Table 12. Body-Weight Supported Treadmill Training (BWSTT) for Standing Balance

Author Year **Country** **Score** **Research Design** **Total Sample Size**	**Methods**	**Outcome**
	Acute SCI (< 1 year)	
Midik et al. (2020); Turkey RCT PEDro=4 Level 2 N=30	**Population:** 30 males with traumatic incomplete SCI and a LEMS of ^{3} 10; mean (range) age 36.6 (19-53) years; AIS C (n=16) and AIS D (n=14); injury level T12 (n=7) and L1-L3 (n=23); median time since injury for the RAGT and control groups was 5 and 24 months, respectively. **Treatment:** All patients received regular physiotherapy (consisting of range of motion exercises, strengthening exercises, body stabilization, self-care ability, and ground walking training) for 5 times a week for a total of 5 weeks. Participants were randomized into two groups: • RAGT group (n=15): Received additional RAGT (using Lokomat) for 3 times a week (each session lasted 30 min) for a total of 5 weeks. Treadmill speed and BWS was increased individually. • Control group (n=15). **Outcome Measures:** SCIM-III, LEMS and WISCI II were assessed at baseline (t1), at the end of the treatment (t2), and at three months after the treatment (t3).	1. Both groups significantly (p<0.01) improved in SCIM-III, but without statistically differences between groups, except in the RAGT group which showed higher SCIM-III values at T3 in comparison with the control group (p=0.01).
Wirz et al. (2017); Switzerland, Germany, Spain and UK RCT PEDro=6 Level 1 N=18	**Population:** 18 participants with acute SCI and limited walking ability (WISCI II < 5); 16 males and 2 females; mean age 34.9 years; level of injury C4 to T12; AIS B (n=9) and AIS C (n=9); and study inclusion was set at maximum of 60 days post-trauma. **Treatment:** Patients performed 3–5 days of training per week of RAGT using Lokomat for a period of 8 weeks. Patients were randomly	1. For the SCIM-III mobility subscore, both groups improved to a statistically significant level; however, changes in the intervention group (19.0 [4-29]) were markedly greater than in control group (5.0 [0-30]).

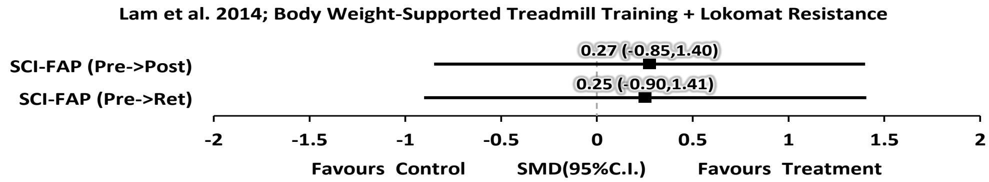
	allocated to one of two groups depending on the stablished walking time per training: • Intervention group (n=9): More than 50 min. • Control group (n=9): Maximum of 25 min. **Outcome Measures:** SCIM-III mobility subscore was assessed at baseline and at 8 weeks of training.	
Shin et al. (2014); Seoul RCT PEDro=5 Level 2 N=53	**Population**: 53 participants- 34 males and 19 females with incomplete SCI; 31 with cervical injuries and 22 with thoracic & lumbar injuries; 36 with traumatic SCI and 16 with non-traumatic SCI; mean age= 48.15 ± 11.14y; months post injury= 3.33 ± 2.02 months. **Treatment**: Patients were included in a prospective, randomized clinical trial by comparing RAGT to regular physiotherapy. • The RAGT group received RAGT three sessions per week at duration of 40 min with regular physiotherapy in 4 weeks. • The conventional group underwent regular physiotherapy twice a day, 5 times a week. **Outcome Measures:** LEMS, ambulatory motor index, SCIM-III mobility section (SCIM-III mobility subscore), and WISCI II.	1. At the end of rehabilitation, both groups showed significant improvement in SCIM-III mobility subscore.
Tang et al. (2014); China and Japan RCT PEDro=4 Level 2 N=30	**Population:** 30 male participants with incomplete SCI; mean (± SD) age 38.6 (± 7.6) years; AIS D (n=30); and time since injury 189 days. **Treatment:** Participants were randomly assigned to two groups: • Lokomat group (n=15): Participants performed one session using Lokomat with an initial training speed of 1.5 km/h (and progressively raised to 1.8 km/h while maintaining gait quality), with	1. The Probe Reaction Time decreased significantly in the Lokomat group; however, it didn't significantly decrease in the Ergo bike group. 2. Post-intervention, the Lokomat group had a significantly shorter Probe Reaction Time than the Ergo bike group.

	a BWS initiated at 35%, and with a 70% guidance force. • Ergo bike group (n=15): Participants were instructed to pedal at a pedaling rate of 45 rpm with a workload of 60 W during 40 min for the session. **Outcome Measures:** Probe Reaction Time and 10MWT were assessed at baseline and after the training.	
Dobkin et al. (2006); USA RCT PEDro=7 Level 1 N=292 (enrolled) N=117 (analyzed)	**Population**: 117 males and females; age 16-69 yrs; AIS B-D; <8 wks post-injury. **Treatment:** BWSTT vs. overground mobility training: 5x/wk, 9-12 wks, 30-45 min/session. **Outcome Measures:** BBS, FIM-L, walking speed, 6MWT, WISCI at 3 and 6 months.	1. AIS C & D participants with upper motor neuron in both groups improved in BBS scores, without statistical difference between groups.
Shahin et al. (2017); Egypt Prospective controlled trial Level 2 N=40	**Population:** 40 participants with acute SCI (onset less than 6 month). • RAGT group (n=20): Mean age 32.4 ± 11.8 years; AIS B-C; tetraplegia (n=3) and paraplegia (n=17); and mean injury duration 4.7 ± 4.6 months • Conventional group (n=20): Mean age 32.7 ± 10.5 years; AIS B-C; tetraplegia (n=3) and paraplegia (n=17); and mean injury duration 3.7 ± 3.1 months **Treatment:** Participants were assigned into one of the following two groups: • RAGT Group (n =20): Participants received RAGT (3 days per week) with the Lokomat system in addition to the rehabilitation program (2 days per week). Each session lasted for 60 minutes. The BWS was adjusted to the minimum without knee buckling or toe dragging. The walking speed was gradually increased up to 1.5 km/hr.	1. The BBS was significantly improved in both groups in week 12; however, there was no statistical changes between groups.

