

Research Summary - 10 Meter Walk Test (10MWT) - Lower Limb and Walking

Author Year Research Design Setting	Demographics and Injury Characteristics of Sample	Validity	Reliability	Responsiveness Interpretability
Willi et al. 2023 Multicenter- observational study Switzerland	N=50 (33M, 17F) Mean age: 52.6 ±16.2 years Time since injury: 6.11 ± 9.8 years Tetraplegic: 24 Paraplegic: 26 AIS A: 2 AIS B: 0 AIS C: 7 AIS D: 41	Construct Validity: Strong correlation between Self 10MWT and 2MWT. Pearson correlation coefficient (95% CIs) r= 0.964 (0.941-0.986) Strong correlation between Maximal 10MWT and 2MWT. Pearson correlation coefficient (95% CIs) r=0.974 (0.956-0.988)		
Sinovas-Alonso et al. 2023 Observational, cross-sectional study Spain	N=35 adults with incomplete SCI (24M, 11F). Average age: 35.2 (17.2) years N=50 non-SCI participants (19M, 31F). Average age: 34.6 (15.2) years	Strong correlation between the self 10MWT and SCI Gait Deviation Index: r=- .711 Strong correlation between the Maximal 10MWT and SCI Gait deviation Index: r= - 0.716		
Musselman et al. 2022	N=618 (141F)	Convergent validity:		

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Retrospective longitudinal study Canada	Average age: 48.7 years Length of inpatient rehabilitation stay: 81.6 (53.1) days AIS A: 164 AIS B: 66 AIS C: 104 AIS D: 283 AIS E: 1 Cervical: 383 Thoracic: 156 Lumbar: 72 Sacral: 7	Weak correlations between preferred speed 10MWT and the Standing and Walking Assessment Tool (SWAT). $r=0.415$, $p=0.001$ Weak correlations between fast walking speed 10MWT and the SWAT. $r=0.409$, $p=0.001$		
Kahn et al. 2020 USA	N=12 (11M, 1F) Mean age: 55.41±11.65 years Mean time since injury: 7.8 ± 7.8 years Chronic motor SCI AIS C=2 AIS D=10 Cervical=7 Thoracic=5	Convergent Validity: High convergent validity with Functional Gait Assessment (FGA) Spearman's Rho=0.90 ($p=0.000$)		

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Rini et al. 2018 Cohort study India	N=25 (22M/3F) Mean age: 27 years Age range: 18-60 years Mean time since injury: 5.5 years AIS A or B		Test-retest: ICC: 0.99 [95%], SEM: 0.01	
Perez-Sanpablo et al. 2017 Observational, descriptive, transversal Mexico	N=95 (15M/8F) Mean Age: 45.6 $\pm$ 12.6 years Mean Time since injury: 42 $\pm$ 117 months AIS D, motor subacute and chronic incomplete	Criterion Validity: High criterion validity with 6MWT (-0.86 to - 0.95) Construct Validity: Moderate to high construct validity with WISCI-II (r=-0.37 to -0.795) Adequate construct validity with LEMS (r= -0.4 to -0.39)	Test-retest: ICC: 0.97- 0.983	
Jorgensen et al. 2017 Cross-sectional validation study Norway	N=46 (32M, 14F) Mean age: 54.5 (17.0) years Median time since injury: 6.5 years AIS D: 39	Construct validity: 10MWT was strongly correlated with Mini BESTest. Spearman's rho=-0.81; p<0.001 10MWT was strongly correlated with Berg		

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	AIS A, B, or C: 7	Balance Scale. Spearman's rho=-0.88; p<0.001		
Shah et al. 2017 Prospective, cross-sectional Canada	N=26 community-dwelling individuals with chronic incomplete SCI (20M, 6F) Mean age: 59.7 ±18.9 years AIS C: 5 AIS D: 21 N= 26 age and sex matched non-SCI participants	Convergent validity: Fast 10MWT had good to excellent convergent validity with the Activity Balance Confidence (ABC) Scale scores. Pearson correlation coefficient: 0.80; p<0.001 Self-selected 10MWT had good to excellent convergent validity with ABC Scale scores. Pearson correlation coefficient: 0.76; p<0.001		
Harkema et al. 2016 Prospective multicenter observation; NRS 13-item version N=152	N=152 (123M, 29F) Mean (SD) age: 36 (15) Median (range) time since SCI: 0.9 (0.1-45.2) years 110 cervical	Pearson's r (95%CI) with ASIA Motor Scales: UEMS: 0.24 (0.15-0.34) LEMS: 0.69 (0.63-0.75)		Responsiveness: Standardized Response Means after Locomotor Training: All individuals: 0.51 AIS-A/B: non ambulatory

