Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

Research Summary - Berg Balance Scale (BBS) – Lower Limb and Walking

Author Year Research Design Setting	Demographics and Injury Characteristics of Sample	Validity	Reliability	Responsiveness Interpretability
Morooka et al. 2024 Observational study to investigate the ceiling and floor effects of BBS, Mini-BESTest, and Brief-BESTest, and determine the intra- and inter-rater reliabilities, as well as the MDC of the Mini-BESTest and Brief-BESTest in patients with acute and subacute incomplete cervical SCI Advanced critical care center of	N = 20 with SCI who could stand without assistance Mean (SD) age: 64.3 (15.2) years 14M, 6F ASIA D Mean (SD) time since injury: 19.6 (15.7) days			**Floor and ceiling effects:** Seven participants (35%) achieving the maximum score, indicating a ceiling effect.

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our university hospital, Japan				
Freixes et al. 2020 Cross-sectional CINER Rehabilitation Center, Spain	N= 20 participants (6F, 14M) Mean age: 48.2 (16.6) years		**Inter-rater reliability:** at first and second observation were excellent= 0.99 (95% CI 0.97-1.00) and 0.99 (95% CI 0.99-1.00) respectively **Intra-rater reliability**: Excellent: rater 1 was ICC= 1.00 (95% CI 1.00-1.00) and rater 2 was ICC= 1,00 (95% CI 0.99-1.00)	
Jørgensen et al. 2017 Cross-sectional Sunnaas Rehabilitation Hospital, Norway	N=46 (32M, 14F) Mean age (SD): 54.4 (17.0) Duration of injury: 6.5 years; range 1-41 years AIS A, B and C = 15% AIS D = 85% 74% able to walk 10m without aid	**Convergent Validity:** Correlation of BBS with: Mini-BESTest: r = 0.899; P<0.001 Timed Up and Go (TUG): r = -0.75; P<0.001 Spinal Cord Independence	**Internal consistency**: 0.94	**Responsiveness:** Known groups: BBS able to discriminate between community walkers without walking aids vs. participants using mobility aids (P<0.001); cutoff points >47/56 on BBS.

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

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	Inclusion criteria: able to walk in Norwegian cohort, able to accomplish Mini-BESTest	Measure version III (SCIM): r = 0.88; P<0.001 Walking Index for Spinal Cord Injury version II (WISCI): r = 0.63; P<0.001 Fall Efficiency Scale – International (FES-I): r = -0.68; P<0.001 Fear of falling: r = -0.32; P=0.83 **Divergent Validity:** No correlation of BBS with Quality of Life (QOL) questionnaire (r = 0.19; P=0.20)		BBS able to discriminate between participants with high vs. low concerns about falling (P<0.001); cutoff points ≤46/56 on BBS. Specificity for BBS in discriminating low vs. high concerns about falling was low (55%). BBS could not discriminate between infrequent vs. recurrent fallers (P=0.78) **Ceiling Effect:** A ceiling effect was present (28% of participants obtained maximal score) **Interpretability:** Median total score: 51/56 Maximum score (%n): 28.3

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

Author Year Research Design Setting	Demographics and Injury Characteristics of Sample	Validity	Reliability	Responsiveness Interpretability
				Minimum score (%n): 0
Harkema et al. 2016 Prospective, multicenter observational 6 outpatient rehabilitation centers in the Christopher and Dana Reeve Foundation NRN, USA	N=152 (123M, 29F) Mean (SD) age: 36 (15) Median (range) time since SCI: 0.9 (0.1-45.2) years 110 cervical, 42 thoracic AIS-A/B/C/D: 43/21/39/49 Physician-referred outpatients without progressive lesions above T11, capable of stepping using body weight support, with ability to wean off anti-spasticity medication Median (range) number of sessions of NRN-standardized locomotor training: 70 (23-520)	Pearson's r (95%CI) with ASIA Motor Scales: UEMS: 0.30 (0.19-0.41) LEMS: 0.79 (0.74-0.85) ASIA Motor Score: 0.75 (0.69-0.81)		**Responsiveness:** Standardized Response Means after Locomotor Training: All individuals: 0.59 AIS-A/B: 0.52 AIS-C: 0.65 AIS-D: 0.91 Median (range) number of sessions of NRN-standardized locomotor training: 70 (23-520) **Interpretability:** Mean (SD) BBS Scores: All individuals: Enrollment: 11 (16) Discharge: 17 (20) AIS-A/B: Enrollment: 3 (2) Discharge: 4 (2)

