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Research Summary - Walking Index for Spinal Cord Injury (WISCI) - Lower Limb and Walking

Author Year Country Research Design Setting	Demographics and Injury Characteristics of Sample	Validity	Reliability	Responsiveness Interpretability
Sato et al. 2023 Japan Validity Study Rehabilitation hospital	N = 30 (5F) Mean age: 63.8 ±10.7 years, Tetraplegia = 17 6 AIS A, 0 AIS B, 8 AIS C, 16 AIS D. Time since injury 1142 ±1720.7 days	Moderate to high correlation coefficient between the trunk assessment scale for spinal cord injury (TASS) and the WISCI II (r=0.67 (0.41-0.83)) Construct validity for WISCI II with trunk control test (TCT-SCI) was r= 0.42 (0.14-0.71)		
Sinovas-Alonso et al. 2023 Spain Observational, cross-sectional Biomechanics and Technical Aids Unit of the National Hospital for	iSCI N= 35 (24M) Mean age: 35.5(17.2) Non-SCI N = 50 (19M) Mean age: 34.6 (15.2)	Self-selected WISCI II levels showed good correlation with the spinal cord injury gait deviation index (SCI-GDI) (r=0.521) Maximum WISCI II levels had no significant correlations with the SCI-GDI (p=0.013)		

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Paraplegics of Toledo, Spain				
Willi et al. 2023 Switzerland Multicenter-observational study	N=50 Age range: 18-79 (52.6 ±16.2 years) Tetraplegic = 24 Paraplegic = 26; 2 AIS A, 0 AIS B, 7 AIS C, 41 AIS D Years since injury = 6.11 ± 9.8	**Construct validity:** Moderate relationship with the 2MWT, r=0.571 (0.356-0.784)		
Kahn et al. 2020 USA	N= 12 (11M, 1F) Mean age: 55.41± 11.65 years (32-73) Chronic motor SCI 2 AIS C, 10 AIS D Level of injury: 7 cervical, 5 thoracic	**Convergent validity**: For the WISCI II with the functional gait assessment (FGA) was high (spearman's rho= 0.74, p=0.006)		

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	Years since injury = 1.7 to 29.7 (7.8 ± 7.8)			
Calhoun et al. 2017 USA Mixed methods	N=52 (22M, 30F) Age range: (2-17) Tetraplegic=14 Paraplegic=38 AIS: 3A, 3B, 9C, 16D, 21Unknown Neurological level: 5 C1-C4, 2 C5-C8, 24 T1-S5, 21 Unknown		**Intra-rater reliability** ICC=0.997, CI=0.995-0.998 **Inter-rater reliability** ICC=0.97, CI=0.95-0.98	
Scivoletto et al. 2014 Test-Retest analysis, calculation of reliability and smallest real difference (SRD)	N=33 (28M, 5F) Mean age: 44 years AIS: 33D 32 AIS-D, 1 AIS-C Injury level: 20 cervical, 8 thoracic, 5 lumbar		**Intra-rater reliability** =0.975-0.999 Maximum WISCI II entire group: ICC=0.996 Maximum WISCI II Tetraplegics (n=20): ICC=0.994	**Responsiveness:** No data available **Floor/Ceiling Effect:** No data available **Interpretability** SEM (WISCI II) for tetraplegics = 0.401 (N=20); for paraplegics

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SCI unit of a rehabilitation hospital	Median time since SCI onset = 40 days Incomplete SCI, subacute and chronic		Maximum WISCI II Paraplegics (n=13):ICC=0.992	= 0.437 (N=13); for both groups = 0.318. MDC for tetraplegics = 1.147 (N=20); for paraplegics = 1.682 (N=13); for both groups = 0.883
Tamburella et al. 2014 Serial cross-sectional study	N=23 (14M) Mean age 48.27 SD = 15.94 Mean time since injury = 16.43 months, SD = 19.03		**Intra-rater** ICC = 0.95, p<0.005	**Responsiveness:** ES = 0.07 **Floor/Ceiling Effect:** No data available **Interpretability:** SEM = 0.73, MDC95 = 0.02, %MDC = 13.0
Ovechkin et al. 2013 USA Prospective cohort study	N = 11 (3F, 8M) Age: 48 ± 19 AIS A: 4 AIS C: 1 AIS D: 6	AIS: Spearman rho = 0.71 (p< 0.05) FIM motor score: Spearman rho =0.69 (p< 0.01) SCIM total score: Spearman rho = 0.74 (p<0.01)		