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6 outpatient rehabilitation centers in the Christopher and Dana Reeve Foundation, USA	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)	ASIA Motor Score: 0.63 (0.57-0.69)		AIS-C: 0.50 AIS-D: 0.98 Median (range) number of sessions of NRN-standardized locomotor training: 70 (23-520) Interpretability: Median (Range) 10MWT Speeds: <u>All individuals:</u> Enrollment: 0 (0-1.96) Discharge: 0 (0-2.62) <u>AIS-A/B:</u> Non-ambulatory <u>AIS-C:</u> Enrollment: 0 (0-0.49) Discharge: 0 (0-1.72) <u>AIS-D:</u> Enrollment: 0.25 (0-1.96) Discharge: 0.81 (0-2.62) * Enrollment = pre-intervention;

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				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 44 cervical, 28 thoracic AIS-A/B/C/D: 17/10/20/25			SRD: 0.105m/s
Duffell et al. 2015 Outpatient service at the	N=83 57 male Mean age=47.28 Incomplete SCI patients (AIS-C/D, SCI lvl above T10,			Interpretability: MID=0.11m/s

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Rehabilitation Institute of Chicago , USA	12month+ post injury, able to ambulate) treated with either Lokomat, tizanidine, or no intervention			
Srisim et al. 2015 Prospective cohort study Tertiary Rehabilitation Center, 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%)	Unable to predict and discriminate non- multiple fallers and multiple fallers Ability of cut-off score (≥ 10 s) to predict risk of multiple falls: Sensitivity: 56% Specificity: 69% AUC: 0.57	Interrater Reliability: ICC= 0.997 (0.994- 0.998)	SEM= 0.20
Forrest et al. 2014 Prospective observational cohort	N= 249, 190M Mean age=42, SD=16 Median time since SCI=0.7 yrs, range=0.1-21.6 AIS-C = 20, D=179; 50 not evaluated	“Significantly higher speeds occurred with higher classifications [SCI-FAI] for both the 6MWT and 10MWT” Pearson’s r with 6MWT:		SRD = 0.10m/s (Nearly no diff. btwn fast (>=0.44m/s) & slow walkers (<0.44m/s)) MCID (for SCI-FAI < 5 at enrollment patients) = 0.15m/s

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7 outpatient clinical sites in the Christopher and Dana Reeve Foundation NeuroRecovery Network (NRN), USA	Etiology: 15 non- trauma, 83 MVA, 54 fall, 45 sporting, 25 medicine/surgery, 10 other causes Median treatment sessions: 40; range=2-353	At enrollment in the NRN: $r=0.93$ At discharge: $r=0.94$ Overall: $r=0.94$ Regression analysis with 6MWT shows regression differing significantly with line of agreement – 6MWT & 10MWT not redundant ($p<0.001$)		(for slow walkers ($<0.44\text{m/s}$) = 0.1- 0.15m/s)
Amatachaya et al. 2014 Cross-sectional Thailand	N= 95 (65M, 30 F) Age (FIM7): 49.2 ± 10.0 Age (FIM6): 51.9 ± 13.2 Age (FIM5): 45.2 ± 13.2 Independent ambulatory individuals with SCI FIM7: 33; Time since Injury (months): 34.6 ± 26.56 FIM6: 31; Time since injury (months): 44.3 ± 43.2	Pearson's correlation with 6MWT: In FIM-L=6 patients, r = 0.74, $p<0.001$ In FIM-L=7 patients, r = 0.83, $p<0.001$ In FIM-L=5 patients, r = 0.31, $p=0.113$		