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

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				AIS-C: Enrollment: 5 (6) Discharge: 13 (15) AIS-D: Enrollment: 26 (19) Discharge: 36 (20) * Enrollment = pre-intervention; discharge = post-intervention; median (range) number of sessions of NRN-standardized locomotor training: 70 (23-520)
Tester et al. 2016 Prospective 6 outpatient sites in the Christopher and Dana Reeve Foundation NeuroRecovery Network, USA	N=72 (57M, 15F) completing 20 sessions of standardized locomotor training Mean (SD) age: 36 (15) Median (range) time since SCI: 0.7 (0.1-14.7) years. N=45 longer than 6 months			**SRD**= 2.5

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

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	44 cervical, 28 thoracic AIS-A/B/C/D: 17/10/20/25			
Srisim et al. 2015 Prospective cohort study Tertiary rehabilitation center in Thailand	N = 83 23 Multiple Fallers (Age: 44.21 ± 10.7): Time Since injury (months): 58.70 ± 60.03 AIS C: 9 (39%) 60 Non-multiple fallers (52.68 ± 11.21): Time Since injury (months): 46.72 ±36.42 AIS C: 12 (20%) Chronic SCI	Unable to predict and discriminate non-multiple fallers and multiple fallers Ability of cut-off score (≥ 40 scores) to predict risk of multiple falls: Sensitivity: 65% Specificity: 53% AUC: 0.61	**Interrater ICC=** 0.998 (0.996-0.999)	**SEM** = 0.66
Tamburella et al. 2014 Serial cross-sectional	N = 23 (9F, 14M) Age: 48.27 ± 15.94 All AIS D Time Since Injury (months): 16.43 ± 19.03	ES: 0.78	**Intra-rater reliability** ICC: 0.97	**Interpretability:** MDC_{95}: 5.74 SEM: 2.07 %MDC = 17.2
Wirz et al. 2010	N= 42 subjects (33M, 9F)	Spearman	In addition to the rater (first author)	**Interpretability:**

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

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Longitudinal study Spinal Cord Injury Center of the Balgrist University Hospital, Zurich, Switzerland	Mean age: 49.3±11.5 AIS A: 2 AIS B: 2 AIS C: 35 AIS D: 3 Inclusion criteria: received either inpatient rehabilitation or out-patient physiotherapy between January 1998 and September 2007. Experienced an SCI at least 1 year prior to enrollment. Able to walk for a minimum distance of 15 m	correlations: There was no statistical association between the number of falls and the score on the BBS (falls total: r=-0.17, P=.28) The BBS correlated strongly and significantly with the SCIM mobility score (r=.89, P<.001), WISCI (r=.82, P<.001), and with the 10MWT (r=.93, P<.001) Participants with high values on the BBS also rated significantly higher on the motor score (r=.62, P<.001). Higher scores on the BBS were significantly associated with lower scores on the FES-I (r=-.81, P<.001)	who obtained the BBS directly from the patients, 3 additional PTs rated the BBS independently, based on video recordings. The agreement among the raters, relating the items as calculated using Kendall's coefficient of concordance, ranged between .838 and .979 (*P*<.001). For the total score, the intraclass correlation coefficient was .953 (95% confidence interval = 0.910-0.975).	Mean (SD) BBS score: 41.1 (15.2) Median (range) BBS score: 44 (11-56)

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

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Lemay & Nadeau 2010 Longitudinal study An intensive rehabilitation center in Montreal, Canada (Institut de readaptation Gingras-Lindsay de Montreal)	N=32 (25M, 7F). Mean age: 47.9± 12.8 yrs Neurological level: 15 paraplegic, 17 tetraplegic Level of injury: 17 cervical, 10 thoracic, 5 lumbar Type of injury: 21 traumatic, 11 non-traumatic Inclusion criteria: (1) Adults with SCI AIS D either of traumatic or nontraumatic etiology and (2) the ability to walk 10m independently with or without upper-extremity assistive devices.	Spearman's correlations with other walking scales: all P<.01) SCI-FAI parameter: 0.747 SCI-FAI assistive devices: 0.714 SCI-FAI mobility: 0.740 2MWT: 0.781 WISCI II: 0.816 10MWT: 0.792 TUG: -0.815 The results showed that subjects with paraplegia and tetraplegia differed regarding the relation between their use of assistive devices and the BBS score		**Ceiling Effect:** A ceiling effect was present (37.5% of subjects reached maximal score) **Interpretability:** See Table 1. below