	Conventional group (n=20): Participants received rehabilitation program only. Sessions were performed 30 minutes each, 5 sessions a week, included functional exercises according to the muscle grading, slow prolonged stretching of the spastic muscles, and strengthening exercises to the anti-spastic muscles. The conventional therapy included active or assisted active exercises. **Outcome Measures:** BBS was assessed before intervention (week 0) and at week 12 after treatment (week 12).	
Schwartz et al. (2011); Israel Case control Level 3 N=56	**Population:** 56 participants with SCI as a result of traumatic (57%) or non-traumatic causes; 37 males and 19 females; mean age 42.5 years; level of injury cervical (n=26), thoracic (n=16), and lumbar (n=14); AIS A (n=6), AIS B (n=7), AIS C (n=13), and AIS D (n=2); and mean time since injury 24 days. **Treatment:** Participants in the intervention group were prospectively included and those in the control group were retrospectively matched. - Intervention group (n=28): Participants received 30-min sessions of RAGT with Lokomat with individualized progression in speed and BWS, and 30-45 min of regular physiotherapy sessions; for 2-3 times a week and 12 weeks. - Control group (n=28): Participants were treated by regular physiotherapy for 30–45 min five times a week using Bobath principles. **Outcome Measures:** FAC scale, SCIM, and WISCI II were assessed upon admission and upon discharge from the rehabilitation department.	1. At the end of the rehabilitation period, both groups showed a significant improvement in ambulation ability according to FAC (Wilcoxon signed ranks test Z =-5.21, p<0.01), with no significant differences between groups. 2. Both groups improved significantly in their SCIM scores during the rehabilitation period, however the RAGT group improved significantly more in SCIM mobility scores than the controls (RAGT: 34±19 points to 64±17 points; Controls: 34±21 to 55±22; $F_{1:54}$=8.84, P=0.05).

Harkema et al. (2012); USA Pre-post Level 4 N=196	**Population**: 196 participants (148 male, 48 female) with incomplete SCI; mean age 41±15 yrs; YPI- <1 yrs (n=101), 1-3 yrs (n=43), >3 yrs (n=52). **Treatment:** Locomotor training with three components: (1) 1 hour of step training in the BWS on a treadmill environment, followed by 30 min of (2) overground assessment and (3) community integration. **Outcome Measures**: BBS, 6MWT, and 10MWT.	1. Scores on the BBS significantly improved by an average of 9.6 points. 2. Increases were significant for patients with AIS grades C and D, and the amount of improvement was significantly different between these groups (rank-sum test, p<0.008). Of the 168 patients classified as at risk for falls at enrollment, 27% improved their scores to a value reflecting minimal risk for falls (11% AIS grade C, 37% AIS grade D).
Chronic SCI (> 1 year)		
Piira et al. (2019a); Norway RCT PEDro=7 Level 1 N=20	**Population:** Participants with chronic and motor incomplete SCI; 15 males and 5 females; mean age 50 years; level of injury cervical (n=8), thoracic (n=8) and lumbar (n=4); AIS C (n=6) and AIS D (n=14); and median time since injury 4 years. **Treatment:** Participants were randomly divided in two groups: • Control group (n=10): Participants received usual care (which might include overground walking). • Intervention group (n=10): A treadmill with body-weight supported system was used for 60 days training, with 2 daily sessions of BWSLT with manual assistance for a total of 90 min per day, 5 days per week for 3 4-weeks periods; with the aim of reducing the BWS to <40% and/or increase walking speed towards normal (3–5 km/h). BWSLT also included overground training. The participants performed home exercises between the training periods. **Outcome Measures:** 10MWT, distance walked with use of necessary walking aids (6MWT),	1. The training intervention was well tolerated with no AEs, and there were only minor side-effects, such as superficial abrasions, which did not interfere with the regular training program. 2. In each group, 2 participants with AIS grade C were unable to walk at baseline and did not gain independent walking post-intervention. Thus, only 7 participants in each group were available for post-intervention walking testing. 3. There was no significant difference in change between the groups for BBS, –1.2 points 95% CI (–4.3, 1.9), *p*=0.42.

	LEMS, BBS, and mFRT were assessed at baseline and 2–4 weeks after program.	
[Piira et al. (2019b)](); Norway RCT PEDro=7 Level 1 N=24	**Population:** 24 participants wheelchair-dependents with or without some walking function and with chronic incomplete SCI; 9 males and 15 females; mean age 50.5 years; level of injury cervical (n=10), thoracic (n=9); and mean time since injury 18 years. **Treatment:** Participants were randomized to either intervention (n=7) or control group (n=12). • Intervention participants received 60 days of robot-assisted locomotor training (with the use of Lokomat®), with 3 training sessions per week over a period of 6 months. Each session included preparation (≈ 20–30 min), stepping on a treadmill (20–60 min) with BWS <40% of the participants' initial weight, and a few minutes of overground walking and/or exercises on the treadmill. • Control participants received low-intensity usual care, usually 1–5 times per week. **Outcome Measures:** Full or partial recovery of walking function, walking speed and endurance (10MWT and 6MWT); LEMS; BBS; and mFRT were assessed within 30 days before randomization, and post-evaluation within 14–30 days after completion of the trial.	1. The intervention was well tolerated with no AEs, except for minor issues such as small leg abrasions. 2. Both groups significantly improved the BBS after the intervention period (4.3 points for intervention participants [p=0.03] and 3.2 points for control group [p=0.04]) but changes were minimal between groups.
[Lam et al. (2014);]() Canada RCT PEDro=8 Level 1 N=15	**Population**: 15 participants - 9 males and 6 females; chronic motor incomplete SCI; 5 AIS C and 10 AIS D; age range= 26-63y; years post injury> 1y. **Treatment**: Participants were randomly allocated to BWSTT with Lokomat resistance (Loko-R group) or conventional Lokomat-assisted BWSTT (controls). Training sessions	1. Training was well tolerated by both groups, although participants in Loko-R tended to report higher levels of perceived exertion during training. 2. Participants in the Loko-R group performed significantly better in the SCI-FAP compared with controls at posttraining and in follow-up assessments.