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	FIM5: 30; Time Since Injury (months): 36.7 ± 30.6 AIS-D=52 Incomplete tetraplegia = 28			
Saensook et al. 2014 Cross-sectional Thailand	N=85, 59 male 30 used walkers, 7 used crutches, 11 used canes, 37 no device AIS-C = 22/85 59/85 paraplegia			10MWT distinguishes persons walking with canes and persons walking with walkers (p<0.001)
Poncumhak et al. 2014 Cross-sectional A tertiary rehabilitation center in Thailand	N=60 (42M,) Mean age = 49.95 Mean time since injury = 55.5 yrs 26 traumatic, 34 non-traumatic 7 AIS-C, 53 AIS-D 23 tetraplegia, 37 paraplegia 30 with walking device, 30 without device Independent ambulatory SCI patients	Score of > 0.67 m/sec “had good-to- excellent capability to determine the ability of walking without a walking device of subjects with SCI” ROC curve area: 0.96 (95%CI=0.91~1.00) Sensitivity=90% Specificity=87%	Interrater: ICC (N=20) = 0.994 (95%CI=0.988~0.998), p<0.001	SEM: 0.03

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Musselman & Yang 2013 Crossover trial	N=20 (14M, 6F) Age: 46.0 ± 13.6 Time since SCI (years): 5.4 ± 8.8		Test-retest: ICC: 0.981 (self-selected pace) and 0.977 (fast pace)	SRM: With 2 month endurance training: 0.62 (Self-selected pace) and 0.75 (fast pace) With 2 month precision training: 0.64 (Self-selected pace) and 0.79 (Fast pace) MDC: 0.15 (self-selected pace) and 0.17 (fast pace) m/s SEM: 0.05 (self-selected pace) and 0.06 (fast pace) m/s
Poncumhak et al. 2013 Cross-sectional A tertiary rehabilitation center in Thailand	Validity Test: N=66 (46M, 20 F) FIM-L 6: N=33, mean age = 50.9±13.5, AIS-C=9, AIS-D=24, tetraplegia=9, paraplegia=24 FIM-L 7: N=33, mean age = 50.23±9.5, AIS-C=1, AIS-D=32, tetraplegia=13, paraplegia=20	Point biserial correlations ($p < 0.05$): With FIM-L Scores: coefficient = 0.778 With TUGT Scores: coefficient = -0.692	Interrater: ICC = 0.999 (0.996-1.000) for FIM-L 6 (N=8); 1.000 (0.999-1.000) for FIM-L 7 (N=8)	

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	Reliability Test: N= 16 mean age = 50.8±10.3 AIS-C=2, AIS-D=15, tetraplegia=6, paraplegia=10			
Scivoletto et al. 2011 Test-retest analysis SCI unit of a rehabilitation hospital	N= 37 (28M, 9F) Median age: 58.5 yrs (range: 19-77) 20 of 37 patients had a non-traumatic lesion 12 cervical 14 thoracic 11 lumbar Setting: SCI unit of a rehabilitation hospital		The 10 MWT was tested with static start (10m) vs dynamic start (14m): The correlation between the results of the two methods was between 0.98 and 0.99. Inter-rater: between 0.95 and 0.98 for both the methods. Intra-rater: between 0.98 and 0.99.	The 10MWT was performed in a median of 19 s (25th– 75th interquartile range 13–28), with the static start and in a median of 18.4s (25th– 75th interquartile range 12.6–29.9) with the dynamic start (P=0.092). When examining the patients according to either high or low WISC level, the results for static and dynamic starts were comparable. Patients (N=15) with high WISC levels (18–20)

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				performed the test in a median of 13.17s (25th–75th interquartile range 10.8–19) with the static start and a median of 12.7s (25th–75th interquartile range 10–18.5) with the dynamic one (P=.17). Patients (N=6) with low WISCI levels (9–12) performed the test in a median of 19.8s (25th–75th interquartile range 15–32.3) with the static start and a median of 19.8s (25th–75th interquartile range 14.6–30.9) with the dynamic one (P=.46).
Wirz et al. 2010 Switzerland	N= 42 (33M, 9F) mean age: 49.3±11.5 yrs AIS A: 2 AIS B: 2 AIS C: 35	The BBS correlated strongly and significantly with the 10MWT (r=.93, P<.001) 10MWT correlations with:		