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University of Louisville		SCIM mobility score: Spearman rho =0.84 (p<0.01)		
Calhoun et al. 2012 USA Pilot study Shriners Hospitals for Children, Clinical Research Department	N=10 (8M, 2F) Age range: 5-13 years Incomplete: 7 Complete: 3 AIS Score: 3 A, 1 B, 1 C, 5 D	Correlation between WISCI II and SCIM indoor mobility item: r=0.96	**Intra-rater reliability:** ICC=0.98, CI=0.95-0.99 **Inter-rater reliability:** ICC=0.97, CI=0.96-0.99	
Burns et al. 2011 USA Test-retest for some participants	N=76 (60M, 16F) Mean age = 43.4±13.8 Mean years from injury = 6.32±5.99 Chronic SCI 45% Paraplegia 55% Tetraplegia	To assess convergent validity for both self-selected and maximum WISCI levels and walking speeds, their relationships with LEMS, UEMS, and MMT were assessed.	ICC for WISCI: SS WISCI – level: 0.994 SS WISCI – speed: 0.930 Max WISCI – level: 0.995	Please see table below.

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Regional Spinal Cord Injury Center of the Delaware Valley and Magee Rehabilitation Hospital, Philadelphia, PA	Injury etiology: 32% motor vehicle accidents 26% falls 13% sports/diving incidents 11% acts of violence 18% other The distribution of AIS grades was A (3%), B (1%), C (8%), and D (88%), which reflects that participants had to ambulate a minimum of 10 m to be assigned a WISCI level and participate.	For both maximum WISCI and self-selected WISCI, the strongest correlations were with LEMS: p=0.717 and p=0.704, respectively. There were profound differences when the composite cohort was split into tetraplegic (n=42) and paraplegic (n=34) cohorts. For tetraplegic participants, there were also significant correlations between WISCI levels and UEMS: p=0.496 (self-selected) p=0.502 (maximum) **Spearman correlations:**	Max WISCI – speed: 0.971	

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		Btwn Self-selected WISCI level and: 1. ASIA UEMS (tetraplegic only, N=41): 0.496 (p<0.0001) 2. ASIA LEMS (N=76): 0.704 (p<0.0001) 3. Manual Muscle Test (Upper & Lower Extremity) (N=75): 0.647 (p<0.0001) **Btwn Self-selected WISCI speed and:** 4. ASIA UEMS (tetraplegic only, N=41): 0.491 (p<0.05) 5. ASIA LEMS (N=76): 0.509 (p<0.05) 6. Manual Muscle Test (Upper & Lower Extremity) (N=75): 0.494 (p<0.0001)		

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		Btwn Max WISCI level: 7. ASIA UEMS (tetraplegic only, N=41): 0.502 (p<0.0001) 8. ASIA LEMS (N=76): 0.717 (p<0.0001) 9. Manual Muscle Test (Upper & Lower Extremity) (N=75): 0.663 (p<0.0001) **Btwn Max WISCI speed:** 10. ASIA UEMS (tetraplegic only, N=41): 0.469 (p<0.0001) 11. ASIA LEMS (N=76): 0.572 (p<0.0001) 12. Manual Muscle Test (Upper & Lower Extremity) (N=75): 0.539 (p<0.0001)		

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<table>
<tr><th>Author Year
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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>More details of paraplegic/tetraplegic values available in article.
When the entire cohort was analyzed, walking speed correlated significantly with MMT, LEMS, and WISCI (maximum and and self-selected).</td><td></td><td></td></tr>
<tr><td></td><td colspan="4">
SRD for WISCI Level and Walking Speed
<table>
<tr><th></th><th></th><th>SEM</th><th>SRD</th></tr>
<tr><td>SS WISCI</td><td>Level</td><td>0.283</td><td>0.785</td></tr>
<tr><td></td><td>Speed</td><td>0.091</td><td>0.254 m/s</td></tr>
<tr><td>Max WISCI</td><td>Level</td><td>0.215</td><td>0.597</td></tr>
<tr><td></td><td>Speed</td><td>0.059</td><td>0.163 m/s</td></tr>
<tr><td colspan="4">WISCI = Walking Index for Spinal Cord Injury