	were 45 min, 3 times/wk for 3 months. **Outcome Measures:** Skilled walking capacity (SCI-FAP), 10MWT, and 6MWT were measured at baseline, post=training, and 1 and 6 months follow up.	
	Effect Sizes: Forest plot of standardized mean differences (SMD ± 95%C.I.) as calculated from pre- to post-intervention data and pre-intervention to retention/follow-up data.  	
[Alexeeva et al. (2011)](); USA RCT PEDro=7 Level 1 N=35	**Population:** 35 participants; 30 males and 5 females; chronic SCI; 8 AIS C and 27 AIS D; level of injury: C2-T10. mean age= 38.5y; median years post injury= 4y. **Treatment:** Patients participated in a 13-week training program, with three 1-hour sessions per week. The comprehensive physical therapy group is a structured rehab program individualized for each participant. The body-weight supported ambulation on a fixed track group consisted of body-weight supported ambulation on a fixed track. The BWSTT group involved body-weight supported ambulation on a treadmill. **Outcome Measures:** Tinetti scale, 10MWT, LEMS and total manual muscle test score (sum of upper extremity motor score and LEMS), and the motor domain component of the FIM measure.	1. A significant improvement in balance was seen for comprehensive physical therapy and body-weight supported ambulation on a fixed track groups but not for participants in the BWSTT group.
	Effect Sizes: Forest plot of standardized mean differences (SMD ± 95%C.I.) as calculated from pre- and post-intervention data.	

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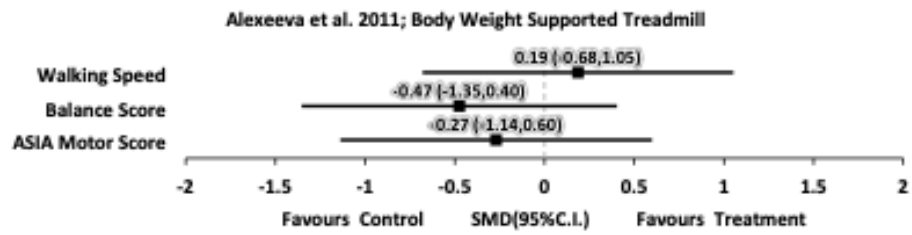

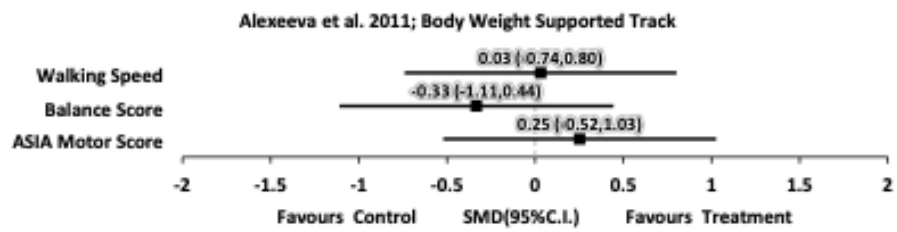

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<td>Wu et al. (2018);
USA
RCT
PEDro=6
Level 1
N=14</td>
<td>Population: 14 participants with incomplete SCI; 10 males, 4 females.
• Robotic group: Mean age: 48.4 years; level of injury C2-T7; AIS C (n=2) and AIS D (n=5); and mean time since injury: 5.8 years
• Treadmill only: Mean age: 48.1 years; level of injury C3-T10; AIS C (n=0) and AIS D (n=7); and mean time since injury: 9.4 years
Treatment: Participants were randomly assigned to one of two groups:
• Robotic treadmill training (n=7): A custom-designed cable-driven robotic gait training system (CaLT) was used for providing a bilateral pelvis assistance load was applied to the pelvis from heel strike to mid-stance on the ipsilateral leg for facilitating weight shifting. The peak force was set at ~9% of body weight. In addition, an assistance load was applied to both legs from toe off to mid-swing to facilitate leg swing with magnitude of the force being determined using an adaptive control algorithm.
• Treadmill only training (n=7): No assistance force was applied during treadmill training.</td>
<td>1. BBS and ABC scale did not show changes after robotic treadmill training or treadmill training only.</td>
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	Participants were fitted with an overhead harness that attached to a counterweight support system. BWS was provided as necessary for both groups to prohibit knee buckling or toe dragging during treadmill walking. Treadmill training speed was set at the participant's comfortable walking speed. Training was conducted 3 times/week for 6 weeks with the training time for each visit set to 45 minutes (i.e., 35 minutes of treadmill training and followed by 10 minutes of overground walking practice), excluding set up time. The targeted RPE was 12 to 16 (somewhat hard to hard levels). **Outcome Measures:** BBS and ABC scale were assessed before, after 6 weeks of treadmill training, and 8 weeks after the cessation of treadmill training.	
Labruyere & van Hedel (2014); Switzerland RCT cross-over PEDro=6 Level 1 N=9	**Population**: 9 participants- 5 males and 4 females; SCI ranging from C4 to T11; mean age= 59 ± 11y; months post injury= 50 ± 56m. **Treatment**: Participants with a chronic iSCI were randomized to group 1 or 2. Group 1 received 16 sessions of RAGT (45 min each) within 4 weeks followed by 16 sessions of strength training (45 min each) within 4 weeks. Group 2 received the same interventions in reversed order. Data were collected at baseline, between interventions after 4 weeks, directly after the interventions and at follow-up 6 months after the interventions. Pain was assessed repeatedly throughout the study. **Outcome Measures:** 10MWT at preferred and maximal speed, walking speed under different conditions, balance (BBS and maximal mediolateral amplitude of the center of pressure movement over 30 s on a force plate), strength, FES-I.	1. There were no significant differences in changes in balance and fear of falling scores between the two interventions.