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	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	Falls total: $r=-.10$ ($P=.52$) Spinal Cord Independence Measure (SCIM) mobility score: $r=.89$ ($P<.001$) WISCI: $r=.81$ ($P<.001$) Falls Efficacy Scale (FES-I): $r=-.83$ ($P<.001$) Motor scores: $r=.60$ ($P<.001$)		
Lemay & Nadeau 2010 Longitudinal An intensive rehabilitation center in Montreal, Canada (Institut de readaptation	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	Spearman's correlations of 10MWT with other walking scales: (all $P<.01$) BBS: 0.792 Spinal Cord Injury – Functional Ambulation Inventory		Mean (SD) 10-MWT score (m/s): All participants: 0.81 (0.34), range: 0.08-1.43 Paraplegia subgroup: 0.73 (0.32), range: 0.08-1.35 Tetraplegia subgroup: 0.87 (0.34), range: 0.34-1.43

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Gingras-Lindsay de Montreal)	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.	(SCI-FAI) parameter: 0.777 SCI-FAI assistive devices: 0.788 SCI-FAI mobility: 0.756 WISCI II: 0.795 The following are Pearson's product moment correlation instead of Spearman's ρ): 1. 2MWT: 0.932 2. TUG: -0.646 (all $P < .01$)		
van Hedel et al. 2009 Euopean Multicenter Study for Human Spinal Cord Injury (EM- SCI)	N= 886 413 AIS A participants: 39±18 yrs, 65% paraplegic, 19% female 113 AIS B participants: 42±18 yrs, 44% paraplegic, 27% female			Interpretability: Five functional ambulation categories from the SCIM-II Mobility items were created based on 10MWT results: <i>Wheelchair- dependant:</i> Mean (SD) walking

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	137 AIS C participants: 48±20 yrs, 47% paraplegic, 32% female 223 AIS D participants: 47±17 yrs, 37% paraplegic, 22% female			speed: 0.015 ± 0.006 m/s • <i>Supervised walker:</i> Mean (SD) minimal required speed: 0.09 ± 0.01 m/s • <i>Indoor walker:</i> Mean (SD) minimal required speed: 0.15 ± 0.08 m/s • Walker with aid: Mean (SD) minimal required speed: 0.44 ± 0.14 m/s • <i>Walker without aid:</i> Mean (SD) minimal required speed: 0.70 ± 0.13 m/s* * This is also the threshold that clinicians might use for a person with SCI “functional ambulation” or safe for walking in the community.

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Datta et al. 2009 Cohort The NeuroRecovery Network (NRN), a specialized network of treatment centers providing standardized, activity-based therapy for patients with SCI, USA	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	Correlation between the first principle component of changes in BBS item in ten-meter walk speed: Kendall $\tau = 0.34$ Spearman $p = 0.46$ $P < 0.01$ for all		
Jackson et al. 2008 Subcommittee of internal experts evaluated locomotion measures	N = 54 expert raters	Content Validity: Expert Evaluations (53 votes): Valid or Useful: 32 (60%) Useful but requires validation: 20 (38%) Not useful or valid for research: 1 (2%)		

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Lam et al. 2008 Meta-analysis				SEM: 0.05 m/s MDC: 0.13 m/s Mean change between 1 and 3 months post-injury: effect size = 0.92 Mean change between 3 and 6 months post-injury: effect size = 0.47
Ditunno et al. 2007 Single-blinded, paralleled-group, multicenter RCT 6 regional SCI inpatient rehabilitation centers	N= 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.	10MWT speed: Spearman correlation w/Walking Index for SCI (all P<.001) At 3 months: r = 0.78 At 6 months: r = 0.85 At 12 months: r = 0.77 Spearman correlation w/6-Minute Walking Test (all P<.001) At 3 months: r = 0.95 At 6 months: r > 0.80 At 12 months: r = 0.92		

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		Spearman correlation w/Berg Balance Scale (BBS) (all $P < .001$) At 3 months: $r = 0.81$ At 6 months: $r > 0.80$ ($r = 0.86$) At 12 months: $r = 0.78$ Spearman correlation w/Functional Independence Measure (FIM) ($P < .001$) At 3 months: $r = 0.57$ Spearman correlation w/FIM Locomotor Score (all $P < .001$) At 3 months: $r = 0.80$ At 6 months: $r > 0.80$ At 12 months: $r = 0.66$ Spearman correlation w/Lower Extremity Motor Score (all $P < .001$) At 3 months: $r = 0.64$		