SS = Self-Selected

Max = Maximum</td></tr>
</table>
</td></tr>
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	SEM = Standard Error of Measurement SRD = Smallest Real Difference			
Lemay & Nadeau, 2010 Canada Longitudinal An intensive rehabilitation center in Montreal, Canada (Institut de readaptation Gingras-Lindsay de Montreal)	N = 32 SCI (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	**Spearman's correlations with other walking scales:** 1. (all P<0.01) 2. BBS: 0.816 3. SCI-FAI parameter: 0.761 4. SCI-FAI assistive devices: 0.980 5. SCI-FAI mobility: 0.630 6. 2MWT: 0.749 7. 10MWT: 0.795 8. TUG: -0.799		**Responsiveness:** No data available **Ceiling effect =** 44.8% (44.8% of subjects reached maximal score on the scale) **Interpretability:** No data available

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	upper-extremity assistive devices.			
Marino et al. 2010 USA Reliability study Regional Spinal Cord Injury Center of the Delaware Valley And the the Spinal Unit	N=26 (9 US, 17 Italy) (16M, 10F) Mean age: 46.4±19.3 years Time post-injury: 8-336 months, mean: 58 months Traumatic SCI = 18 Spinal cord lesions = 8 Neurological levels: 7 cervical, 11 thoracic, 8 lumbar AIS: 23D, 2A, 1C		**Intra-rater reliability (**self-selected (SS), maximum) ICC=1.00 **Interrater reliability:** ICC=1.00 (self selected WISCI) ICC=0.98 (maximum WISCI)	
Marino et al. 2010 USA/Italy	N = 26 SCI (16M, 10F; 9 from USA, 17 from Italy)		**Intraclass correlation:** coefficients for intrarater reliability were 1.00 for self-selected and	

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Reliability study Study subjects were recruited from (1) the Regional Spinal Cord Injury Center of the Delaware Valley, a partnership of Thomas Jefferson University Hospital and Magee Rehabilitation Hospital, Philadelphia, PA, and (2) the Spinal Unit, IRCCS Santa Lucia, Rome, Italy.	Mean age: 46.4±19.3 yrs Neurological levels: 7 cervical, 11 thoracic, 8 lumbar AIS A: 2 AIS C: 1 AIS D: 23		maximum WISCI levels for both therapists. **Interrater reliability:** was 1.00 for self-selected WISCI and 0.98 for maximum WISCI. Bland-Altman plots for differences in time show that the time for the 10-m walk at SS WISCI varied more from 1 day to the next than between raters on the same day. The difference in time for the two walks on the same day (interrater) was within 25% of the average time in all cases, whereas the difference in time	

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			from days 1 to 2 (intrarater) exceeded 25% of average time on several occasions. There was more variability in times for the maximum WISCI than the SS WISCI for both days and raters	
Wirz et al. 2010 Switzerland Prospective study Spinal Cord Injury Center of the Balgrist University Hospital, Zurich, Switzerland	N = 42 (33M, 9F) Mean age: 49.3±11.5 Mean time since injury (SD) = 66.5 months (66.2) AIS A: 2 AIS B: 2 AIS C: 35 AIS D: 3 Inclusion criteria: Received either inpatient rehabilitation or out-patient physiotherapy	WISCI II correlation with: 1. Berg Balance: r=.82 (P<.001) 2. Falls total: r=-.03 (P=.84) 3. SCIM mobility score: r= .81 (P<.001) 4. 10MWT: r=.81 (P<.001) 5. FES-I: r=-.71 (P<.001) 6. Motor scores: r=.66 (P<.001)		**Responsivness:** No data available **Floor/Ceiling Effect:** No data available **Interpretability:** WISCI mean (SD) score: 16.9 (3.4) Median (range): 18.5 (11-20)