[Yang et al. (2014)](); Canada RCT PEDro=6 Level 1 N=22	**Population**: 22 participants; 16 males and 6 females; Level of injury between C2 and T12; mean age= 48 ± 13y; years post injury= 5.7 ± 10.5y. **Treatment**: Twenty-two participants, ≥7 months post injury, were randomly allocated to start with Precision (precise, visually guided walking over obstacles) or Endurance Training (mass practice treadmill walking). Each phase of training was 5 times per week for 2 months, followed by a 2-month rest. **Outcome Measures:** Walking skills (SCI-FAP), walking speed (10MWT), walking distance (6MWT), walking ability (WISCI II), walking confidence (ABC scale), depression (Center for Epidemiologic Studies–Depression Scale), manual muscle strength of the lower extremities.	1. Both forms of training led to significant improvements in walking and confidence, though the changes in ABC scores were not significantly different in either the Precision group or the Endurance group (p=0.52).
[Niu et al. (2014)](); USA RCT PEDro=5 Level 2 N=40	**Population**: 40 participants - 27 males and 13 females; spastic hypertonia in lower extremities. **Treatment**: Each participant was assigned either to the control or intervention (Lokomat training) group according to a permuted block randomization design. All participants were injured within their cervical or upper thoracic (superior to T10) vertebrae. Each participant received a one-hour training session three times per week for four consecutive weeks; as it took 15-20 mins to set up the participant, the gait training lasted up to 45 mins per session. **Outcome Measures:** 10MWT, 6MWT, TUG test, isometric torque resulting from MVC, Modified Ashworth Score, EMG, WISCI II.	1. The baseline (i.e., pre-training) measures of MVC torque (dorsiflexion and plantarflexion torques) could predict the differential treatment response, i.e., participants with high plantarflexion torque and dorsiflexion torque were more likely to have both high walking capacity and receive significant benefit from Lokomat training. 2. For TUG, the Growth Mixture Modeling analysis of joint groups found a beneficial training effect on participants with high walking capacity (P=0.05). Participants in Class 2 of the Lokomat group decreased their time at a rate of 0.41 s/week (p=0.02). Participants in Class 1 did not show significant benefit from the Lokomat training (p>0.05).
[Wu et al. (2016)](); USA RCT PEDro=6 Level 1 N=14	**Population:** 14 participants with incomplete SCI; the ability to ambulate overground with/without assistive device as necessary, and with orthotics that do not cross the knee; walking with impaired walking function (self-selected walking speed < 1.0 m/s); mean age: 51.9 years; 10	1. Six participants in the resistance training group and six in the assistance training group completed all the 18 training sessions and three evaluation sessions. 2. BBS and ABC scale had modest changes (all ns) after treadmill

	males, 4 females; level of injury C1-T10; AIS C (n=1) and AIS D (n=13); and time since injury: more than one year. **Treatment:** Participants were blocked by gait speed into slow (<0.5 m/s) or fast (<0.5 m/s) and randomly assigned to 1 of 2 groups of robotic treadmill training with resistance (n=7) or assistance (n=7) training. Training was performed 3 times per week for 6 weeks, with the training time for each visit set to 45 minutes (35 minutes of treadmill followed by 10 minutes of overground walking practice) as tolerated. For each training session, participants were fitted with an overhead harness attached to a counterweight support system. BWS was only provided in the instance that a counterweight was necessary to prohibit knee buckling or toe dragging during stepping. Treadmill speed was consistent with the participant's maximum comfortable walking speed, determined on the treadmill at the beginning of each training session. The RPE was monitored during the course of training and was 12 to 16. * A custom-designed cable-driven robotic gait training system (CaLT) was used to provide controlled bilateral resistance or assistance load to the leg at the ankle of subjects during treadmill training. **Outcome Measures:** BBS and ABC scale were assessed before, after 6 weeks of treadmill training, and 8 weeks after the cessation of treadmill training.	training for both the resistance and assistance training groups.
Wu et al. (2012); USA Repeated assessment with crossover PEDro=5 Level 2	**Population:** 10 participants with chronic SCI (8M 2F); mean (SD) age: 47(7); mean (SD) DOI: 5.8(3.8) yrs; level of injury: C2-T10. **Treatment:** Group 1: BWSTT with 4 wks assistance training, then 4 weeks resistance training. Group 2: BWSTT with 4 wks resistance	1. Mean BBS scores increased following resistance and assistance training, but there were no significant differences between these training conditions on the balance scores (P= .35), although BBS scores after resistance training were 2.7 times greater

N=10	training, then 4 wks assistance training. Resistance provided by a cable-driven robotic locomotor training system. Sessions were 45 min, 3x/wk x 8 weeks. **Outcome Measures:** Primary: self-selected and fast walking speed, 6MWT, BBS. Secondary: muscle strength tests, WISCI II, Physical SF-36, ABC scale.	than those after assistance training. 2. The Activities-specific Balance Confidence Scale score significantly increased from 34.0 7.8 to 39.5 7.3 (P= .02) and from 54.9% 18.5% to 70.4% 14.2% (P= .01), respectively, after robotic training.
Duffell et al. (2015); USA RCT PEDro=4 Level 2 N= 48	**Population**: 26 individuals in locomotor treadmill training group- 19 males and 7 females; mean age= 46.6 ± 12.6y; years post injury= 9.3 ± 8.9y; 22 individuals in combined locomotor treadmill training and tizanidine group- 15 males and 7 females; mean age= 46.5 ± 11.9y; years post injury= 10.2 ± 10.4y; Level of injury 30 C and 15 T **Treatment**: Participants were randomly assigned into one of two intervention groups; locomotor treadmill training alone (n=26) or combined locomotor treadmill training and Tizanidine (n=22). Participants assigned to the combined locomotor treadmill training and Tizanidine group, were initially provided with Tizanidine alone for a period of 4 weeks, and results for that period have been presented elsewhere, together with the locomotor treadmill training group clinical outcomes. **Outcome Measures:** TUG, 10MWT, 6MWT, Modified Ashworth Score, Maximum voluntary isometric contractions, active range of motion, Peak isokinetic velocity were measured at 0, 1, 2 and 4 weeks from the start of locomotor treadmill training for both groups.	1. For TUG, there were no significant effects of either time point or group. 2. Participants were classified in 2 ways: a. Based on achieving an improvement above the minimally important difference: Those who achieved the minimally important difference for the TUG had significantly longer times in the control (p=.04) and Lok (p=.04) groups. b. Using growth mixture modeling: For the TUG, significant improvements with time were also found for the Lok group in the higher-functioning class only (class 2, p<.05).
Okawara et al. (2020); Japan Prospective controlled trial Level 2	**Population:** 20 participants with chronic SCI who had reached a plateau in recovery from paralysis symptoms; 15 males and 5 females; mean (± SD) age 43.3 (± 16.6) years; level of injury cervical (n=10), thoracic (n=9) and lumbar (n=1); AIS A (n=2), AIS B (n=4), AIS C (n=8) and AIS D	1. There were no AEs. 2. Overground walking ability without voluntary driven exoskeleton: a. In the high walking ability group, there was a significant improvement in