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		At 6 months: $r > 0.80$ At 12 months: $r = 0.92$		
van Hedel et al. 2006 Longitudinal study European Multicenter Study of Human SCI	N= 22 (18M, 4F) Mean age=45.5±16.7 years All participants have incomplete injuries and have achieved walking capacity in early stages after injury. Cervical =13 Thoracic = 1 Lumbar = 7 Sacral = 1	10MWT time: Spearman correlation w/Lower Extremity Motor Score Within 1 month: $r = -0.45$ [P=.04] After 3 months: $r = -0.30$ [P=.18] After 6 months: $r = -0.40$ [P=.06] After 12 months: $r = -0.39$ [P=.07] Spearman correlation w/Walking Index for SCI II Within 1 month: $r = -0.79$ [P<.001] After 3 months: $r = -0.21$ [P=.35] After 6 months: $r = -0.37$ [P=.09] After 12 months: $r = -0.37$ [P=.09]		Responsiveness: The 10MWT differed between 1 month and 3 months (mean time taken to complete the test decreased from 13 to 8 seconds, P<.001) and between 3 months and 6 months (mean time taken to complete the test stayed at 8 seconds, P=.005) but not between 6 months and 12 months (mean time taken to complete the test stayed at 8 seconds, P=.91)

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		Spearman correlation w/ 6 minute Walk Test Within 1 month: $r = -0.91$ [$P < .001$] After 3 months: $r = -0.90$ [$P < .001$] After 6 months: $r = -0.87$ [$P < .001$] After 12 months: $r = -0.86$ [$P < .001$]		Friedman's test ($\alpha = 0.05$) between 4 intervals: $DF = 3$ $F_r = 41.4$ $P < 0.001$ Pair-wise comparisons via Wilcoxon's signed rank test: Between intervals 1 and 2: $P < .001$ Between intervals 2 and 3: $P = .005$ Between intervals 3 and 4: $P = .91$ Interpretability: 10 MWT scores in seconds: Mean (SD), Median Within 1st month: 13 (6.8), 11 After 3 months: 8 (3.2), 8

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				After 6 months: 8 (2.6), 7 After 12 months: 8 (2.6), 7
van Hedel et al. 2005 Cross-sectional study with repeated assessment Switzerland	Validity: N = 75 (45M, 30F) Mean age = 54±20 years Cervical = 25 Thoracic = 21 Lumbar = 21 Sacral = 8 Reliability: N = 22 (14M, 8F) Mean age = 52±20 years Cervical = 7 Thoracic = 7 Lumbar = 7 Sacral = 1	10MWT and Timed Up and Go (TUG): r = 0.89, n=70 6 Minute Walk Test (6MWT) and 10MWT: ρ = -0.95, n=62 Subgroups: Walking Index for Spinal Cord Injury (WISCI) scores of 0 to 10: 10MWT and TUG: r=0.92, n=23 6MWT and 10MWT: r=- 0.96, n=15 WISCI scores of 11 to 20 10MWT and TUG: r=0.79, n=47 6MWT and 10MWT: r=- 0.93, n=47 Dependent walking group: 10MWT and	Intrarater: r = 0.983, P<.001 Interrater: r = 0.974, P<.001 Bland-Altman plot: No significant differences between intra-rater (0.5±6.0s) and inter-rater (- 0.1±7.0s) assessment	

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		TUG: $r=0.88$, $n=27$ 6MWT and 10MWT: $\rho=-0.92$, $n=19$ Independent walking group: 10MWT and TUG: $r=0.86$, $n=43$ 6MWT and 10MWT: $\rho=-0.94$, $n=43$ 10MWT with WISCI II: Overall: $\rho=-0.68$, $n=67$ <u>Subgroups:</u> WISCI II scores of 0 to 10: $\rho = -0.24$, $n=20$ WISCI II scores of 11 to 20: $\rho = -0.49$, $n=47$ WISCI II dependent walking group: $\rho = -$ 0.35, $n=24$ WISCI II independent walking group: $\rho = -$ 0.48, $n=43$		