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	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			
Ditunno et al. 2008 Denmark, Germany, Italy, USA Prospective cohort	N= 150 (USA = 112; Europe = 38) AIS A: Tetra = 18, Para = 41 AIS B: Tetra = 12, Para = 7 AIS C: Tetra = 22 , Para = 10 AIS D: Tetra = 32, Para = 8	**Monotonic Directional Improvement (MDI)** 77 participants showed improvement, 62/77 participants demonstrated MDI. 10/15 participants failed to show MDI because a walking device was removed too early. **Total Group Spearman correlation w/Lower Extremity Motor Score (LEMS):** Initial = 0.47 [P < 0.001] Final = 0.91 [P < 0.001]		

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		Improvement = 0.59 [P < 0.0001] Final for those who progressed = 0.71 [P < 0.001] **USA Group Spearman correlation w/LEMS:** Initial = 0.39 [P < 0.001] Final = 0.91 [P < 0.001] Improvement = 0.54 [P < 0.001] Final for those who progressed = 0.79 [P < 0.001] **European Group Spearman correlation w/LEMS:** Initial = 0.62 [P < 0.001] Final = 0.89 [P < 0.001] Improvement = 0.79 [P < 0.001] Final for those who progressed = 0.42 [P = 0.118]		

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		Total Group Spearman correlation w/Locomotor Functional Independence Measure (LFIM): Initial = 0.89 [P < 0.001] Final = 0.76 [P < 0.001] Final for those who progressed = 0.78 [P < 0.001] **USA Group Spearman correlation w/LFIM:** Initial = 0.89 [P < 0.001] Final = 0.79 [P < 0.001] Final for those who progressed = 0.84 [P < 0.001] **European Group Spearman correlation w/LFIM:** Final = 0.72 [P < 0.004]		

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		Final for those who progressed = 0.72 [P = 0.004]		
Jackson et al. 2008 A subcommittee of international experts evaluated locomotion measures	N= 54 expert raters	**Content Validity:** Expert Evaluations (54 votes): Valid or Useful: 52% Useful but requires validation: 43% Not useful or valid for research: 6%		
Ditunno et al. 2007 USA Single-blinded, paralleled-group, prospective multicenter RCT clinical trial	N = 146 (114M, 32F) Mean age: 32 (16-69) Level of Injury: 58 cervical, 18 thoracic, 24 lumbar AIS: 36B, 90C, 20D Incomplete spinal cord injury patients who had a Functional Independence Measure locomotor	**Correlation with Berg Balance Scale (BBS):** r=0.90 **Correlation with Lower Extremity Motor Score (LEMS):** r=0.85 **Correlation with FIM locomotor score (LFIM):** r=0.89		**Responsiveness:** No data available **Interpretability:** N=142 Mean WISCI (0-20) score: 1.49 **Floor/ceiling effect** At 6 months, the walking speed

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6 regional SCI inpatient rehabilitation centers	score for walking of < 4 on entry	**Correlation with Functional Independence Measure**: r=0.77 **Correlation with 50-foot walking speed (50FW-S):** r=0.85 **Correlation with 6-minute walking distance (6MW-D):** r=0.79 **Spearman correlation w/LEMS** [all P < 0.001] At 3 months: r = 0.85 At 6 months: r = 0.85 At 12 months: r = 0.88 **Spearman correlation w/6-Minute Walk Test** [all P < 0.001] At 3 months: r = 0.76 At 6 months: r = 0.68 At 12 months: r = 0.69		showed a linear trend to the point of 1 – 1.5 meters/second, and subsequently, a ceiling effect on the WISCI, with walking speed continuing to improve after the WISCI was at or near its maximum value.

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		Spearman correlation w/50-foot Walking Speed [all P < 0.001] At 3 months: r = 0.78 At 6 months: r = 0.85 At 12 months: r = 0.77 **Spearman correlation w/Berg Balance Scale (BBS)** [all P < 0.001] At 3 months: r = 0.91 At 6 months: r = 0.89 At 12 months: r = 0.92 **Spearman correlation w/6-Minute Walk Test** [all P < 0.001] At 3 months: r = 0.76 At 6 months: r = 0.68 At 12 months: r = 0.69 **Spearman correlation w/50-foot Walking Speed** [all P < 0.001] At 3 months: r = 0.78 At 6 months: r = 0.85		