N=20	(n=6); and mean (± SD) time since injury 80.4 (± 128.8) months. Based on baseline WISCI II score, 8 participants were categorized into the low walking ability group (n=8) and into the high walking ability group (n=12). **Treatment:** Participants underwent 20 sessions of BWSTT with voluntary driven exoskeleton (using the hybrid assistive limb [HAL]) (2–5 sessions per week [mean frequency 2.6 ± 1.1 sessions] with 60 min of duration) on a treadmill with 50% BWS. The velocity of the treadmill was individually set to the participant's comfortable walking speed, and there was no inclination. **Outcomes Measures:** The speed, distance, and duration walked, and RPE were recorded in each session. WISCI II, 10MWT*, 2MWT, TUG, BBS, BBS in three categories (sitting balance, standing balance, and dynamic balance), and LEMS were evaluated at pre and post intervention. *No participants in the low group were able to complete the 10MWT at either time point.	TUG test (83.5 to 68.5 s, p=0.01) and BBS score (p=0.02).
Behrman et al. (2012); USA Prospective controlled trial Level 2 N=95	**Population:** 95 participants with SCI (75M, 20F); <1 yr (n=47), 1-3 yrs (n=24), ^{3}3 yrs (n=24) since injury; level of injury: T11 or above; Mean (SD) age: 43(17); median time since injury: 1 year; 31 AIS C, 64 AIS D. **Treatment:** At least 20 sessions of the NeuroRecovery Network Locomotor Training Program consisting of manual-facilitated body-weight supported standing and stepping on a treadmill and overground. Training consisted of 1hr of treadmill training, 30 min overground assessment, and 15-30 min of community reintegration. Frequency: 5 days/wk for non-ambulators, 4 days/wk for ambulators with pronounced assistance, 3 days/wk for independent walkers. Patients split	1. For those who enrolled in phase 1 and were still classified phase 1 after NeuroRecovery Network training, no change was seen in BBS scores. 2. For those who enrolled in phase 1 and were classified phase 2 after NeuroRecovery Network training, mean change scores were 1 for BBS. 3. For those enrolled at Phase 1 and classified as Phase 3 after NeuroRecovery Network training, mean change scores were 38.5 for BBS. 4. For those enrolled in Phase 2 and classified as Phase 2 after training, mean change scores were 7 for BBS.

	into phases 1-3 depending on level of ability (higher ability = higher phase). **Outcome Measures:** ISNSCI AIS, BBS, 6MWT, 10MWT.	5. For those enrolled in Phase 2 and classified as Phase 3 after training, mean change scores were 15 for BBS.
Buehner et al. (2012); USA Prospective controlled trial Level 2 N=225	**Population:** 225 participants with chronic incomplete SCI (167M, 58F); mean (SD) age=42.5 (15.9); Median DOI=2.45; 57 AIS C, 167 AIS D. **Treatment:** NeuroRecovery Network Locomotor Training Program. Training consisted of 1 hr of treadmill training, 30 min overground assessment, and 15-30 min of community reintegration. Frequency: 5 days/wk for non-ambulators, 4 days/wk for ambulators with pronounced assistance, 3 days/wk for independent walkers. **Outcome Measures:** LEMS, pinprick, light touch, 10MWT, 6MWT, BBS.	1. Significant gains in balance (43%) occurred after NeuroRecovery Network training regardless of initial AIS classification.
Lorenz et al. (2012); USA Longitudinal Level 2 N=337	**Population:** 337 participants with SCI (255M, 82F); mean (SD) age: 40 (17); 99 AIS C, 238 AIS D. **Treatment:** At least 20 sessions of the NeuroRecovery Network Locomotor Training Program. Training consisted of 1hr of treadmill training, 30 min overground assessment, and 15-30 min of community reintegration. Frequency: 5 days/wk for non-ambulators, 4 days/wk for ambulators with pronounced assistance, 3 days/wk for independent walkers. **Outcome Measures:** BBS; 6MWT; 10MWT.	1. There was significant improvement on each outcome measure and significant attenuation of improvement over time. 2. Patients varied significantly across groups defined by recovery status and AIS grade at enrollment with respect to baseline performance and rates of change over time. 3. Time since SCI was a significant determinant of the rate of recovery for all measures.
Musselman et al. (2009); Canada Prospective controlled trial Level 2 N=4	**Population:** 2 male and 2 female participants, age 24-61, level of injury C5-L1, all AIS-C. **Treatment:** Initial 3 months BWSTT by all 4 patients. Patients 1, 2 received 3 months skills training, followed by 3 months BWSTT. Patients 3, 4 received the training in reverse order. Sessions were 1 hour long, 5 days a week for 3 months.	1. Improvement of Modified Emory Functional Ambulation Profile with skill training in all participants (average improvement 731.5); improvement also seen with BWSTT in 2 of 4 participants (-1379 and -731 respectively); gains were maintained after training (statistical test for significant was not done). 2. Minor improvements in BBS (9,

