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Research Summary - 6-Minute Walk Test (6MWT) - 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 Swiss Paraplegic Center, Nottwill, Switzerland; Balgrist University Hospital, Zurich, Switzerland	N= 50 Mean age: 52.6 ±16.2 years Years 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 with the 2MWT r= 0.992 (0.986-0.995)		
Musselman et al. 2022 Retrospective longitudinal study Canada	N= 618 people with traumatic SCI (141F) 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	**Convergent validity:** 6MWT with the Standing and Walking Assessment Tool (SWAT) r= 0.521; p<0.001		

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	AIS E: 1 Cervical: 383 Thoracic: 156 Lumbar: 72 Sacral: 7			
Perez-Sanpablo et al. 2017 Observational, descriptive, transversal National Institute of Rehabilitation, Mexico City, Mexico	N=23 (15M/8F) Mean Age: 45.6 ± 12.6 years Mean Time since injury: 42 ± 117 months AIS D, motor subacute and chronic incomplete	Spearman correlation with WISCI-II: r=0.36-0.69 Spearman correlation with LEMS: r=0.49-0.55		
Harkema et al. 2016 Prospective observational cohort 6 outpatient rehabilitation centers in the Christopher and	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	Pearson's r (95%CI) with ASIA Motor Scales: UEMS: 0.24 (0.15-0.34) LEMS: 0.70 (0.64-0.76) ASIA Motor Score: 0.64 (0.58-0.71)		**Responsiveness:** Standardized Response Means after Locomotor Training: All individuals: 0.48 AIS-A/B: non-ambulatory AIS-C: 0.50 AIS-D: 0.83

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Dana Reeve Foundation, NRN, USA	Physician-referred outpatients without progressive lesions above T11, with ability to step 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)			Median (range) number of sessions of NRN-standardized locomotor training: 70 (23-520) **Interpretability:** <u>Median (Range) 6MWT Distances:</u> All individuals: Enrollment: 0 (0-549) Discharge: 0 (0-700) AIS-A/B: Non-ambulatory AIS-C: Enrollment: 0 (0-114) Discharge: 0 (0-534) AIS-D: Enrollment: 57 (0-549) Discharge: 264 (0-700)

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				* 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 44 cervical, 28 thoracic AIS-A/B/C/D: 17/10/20/25			**SRD:** 0.086m/s *Analogous to Minimal Detectable Change
Duffell et al. 2015 Outpatient service at the	N=83 (26F, 57M) Age: 18 – 50			**MDC**: 37.1 m (0.103 m/s)

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Rehabilitation Institute of Chicago, USA	Mean age = 47.28 Incomplete SCI patients (AIS-C/D, SCI lvl above T10, 12month+ post injury, able to ambulate) treated with either Lokomat, tizanidine, or no intervention			
Pithon et al. 2015 Ambulatory clinic of Hospital Universitário da Universidade Estadual de Campinas, Brazil	N=9, all male Mean age: 32.78±11.58 Time since SCI: 4~13yrs All AIS-A Level of injury: T4~T12		**Intra-rater:** r^2 = 0.96	
Forrest et al. 2014 Prospective observational cohort 7 out-patient clinical sites in	N=249, 190 male 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 Etiology: 15 non-trauma, 83 MVA, 54	"Significantly higher speeds occurred with higher classifications [SCI-FAI] for both the 6MWT and 10MWT" **Pearson's r with 10MWT:**		**SRD** = 0.08m/s (Nearly no diff. btwn fast (>=0.44m/s) & slow walkers (<0.44m/s)) **MCID** (for SCI-FAI < 5 at enrollment patients) = 0.11m/s (for slow walkers

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the Christopher and Dana Reeve Foundation NeuroRecovery Network (NRN), USA (Feb 2008-Apr 2011)	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 10MWT shows regression differing significantly with line of agreement – 6MWT & 10MWT not redundant (p<0.001)		(<0.44m/s) = 0.1-0.15m/s)
Amatachaya et al. 2014 Cross-sectional A major tertiary referral hospital in Thailand	N=94, 65 male Age (FIM7): 49.2 ±10.0 Age (FIM6): 51.9 ±13.2 Age (FIM5): 45.2 ±13.2 Independent ambulatory individuals with SCI. FIM-Locomotor 7: 33; Time since Injury (months): 34.6 ± 26.56 FIM-L 6: 31; Time since injury (months): 44.3 ± 43.2	**Pearson's correlation with 10MWT:** 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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	FIM-L 5: 30; Time Since Injury (months): 36.7 ± 30.6 AIS-D=52 Incomplete tetraplegia = 28			
Musselman & Yang, 2013 Crossover trial	N=20 (14M, 6F) Age: 46.0 ± 13.6 Time since SCI (years): 5.4 ± 8.8 Fast walkers (>0.5 m/s): N=9 Self-selected walkers: N=11		**Test-retest ICC**: 0.989	**Responsiveness:** With 2 month endurance training: SRM: 0.88 **Interpretability:** MDC: 34.4 m (0.0956 m/s) SEM: 12.3 m (0.0342 m/s)
Scivoletto et al. 2011 Methodological 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 injury level: 12 cervical, 14 thoracic, 11 lumbar		The 6-MWT was tested on a longer track (50m) vs. on a short track (10m): The correlation between the results of the two methods was between 0.91	