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		At 12 months: r = 0.77 **Spearman correlation w/Functional Independence Measure (FIM)** [all P < 0.001] At 3 months: r = 0.73 At 6 months: r = 0.77 At 12 months: r = 0.74 **Spearman correlation w/FIM locomotor score** [all P < 0.001] At 3 months: r = 0.92 At 6 months: r = 0.89 At 12 months: r = 0.88 **Predictors of the WISCI at 12 months (Spearman's rho)** **Baseline:** LEMS = 0.73 BBS = 0.47 FIM Locomotor = 0.30		

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		FIM = 0.12 **3 Months:** LEMS = 0.81 BBS = 0.84 FIM Locomotor = 0.79 FIM = 0.63 Speed = 0.71 Distance = 0.77 **6 Months:** LEMS = 0.86 BBS = 0.89 FIM Locomotor = 0.85 FIM = 0.69 Speed = 0.81 Distance = 0.80		
Kim et al. 2007 Prospective cohort Academic medical center.	N = 50 (86%M) Mean age: 47.4 +- 13.2 Ambulatory subjects with traumatic incomplete SCI			**Reponsiveness:** No data available **Floor/ceiling effect:** Ceiling effect: 48% (24/50) subjects at greater than 1 year post injury has WISCI

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				=20 at entry into the study. **Interpretability:** No data available
Musselman, 2007 Canada Determining clinical significance via distribution-based and anchor-based approaches Center for Ambulatory Rehabilitation, Research, and Education at the University of Alberta	N = 19 Incomplete SCI Mean age = 42 Time since injury range = 0.6-28.2 years Mean = 6.97 years			1. MCID: 0.06 m/s 2. SEM: 0.05 m/s 3. Effect Size: 0.46

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Van Hedel et al. 2006 Europe Longitudinal study; analyzed at 1, 3, 6, and 12 months after injury European Multicenter Study of Human Spinal Cord Injury	N = 22 (18M, 4F) Mean age = 45.5±16.7 years (range 17 – 78 years) Incomplete spinal cord injury patients who were able to stand or walk within the first month after SCI. Level of Injury: Cervical =13; Thoracic = 1; Lumbar = 7; Sacral = 1	**Spearman correlation w/Lower Extremity Motor Score** Within 1 month: r = 0.49 [P=.02] After 3 months: r = 0.50 [P=.02] After 6 months: r = 0.38 [P=.08] After 12 months: r = 0.32 [P=.15] **Spearman correlation w/6-Minute Walk Test** Within 1 month: r = 0.78 [P<.001] After 3 months: r = 0.28 [P=.20] After 6 months: r = 0.36 [P=.10] After 12 months: r = 0.36 [P=.10] **Spearman correlation w/10-Meter Walk Test** Within 1 month: r = -0.79 [P<.001]		**Responsiveness:** 4 time intervals: 1) within first month; 2) after 3 months 3) after 6 months; 4) after 12 months: Friedman's test (α = 0.05) between 4 intervals: DF = 3, F_r = 28.7, P < 0.001 **Pair-wise comparisons via Wilcoxon's signed rank test:** Between intervals 1 and 2: P = 0.005 Between intervals 2 and 3: P = 0.18 Between intervals 3 and 4: P = 0.31

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		After 3 months: r = -0.21 [P=.35] After 6 months: r = -0.37 [P=.09] After 12 months: r = -0.37 [P=.09]		**Ceiling effect:** All but one of the iSCI subjects qualified up to the max WISCI II score of 20 **Interpretability:** WISCI II mean (SD) score: Within 1st month: 16 (4.6) After 3 months: 19 (2.4) After 6 months: 20 (0.9) After 12 months: 20 (0.2)
Morganti et al. 2005 Italy	N=284 (184M, 100F) Mean age: 50.4 ± 19.3 (12-86) Mean time post-injury: 56.9±43.9 days	Correlations between: 1. WISCI and SCIM: r=0.97 2. WISCI and FIM: r=0.7	**Inter-rater reliability for the WISCI II:** r = 1.00 (p<0.001)	