	Outcome Measures: BBS, Modified Emory Functional Ambulation Profile, 10MWT, 6MWT, ABC scale.	0, 10 and 5 points for participants 1, 2, 3 and 4 respectively), and no improvement for ABC.
Lin et al. 2022; USA Prospective controlled trial Level 2 N=15	**Population:** 15 individuals with chronic incomplete SCI; 5 males and 10 females; mean age 46.5 years; injury level between C4-T10; and mean time since injury 9.4 years. **Treatment:** Participants were tested on 2 separate days, with a one-week separation between the two testing conditions (pelvis perturbation with anodal transcutaneous spinal direct current stimulation vs. with sham). The order of the testing sequence was randomized across participants. • On day 1, participants completed 3 continuous sessions of treadmill walking, which consisted of a 1 min of treadmill walking without pelvis perturbation or transcutaneous spinal direct current stimulation (baseline), 10 min of treadmill walking with the application of pelvic bilateral perturbation in the lateral directions (applied in every step) paired with anodal transcutaneous spinal direct current stimulation, and 2 min of treadmill walking without the application of force perturbation and transcutaneous spinal direct current stimulation. • On day 2, a protocol comparable to day 1 was used but only a sham stimulation was applied. The magnitude of peak perturbation force of each step was varied randomly within the range between 30 and 100% of the pre-determined force, which was set at 8–12% of body weight and was adjusted depending on participants' tolerance. transcutaneous spinal direct current stimulation was delivered with the	1. Participants demonstrated a smaller margin of stability during the late adaptation period for the anodal transcutaneous spinal direct current stimulation condition compared to sham (p=0.041), and this margin of stability intended to retain during the early post-adaptation period (p=0.05).

	anodal/sham electrode placed over the T10-12 spinous process and the reference electrode placed above the right shoulder; and the current stimulation was set at 2.5 mA. **Outcome measures:** Lateral dynamic balance (assessed using the minimal margin of stability in the mediolateral direction) and electromyography of leg muscles (tibialis anterior, medial gastrocnemius, soleus, vastus medialis, rectus femoris, medial hamstring, adductor magnus, and hip abductor [gluteus medius]) from the weaker leg were assessed at baseline and post intervention.	
Lin et al. 2020; USA Prospective controlled trial Level 2 N=14	**Population:** 14 individuals with chronic incomplete SCI; 11 males and 3 females; mean (± SD) age 53 (±13) years; injury level between C4-T10; and mean (±SD) time since injury 14 (±9) years. **Treatment:** A customized cable-driven robotic system was used to provide varied pelvis perturbation during treadmill walking. All participants were tested in two testing conditions (i.e., treadmill walking with pelvis perturbation force and treadmill walking only), with more than 1-week interval inserted in between, and with a randomization across participants in the order of testing conditions. The treadmill speed was set at each participant's comfortable speed and was consistent for the two testing sessions. For each testing day, participants were instructed to walk on a 6-m gait mat at self-selected speeds. For the experimental condition, the next procedures were performed consecutively in the same order for each participant: • Baseline: Walking on a treadmill without pelvis perturbation for 1 min. • Adaptation: A bilateral pelvis force was applied while	1. Compared to treadmill training only, participants showed significant smaller margin of stability and double-leg support time after treadmill walking with pelvis perturbation.

	walking on the treadmill for 10 min. • Post-adaptation: The perturbation was removed, and participants walked on the treadmill for another 1 min. • Re-adaptation: 5-min sitting break, followed by walking on the treadmill for another 10 min with the application of a bilateral pelvis force. • Test the transfer effect from treadmill to overground walking: Walking on the gait mat immediately after treadmill walking. • Test the retention of the training effect: Walking on the gait mat 10 min after the end of treadmill walking. For the control condition, the protocol was similar to the experimental condition, but no pelvis perturbation force was applied. **Outcome measures:** Margin of stability, weight shifting, step length, step width, and double-leg support time were calculated.	
Lin et al. 2019; USA Pre-post Level 4 N=17	**Population:** 17 individuals with chronic incomplete SCI; 12 males and 5 females; mean age 55.1 years; injury level between C4-T10; AIS B (n=1), AIS C (n=4) and AIS D (n=12); and mean time since injury 12.3 years. **Treatment:** A customized cable-driven robotic system was used to provide a controlled pelvis assistance force (set at 0 at the beginning and gradually increased at each step during the course of 10 minutes of walking [until the maximum magnitude of pelvis force 8~12% body weight was achieved]) while participants walked on a treadmill for one session. The intervention was performed consecutively in the following order for each participant:	1. During treadmill walking, participants significantly improved weight shifting (i.e., center of mass lateral distance reduced from 0.16 ± 0.06 m to 0.12 ± 0.07 m, p=.012), and increased step length (from 0.35 ± 0.08 m to 0.37 ± 0.09 m, p=.037) on the stronger side when the force was applied, which were partially retained (i.e., center of mass distance was 0.14 ± 0.06, p=.019, and step length was 0.37 ± 0.09 m, p=.005) during the late post-adaptation period when the force was removed. 2. In addition, weight shifting and step length on the weaker side during overground walking also improved (support base reduced from 0.13 ± 0.06 m to 0.12 ± 0.06 m,