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			and 0.93 **Inter-rater:** 0.99 and 1 for the two methods. **Intra-rater:** between 0.98 and 0.99 for the two methods.	
Datta et al. 2009 USA Cohort The NeuroRecovery Network (NRN), a specialized network of treatment enters providing standardized, activity-based therapy for patients with SCI.	**Population:** 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 change in Berg Balance Scale items and changes in six-minute walk distance: Kendall τ =0.34 Spearman p = 0.48 P<0.01 for all		

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Jackson et al. 2008 International	**N/A** A subcommittee of international experts evaluated locomotion measures	**Content Validity:** Expert Evaluations (52 votes): Valid or Useful: 19 (37%) Useful but requires validation: 30 (58%) Not useful or valid for research: 3 (6%)		
Olmos et al. 2008 Cross-sectional study	N=18 (12M, 6F) Age range: 19-72 years old All community-ambulating AIS D SCI patients, > 6 months post-injury, walking at a speed of at least 0.25 m/s			All participants were tested 3 times in both environments (Experimental – indoor gym and Natural – community setting) on the same time with an interval of 60 min between each test. (Table 1.)

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<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 colspan="4">Table 1.
<table>
<tr><td></td><td>Experimental environment</td><td>Natural environment</td></tr>
<tr><td>Mean</td><td>382.39 m</td><td>401.44 m</td></tr>
<tr><td>Medi</td><td>371.75 m</td><td>367.80 m</td></tr>
<tr><td>SD</td><td>120.988 m</td><td>130.276 m</td></tr>
<tr><td>Min</td><td>151 m</td><td>151 m</td></tr>
<tr><td>Max</td><td>560 m</td><td>584 m</td></tr>
</table></td></tr>
<tr><td>Barbeau et al. 2007

Longitudinal

Spinal Cord Injury Locomotor Trial (SCILT), multicenter RCT</td><td>N=107 AIS C and D
N=38 ASIA B
All had lesions b/w C5 and L3

Group 1:
N=66 individuals with SCI who completed both assessments 3 months after entry to rehab

Group 2:
N=69 individuals with SCI who completed both assessments 6</td><td></td><td></td><td>Comparison of walking speed within subjects with upper motor neuron lesions during the SCILT:

Gait speed was very similar at 3 and 6 month testing b/w 15.2m and 6 minute walking tests; however, gait speed was significantly faster during the 12 month follow up for the 15.2 m test. (Table 2.)</td></tr>
</table>

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<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>months after entry to rehab

Group 3:
N=70 individuals with SCI who completed both assessments 12 months after entry to rehab
All patients underwent either 12 weeks of step training with body weight support on a treadmill combined with overground practice OR a defined overground mobility intervention (CONT).</td><td></td><td></td><td>Table 3. below: Walking Speeds (Mean, Standard Error) Used for the 15.2-m Versus 6-Minute Walk by the Slowest, Middle (25%-75%), and Fastest Patients at Each Data Collection</td></tr>
<tr><td></td><td colspan="4">Table 2. Comparison of walking speed within subjects with upper motor neuron lesions during the SCILT:
<table><tr><th>Months after entry to trial:</th><th>n</th><th>Walking speed (m/s) over 6 minutes</th><th>Walking speed (m/s) over 15.2 m</th><th>P value</th></tr></table></td></tr>
</table>

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3	66	0.64 (0.06)	0.72 (0.05)	.14
6	69	0.79 (0.05)	0.92 (0.06)	.29
12	70	0.88 (0.06)	1.08 (0.06)	.001

Table 3. Walking Speeds (Mean, Standard Error) Used for the 15.2-m Versus 6-Minute Walk by the Slowest, Middle (25%-75%), and Fastest Patients at Each Data Collection

Time:	Variable:	Quartile:	# of patients:	Mean (m/s) (Standard error)	P value
3 months	15.2-m 6-minute	Lower	14	0.20 (0.06) 0.16 (0.06)	.15
	15.2-m 6-minute	Middle	33	0.74 (0.05) 0.62 (0.29)	.07
	15.2-m 6-minute	Upper	19	1.55 (0.06) 1.33 (0.41)	.01
6 months	15.2-m 6-minute	Lower	10	0.18 (0.06) 0.16 (0.09)	.84
	15.2-m 6-minute	Middle	39	0.86 (0.04) 0.82 (0.04)	.53