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		obtained. For the paraplegia group, walker users (n=3; 20%) had BBS scores below 30/56, whereas those in the tetraplegia group (n=5; 29%) had a broader range of BBS scores (31–55/56). The use of two walking aids (cane, crutches) was restricted to the paraplegia group (BBS range 44–51/56; n=4). Walking with a cane or without any assistive devices was achieved with a BBS score above 50 in the paraplegia group. It ranges from 39 to 56 in the tetraplegia group. Except for two participants, walking with no assistive device in the tetraplegia group was seen when the score		

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

Last Updated: January 23rd, 2024

<table>
<tr><th>Author Year Research Design Setting</th><th>Demographics and Injury Characteristics of Sample</th><th>Validity</th><th>Reliability</th><th>Responsiveness Interpretability</th></tr>
<tr><td></td><td></td><td>in the BBS was normal (56/56).</td><td></td><td></td></tr>
<tr><td></td><td colspan="4">Table 1. Published data for 56 individuals with SCI
<table><tr><td>Population</td><td>BBS score: mean (SD), range</td></tr><tr><td>Individuals with SCI (n=32)</td><td>47.9 (10.7), 17-56</td></tr><tr><td>Paraplegia (n=15)</td><td>44.8 (13.0), 17-56</td></tr><tr><td>Tetraplegia (n=17)</td><td>50.7 (7.5), 31-56</td></tr></table></td></tr>
<tr><td>Datta et al. 2009

Cohort study

The NeuroRecovery Network (NRN), a specialized network of treatment centers providing standardized, activity-based therapy for patients with SCI</td><td>N=97 (71M, 26F).
Mean Age: 38±17y.
Mean time since SCI = 11.9 months/ Incomplete SCI, AIS C or D

Mechanism of Injury:
Motor Vehicle Accident = 34
Fall = 29
Sporting Accident = 16
Other nontrauma = 8
Medical/surgical = 6
Violence = 4</td><td>With the exception of correlations involving BBS item 3 (sitting with back unsupported), all correlation coefficients (Spearman rank correlation) were positive. This suggests that a higher rate of change in each of these BBS variables indicated faster recovery for a patient.

The size of the correlation</td><td></td><td></td></tr>
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Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

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		coefficients ranged from very small (P=.03 for item 1, sitting to standing, and 14, standing on one leg) to very large (P=.85 for items 9, picking up object from the floor from a standing position, and 10, turning to look behind over left and right shoulders while standing). Correlation between the first principal component of change in BBS items and changes in clinical measures of walking: **(Kendall's τ, Spearman rank (ρ))** 6MWT: (.34*, .48*) SCI-FAI Gait subscale: (.22*, .31*)		

Reviewer ID: Carlos L. Cano Herrera, Tyra Chu, William Miller

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		SCI-FAI Assistive Devices subscale: (-.07 (P=.42), -.10 (P=.40)) SCI-FAI Walking Mobility subscale: (.33*, .44*) 10MWT speed: (.34*, .46*) *P<.01		
Ditunno et al. 2007 Single-blinded, paralleled-group, multicenter RCT 6 regional SCI inpatient rehabilitation centers	146 (114M, 32F) Mean age = 32 years (range 16 – 69 years) Incomplete spinal cord injury patients who had a Functional Independence Measure locomotor score for walking of < 4 on entry.	**Spearman correlation of the BBS:** w/Walking Index for SCI At 3 months: r = 0.91 At 6 months: r = 0.89 At 12 months: r = 0.92 w/50-Foot Walking Speed At 3 months: r = 0.81 At 6 months: r = 0.86 At 12 months: r = 0.78 w/Functional Independence Measure (FIM) At 3 months: r = 0.76		

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		At 6 months: r = 0.72 At 12 months: r = 0.77 <u>w/FIM Locomotor Score</u> At 3 months: r = 0.89 At 6 months: r = 0.86 At 12 months: r = 0.86 All correlations P<.001		