	• T1: Overground walking at each participant self-selected walking speed. • T2, baseline (1 min): Walking on a treadmill with no force applied. • T3, adaptation (10 min): Walking on a treadmill with force applied. • T4, post-adaptation (1 min): Walking with no force applied. • Seated break for 5 minutes and walking on the treadmill with force applied for another 10 minutes. • T5: Walking overground immediately after treadmill training. • T6, follow-up: Walking overground 10 minutes after the end of treadmill walking. Treadmill speed was set at each participant's comfortable speed and remained the same throughout all testing sessions. BWS was provided as necessary. **Outcome measures:** Weight shifting, step length, margin of stability, and muscle activities (from 8 muscles, including tibialis anterior, medial gastrocnemius, soleus, vastus medialis, rectus femoris, medial hamstring, adductor magnus, and gluteus medius) of the weaker leg were used to quantify gait performance. The spatial-temporal gait parameters during overground walking were collected	p=.042, and step length increased from 0.48 ± 0.12 m to 0.51 ± 0.09 m, p=.045) after treadmill training.
Covarrubias-Escudero et al. (2019); Chile Pre-post Level 4 N=34	**Population:** 17 healthy participants (13 males and 4 females; mean [± SD] age 37.5 [± 8.9] years) and 17 patients with chronic incomplete SCI (14 males and 3 females; mean [± SD] age 43.5 [± 3.7] years; level of injury cervical [n=11], thoracic [n=5] and lumbar [n=1]; AIS C [n=10] and AIS D [n=7]; and time since injury 19 [16-30] months).	1. Despite achieving decreased normalized jerk values post-training (but not in ISway root mean square values), no changes in gait independence were found. 2. An inverse correlation was found between the initial measures (p=0.020, r=0.564). However, no statistically

	Treatment: The BWSTT program was distributed across 18 sessions over a 6-week period. Each session consisted of three 6-min series of locomotor treadmill training. Appropriated amount of BWS and treadmill speed were set individually. **Outcome Measures:** Standing balance test (ISway test with an accelerometer, a magnetometer, and a gyroscope) and WISCI II were assessed prior to and after the program. *Differences in standing balance between patients with SCI and healthy participants were established with the normalized jerk and root mean square, both computed during the ISway test.	significant correlation was observed between post-training normalized jerk values and WISCI II scores (p=0.526, r=0.151).
Jansen et al. (2017); Germany and USA Pre-post Level 4 N=21	**Population:** 21 participants with chronic SCI and some residual motor function of hip and knee extensor and flexor muscle groups; 15 males and 6 females; mean (± SD) age 44.8 (± 13.8) years; neurologic lesion level between C4 and L3 (paraplegia, n=18; tetraplegia, n=3); AIS A (n=10), AIS B (n=1), AIS C (n=7) and AIS D (n=3); and mean (± SD) time since injury 6.5 (± 5.8) years. **Treatment:** All participants underwent BWSTT 5 times per week using the HAL robot suit exoskeleton for a 12-week period (5 sessions per week). Overall, each training session lasted approximately 90 min, divided into 30 min for preparation, 30 min of functional testing, and 30 min of HAL-BWSTT. During the intervention, training intensity was increased progressively by changing walking speed, time, and level of BWS, depending on each patient's abilities. Additionally, the training was supplemented by specific task exercises such as downhill/uphill/backwards walking and climbing stairs, using a mobile body-weight supported system. **Outcome Measures:** LEMS was assessed biweekly. 10MWT (gait	1. There was only temporary skin reddening at the site of the skin electrodes, leg cuffs, and shoes in four patients, but without causing an interruption of the training. 2. TUG showed a significant improvement from baseline (53.29 ± 6.84 s) to midtraining (44.85 ± 6.54 s; p=0.002), from baseline to post-training (38.75 ± 5.70 s; p<0.001), and from 6 weeks to 12 weeks (p=0.007).

	speed, total time, and number of steps), 6MWT, TUG, and WISCI II were assessed without the exoskeleton at baseline, 6 weeks midtraining, and 12 weeks after training. The treadmill training performance parameters (walking distance, speed, and walking time) were recorded continuously.	
Fleerkotte et al. (2014); Netherlands Pre-post Level 4 N=10	**Population**: 10 participants - 4 males and 6 females; motor incomplete chronic SCI; 1 AIS B, 5 AIS C, 4 AIS D; mean age= 48.75 ± 11.3y; months post injury= 46.75 ± 41.03 **Treatment**: Participants participated in an eight-week training program. Participants trained three times per week, for a maximum of 60 min per session. The training period was divided in two four-week periods, with one week scheduled for clinical tests in between. During training sessions, rest intervals were introduced if required by the participant or suggested by the therapist. The first training session was used to 1) fit the impedance-controlled robotic gait trainer (LOPES: Lower extremity Powered Exo Skeleton) to the participant, 2) let participants get used to walking in the device and 3) select their preferred walking speed. **Outcome Measures:** 10MWT, WISCI II, 6MWT, TUG test, LEMS, spatiotemporal, kinematics measures.	1. Participants experienced significant improvements in TUG (3.4 s, p=0.012) after eight weeks of training with LOPES. 2. At the eight-week follow-up, participants retained the improvements measured at the end of the training period.
Sczesny-Kaiser et al. (2015); Germany Pre-post Level 4 N= 11	**Population**: 11 participants - 7 males and 4 females; traumatic SCI with incomplete or complete paraplegia; mean age= 46.9 ± 2.7y; years post injury= 8.8 ± 2.1y. **Treatment**: Eleven SCI patients took part in HAL® assisted BWSTT for 3 months. Each patient was scheduled for a 30min training session 5 times a week for 12 weeks, as previously described by our group. Paired-pulse somatosensory evoked potentials were conducted before and after this training period, where the amplitude	1. After training, there was a significant improvement in TUG from 56.35 s ± 10.06 s to 38.65 s ± 7.2 s (p=0.01).

