsupported sitting balance. They can be easily administered as against the ordinal scales with less efforts, minimal errors and can be employed in lesser time. They also prove to be cost-effective.

For the standing based balance assessment majority of the scales targeted walking stability during various activities. According to the studies BBS was found to be well correlated with gait function. This is consistent with the idea that impaired balance to some extent affects the ability to walk fast. BBS was observed to be majorly applied in these patients for assessing standing balance. The measures of Mini-BESTest, The Activities-specific Balance Confidence (ABC), CBMS and FES scales helped advance the assessment, also the training of reactive balance control in the incomplete SCI population, potentially leading to fewer falls and improved clinical outcomes. The TUG was a test used to assess patients' dynamic balance during a functional task.

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