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<tr><td></td><td>
<table>
<tr><td>12 months</td><td>15.2-m 6-minute</td><td>Lower</td><td>16</td><td>0.32 (0.07)
0.27 (0.08)</td><td>.56</td></tr>
<tr><td></td><td>15.2-m 6-minute</td><td>Middle</td><td>34</td><td>1.01 (0.06)
0.87 (0.05)</td><td>.03</td></tr>
<tr><td></td><td>15.2-m 6-minute</td><td>Upper</td><td>20</td><td>1.88 (0.06)
1.46 (0,07)</td><td><.001</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Ditunno et al. 2007

Single-blinded, paralleled-group, multicenter RCT

6 regional SCI inpatient rehab. centres</td><td>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.</td><td>Spearman correlation w/Walking Index for SCI (all P<.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 (50-foot Walking Speed is very similar to 10-meter walk test) (all P<.001):

At 3 months: r = 0.95</td><td></td><td></td></tr>
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		At 6 months: r > 0.80 At 12 months: r = 0.92 Spearman correlation w/Functional Independence Measure- Locomotor Score (all P<.001) At 3 months: r = 0.78 At 6 months: r =0.69 At 12 months: r = 0.62 Spearman correlation w/Berg Balance Scale (P<.001): At 3 months: r = 0.79 The correlations with the Lower Extremity Motor Score at each of the time periods were 0.56 < r < 0.63.		
van Hedel et al. 2006 Longitudinal	N= 22 (18M, 4F) Mean age = 45.5 years (range 17 – 78 years)	Spearman correlation w/Lower Extremity Motor Score		**Responsiveness:** The 6MWT differed between 1 month and

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European Multicenter Study of Human Spinal Cord Injury	All subjects have incomplete injuries and have achieved walking capacity in early stages after injury. Cervical =13 Thoracic = 1 Lumbar = 7 Sacral = 1	Within 1 month: r = 0.54 [P=.01] After 3 months: r = 0.34 [P=.12] After 6 months: r = 0.49 [P=.02] After 12 months: r = 0.55 [P<.01] Spearman correlation w/Walking Index for SCI II 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 = -0.91 [P <.001]		3 months (mean score increased from 314 to 473 metres, P<.001) and between 3 months and 6 months (mean score increased from 473 to 502 metres, P=.01) but not between 6 months and 12 months (mean score decreased from 502 to 495 metres, P=.76) Friedman's test (α = 0.05) between 4 intervals: DF = 3 F_r = 38.9 P < 0.001 Pair-wise comparisons via Wilcoxon's signed rank test:

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		After 3 months: r = -0.90 [P<.001] After 6 months: r = -0.87 [P<.001] After 12 months: r = -0.86 [P<.001]		Between intervals 1 and 2: P<.001 Between intervals 2 and 3: P=.01 Between intervals 3 and 4: P=.76 **Interpretability:** 6 MWT scores in metres: Mean (SD), Median Within 1st month: 314 (137.0), 323 After 3 months: 473 (110.1), 465 After 6 months: 502 (132.6), 505 After 12 months: 495 (125.1), 285
van Hedel et al. 2005 Cross-sectional study with	**Validity:** N = 75 (45M, 30F) Mean age = 54±20 years	**Correlations (Spearman rank):** 6 Minute Walk Test (6MWT) and 10 Meter		

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repeated assessments The SCI centre of a university hospital in Switzerland.	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	Walk Test (10MWT): ρ = -0.95, n=62 6MWT and Timed Up and Go (TUG): ρ = -0.88, n=62 <u>Subgroups:</u> WISCI II scores of 0 to 10: 6MWT and TUG: r=-0.70, n=15 6MWT and 10MWT: r=-0.96, n=15 WISCI scores of 11 to 20 6MWT and TUG: r=-0.78, n=47 6MWT and 10MWT: r=-0.93, n=47 Dependent walking group: 6MWT and TUG: ρ=-0.74, n=18 6MWT and 10MWT: ρ=-0.92, n=19		

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		Independent walking group: 6MWT and TUG: ρ =-0.88, n=44 6MWT and 10MWT: ρ=-0.94, n=43 <u>Correlation of 6MWT with Walking Index for Spinal Cord Injury (WISCI) II:</u> Overall: ρ = 0.60, n=60 <u>Subgroups:</u> WISCI II scores of 0 to 10: ρ = -0.22, n=13 WISCI II scores of 11 to 20: ρ = 0.64, n=47 WISCI II dependent walking group: ρ = -0.21, n=15 WISCI II independent walking group: ρ = 0.65, n=45		