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Retrospective examination Large rehabilitation hospital in center of Italy Rehabilitation hospital in Italy	Non-traumatic = 177 Rraumatic = 107 Lesion Level: 81 Cervical, 148 Thoracic, 55 Lumbar-sacral AIS: 84A, 19B, 129C, 52D Concurrent validity sample: N=76 Traumatic or non traumatic SCLs admitted between 1997-2001. Non-traumatic etiology was present in the majority of the patients (177/284): inflammatory (40), vascular (36), neoplastic (39), degenerative (62); traumatic lesions (107/284): car accident	3. WISCI and LEMS=0.58 4. WISCI and Barthel Index (BI): r=0.67 5. WISCI and RMI: r=0.67 *Groups:* Lower Extremity Motor Score (LEM) and WISCI: r=0.58 ($p<0.001$) (subgroup of 200 patients) Locomotion outcome at discharge - LEMS and WISCI (eliminating levels 0 and 20): r=0.57 ($p<0.001$) Levels at discharge for young patients – LEMS and WISCI: r=0.50 ($p<0.01$) Levels at discharge for older patients – LEMS		

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	(38), motorcycle accident (15), sport accident (7), act of violence (6), suicide attempts (6), and accidental falls (31).	and WISCI: r=0.64 (p<0.01) Discharge for non-trauma - LEMS and WISCI: r= 0.58 (p<0.01) Discharge for trauma - LEMS and WISCI: r= 0.49 (p<0.01) WISCI compared to; Rivermead Mobility Index (RMI): ρ= 0.67 Barthel Index (BI) ρ= 0.67 Spinal Cord Independence Measure (SCIM): ρ= 0.97 Functional Independence Measure (FIM): ρ= 0.70 RMI and BI: ρ=0.6 RMI and SCIM: ρ=0.75 RMI and FIM: ρ=0.9		

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		BI and SCIM: ρ=0.7 BI and FIM: ρ=0.7 SCIM and FIM: ρ=0.8 All p < 0.001 WISCI (walking with assistance) levels at discharge and AIS at admission: AIS A vs B: r=0.573 AIS AB vs C: r=0.07 AIS AB vs D: r=0.002 AIS C vs D: r=0.1 WISCI (independent walking) levels at discharge and ASIA at admission: AIS A vs B: r=0.02 AIS AB vs C: r=<0.001 AIS AB vs D: r=<0.001 AIS C vs D: r=<0.001 WISCI scale is more sensitive scale for documenting change		

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		in levels of walking along a hierarchical order, integrating devices, braces and physical		
Ditunno & Ditunno, 2001 USA Retrospective analysis Clinical setting	N=103 SCI AIS classification: A=14 B=18 C=52 D=19	Correlation of ASIA grades with WISCI levels were significant: at initial ambulation ($p<0.03$) and at maximum recovery of walking function ($p<0.001$). Initial ASIA grades and final WISCi levels correlated at $p<0.001$. Improvements occurred in one direction in 94% of subjects.		
Ditunno et al. 2000 8 SCI centers in Australia, Brazil,	N = 24 individuals (8 teams of three composed of health professionals) created this measure.	The WISCI was analyzed to examine whether it appears to measure the	100% agreement across all 24 individual international	

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Author Year Country Research Design Setting	Demographics and Injury Characteristics of Sample	Validity	Reliability	Responsiveness Interpretability
Canada, Korea, Italy, the UK, and the USA Methodological study using a modified Delphi technique		construct that it purports to measure. Pilot data at two SCI centers: W = 0.843 (P<.001) Across all eight SCI centers: International individual data sets: W=0.860 (P<.001). Team data sets: W = 0.872 (P<.001) Sub-group possible pairs of ranking: Clinical physician and Spinal cord injury expert: ρ=0.968 (P<.01). Physical therapist and Spinal cord injury expert: ρ=0.944 (P<.01). Physical therapist and Clinical physician: ρ=0.974 (P<.01)	participants and all eight teams.	

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		Group Consensus: Using a walker is less impaired than parallel bars. Item 10 was eliminated as there was unacceptable variance. Using a brace, irrespective of one or two canes, reflects a more severely impaired individual than someone without braces. Functional Independence Measure (FIM): ρ= 0.765 (P<.001). 80% of WISCI items fell into two of the FIM categories.		