	ratios (somatosensory evoked potential amplitude following double pulses - somatosensory evoked potentials amplitude following single pulses) were assessed and compared to eleven healthy control participants. **Outcome Measures:** 10MWT, 6MWT, TUG test, and LEMS.	
Varoqui et al. (2014); USA Post-test Level 4 N=30	**Population**: 30 participants; ambulatory chronic incomplete SCI; mean age= 50.80 ± 2.12y; years post injury= 11.80 ± 2.54y. **Treatment:** 15 participants with iSCI performed twelve 1-hour sessions of Lokomat training over the course of a month. The voluntary movement was qualified by measuring active range of motion, maximal velocity peak and trajectory smoothness for the spastic ankle during a movement from full plantar-flexion to full dorsi-flexion at the patient's maximum speed. Dorsi- and plantar-flexor muscle strength was quantified by isometric MVC. Clinical assessments were also performed using the TUG test, the 10MWT and the 6MWT. All evaluations were performed both before and after the training and were compared to a control group of fifteen patients with iSCI. **Outcome Measures:** Active range of motion, maximal velocity peak and trajectory smoothness from full plantar-flexion to full dorsi-flexion at patient's maximum speed, MVC, TUG test, 10MWT, 6MWT, Modified Ashworth Scale.	1. For the training group, the TUG showed a significant reduction of 13.99 ± 3.53% in the time needed to perform the task ($p<0.05$). 2. For the control group, there was no significant difference in TUG ($p=0.45$).
Aach et al. (2014); Germany Pre-post Level 4 N=8	**Population:** 6 males and 2 females; mean age 48 ± 9.43 years; years post injury= 97.2 ± 88.4 months; chronic stage of traumatic SCI; incomplete and complete SCI AIS A-D **Treatment:** The participants underwent a BWSTT five times per week using the HAL exoskeleton. **Outcome Measures:** Walking distance, speed, time, 10MWT, timed-	1. Significant improvements of HAL-associated walking time, distance, and speed were determined. 2. Significant improvements were shown in the functional abilities without the exoskeleton for over-ground walking obtained in the 6MWT, TUG test, and the 10MWT, including an increase in the WISCI II score of three patients.

	up and go test (TUG test), 6MWT, the walking index for SCI II (WISCI II), AIS with the lower extremity motor score (LEMS), spinal spasticity (Ashworth scale), and the lower extremity circumferences.	3. Muscle strength (LEMS) increased in all patients accompanied by a gain of the lower limb circumferences.
Knikou (2013); USA Pre-post Level 4 N=14	**Population:** 14 participants with chronic SCI (10M 4F); 21-55 yrs old; 0.5-11 yrs post-injury; 1 AIS A, 1 AIS B, 4 AIS C, 8 AIS D. **Treatment:** All participants received body-weight supported robot-assisted step training with a robotic exoskeleton system (Lokomat). Each participant was trained 1h/day, 5 days/wk. **Outcome Measures:** WISCI II; 6MWT; number of sit-to-stand repetitions completed within 30s; TUG; EMG measurements.	1. Body-weight supported robotic-assisted step training reorganized the soleus H-reflex in a functional manner during assisted stepping in people with clinically complete, motor incomplete and motor complete SCI. 2. Training changed the amplitude and onset of muscle activity during stepping, decreased the step duration, and improved gait speed. 3. For the AIS D group, TUG time non-significantly (p=0.11) decreased after body-weight supported training.
Harkema et al. (2012); USA Pre-post Level 4 N=196	**Population**: 196 participants (148 male, 48 female) with incomplete SCI; mean age 41±15 yrs; YPI- <1 yrs (n=101), 1-3 yrs (n=43), >3 yrs (n=52). **Treatment**: Locomotor training with three components: (1) 1 hour of step training in the BWS on a treadmill environment, followed by 30 min of (2) overground assessment and (3) community integration. **Outcome Measures**: BBS, 6MWT, and 10MWT.	1. Scores on the BBS significantly improved by an average of 9.6 points. 2. Increases were significant for patients with AIS grades C and D, and the amount of improvement was significantly different between these groups (rank-sum test, p<0.008). 3. Of the 168 patients classified as at risk for falls at enrollment, 27% improved their scores to a value reflecting minimal risk for falls (11% AIS grade C, 37% AIS grade D).
Yang et al. (2011); Canada Pre-post Level 4 N=19	**Population:** 14 males, 5 females; mean age 44±13; >7 months post-injury (mean 5.8±8.9 years); AIS C or D. **Treatment:** 1 hour/day, 5 days/week of BWSTT until parameters did not progress for 2 weeks (minimum 10 weeks total, mean=18 weeks). **Outcome Measures:** 10MWT, WISCI II, LEMMT, BBS, EMG measurements (tibialis anterior, soleus, quadriceps, hamstrings), movement at the knee and ankles.	1. After training, 17/19 participants improved in duration of walking in a session (mean (SD) 15(11) min), 16/19 improved in treadmill speed (0.14(0.11) m/s), and 16/19 improved in their ability to support their own body weight (18-19%) decrease in BWS). 2. 13 participants responded to the treatment; 9 showed improvements of >1 m/s (exceeding the smallest real difference in overground walking speed) and 4 showed improvements <1 m/s but greater

		WISCI II scores. 3. BBS scores were not related to improvements in walking speed.
Fritz et al. (2011); USA Pre-post Level 4 N=15	**Population:** 15 participants - 11 males and 4 females; incomplete chronic SCI; Lower functioning group: 10 participants - 8 males and 2 females; mean age= 38.5y; time since injury: 6.6y; AIS lower extremity score= 24; Higher functioning group: 5 participants - 3 males and 2 females; mean age= 50.4y; time since injury= 5.7y; AIS lower extremity score= 44. **Treatment:** Participants received intensive mobility training in activities that encouraged repetitive, task specific training of the lower extremities. Intensive mobility training combines BWSTT, balance exercises, muscle strengthening, coordination and range of motion in a massed intensive therapy. Sessions were 3 hours a day for 3-5 days per week for a total of 10 weeks. **Outcome Measures:** GAITRite (gait speed), BBS, Dynamic Gait Index (DGI), 6MWT, Timed Go Walk (modified version of TUG), and SCI-FAI.	1. Participants in the higher functioning iSCI group (BBS score ≥45 and gait speed ≥0.6m/s) spent more time in the intensive therapy on average than participants in the lower functioning ISCI group. 2. Effect sizes were comparable for changes in balance and mobility assessments between the lower and higher functioning groups, with the largest effect sizes observed for the DGI.
Hornby et al. (2005); USA Pre-post Level 4 N=3	**Population:** 2 males, 1 female; AIS C; 5 weeks/ 6 weeks/ 18 months post-injury. **Treatment:** Therapist and Robotic-assisted, BWSTT (parameters varied between participants). **Outcome Measures:** LEMS, FIM, WISCI II, 10MWT, 6MWT, TUG test, Functional Reach test, and modified sitting Functional Reach Test.	1. Balance results varied between the 3 participants suggesting low generalizability.