Table 5. Body-Weight Supported Locomotor Training (BWSLT) for Sitting Balance

Author Year **Country** **Research Design** **Score** **Total Sample Size**	**Methods**	**Outcome**
Piira et al. (2019a); Norway RCT PEDro=7 Level 1 N=20	**Population:** 20 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 body-weight supported locomotor training (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 body-weight support (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, 6MWT, LEMS, BBS, and mFRT were assessed at baseline and 2–4 weeks after the program.	1. There was no significant difference in change between the groups for mFRT, 6.6 cm (–5.4, 18.5), p=0.26. 2. 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.
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 Lokomat®), with 3 training sessions per week over a	1. There was a statistically significant group difference in postural control (mFRT), which declined 8.6 cm more in the intervention compared with the control group. 2. The intervention was well tolerated with no AEs, except for minor issues such as small leg abrasions.

	period of 6 months. Each session included preparation (≈ 20–30 min), stepping on a treadmill (20–60 min) with BWS <40% of the participants's weight, and a few min of overground walking and/or exercises on the treadmill. • Control participants received low-intensity usual care, 1–5 times per week. **Outcome Measures:** Full or partial recovery of walking function, 10MWT and 6MWT; LEMS; BBS; and mFRT were assessed within 30 days before randomization, and within 14–30 days after completion of the program.	
Martinez et al. (2018); USA RCT cross-over PEDro=5 Level 2 N=13	**Population:** 13 participants with chronic SCI; mean age: 37.2 years; 9 males, 3 females; traumatic (n=11) and non-traumatic (n=2); level of injury: T1-T11; AIS A (n=1), AIS B (n=1), AIS C (n=7), and AIS D (n=3); and > 1 year of duration. **Treatment:** Each phase consisted of 48 sessions (three to five sessions per week) of one intervention followed by a washout period of at least 6 weeks. Sessions lasted 30 minutes not including setup, with 1–2 minute rest periods at least every 10 minutes. Exercise task difficulty was adjusted to achieve a desired range of RPE between 11 to 15 (out of 20). BWS for both interventions was provided by the overhead harness of the Lokomat system. BWS was set to 60% of body-weight initially, and then gradually reduced as tolerated. Several participants who reached independent weight support still wore the harness for safety. • Treadmill exercise: Participants walked on a robotic-assisted treadmill (Lokomat) at initial speeds of 1–1.5 km/h. Speed was gradually increased as tolerated to a maximum of 3.2 km/h. The Lokomat's built-in guidance force (amount of assistance to reach a pre-defined gait kinematic pattern) was also gradually reduced as tolerated. Participants were reminded to swing their arms while walking.	1. Only 13 participants (of a planned 24) completed at least one intervention phase of the study, and 9 completed both phases of the study. 2. There were no serious AEs during the study. 3. No statistically significant differences between or within interventions were found for any balance outcome.

	• Multimodal exercise: Participants performed simultaneous balance and skilled upper extremity exercises. In addition to partial BWS, study personnel provided manual stabilization and perturbation as necessary.
	  o *Balance (subcortical) component*: Participants' feet were placed on a semi-spherical balance platform (Bosu). Participants were instructed to keep the balance surface as stable as possible.
	  o *Fine upper extremity (corticospinal) component*: During balance exercise, participants performed a variety of skilled arm or hand manipulations, either unimanually or bimanually. All tasks were designed to require movements that engage corticospinal circuits.
	Outcome Measures: 'Sitting with back unsupported' subsection of the BBS and computerized posturography (sitting balance) were assessed at baseline and within one week of completing an intervention. A follow-up evaluation was planned for 6 weeks after intervention completion.	

Okawara et al. (2022); Japan Pre-post Level 4 N=9	**Population:** 9 outpatients with chronic SCI; 6 males and 3 females; mean (± SD) age 37.8 (± 15.6) years; level of injury C5 (n=1), C6 (n=4), C7 (n=1), T1 (n=1), T11 (n=1), and T12 (n=1); AIS A (n=2), AIS B (n=3), AIS C (n=2) and AIS D (n=2); and mean (± SD) time since injury 51.1 (± 31.8) months. **Treatment:** All participants underwent 20 BWSTT with the voluntary driven exoskeleton (using the hybrid assistive limb [HAL]) training sessions, which lasted 60 min and were performed 2-5 times a week. **Outcome Measures:** Trunk muscle strength (defined as the ability to maintain a seated posture in four directions [anterior, posterior, left lateral and right lateral]; and 10MWT (only performed by 5 participants)	1. There were significant improvements in lateral (from 3.4 ± 2.8 to 6.9 ± 3.6, *P*=0.002) and posterior (from 3.5 ± 2.9 to 6.9 ± 4.4, *P*=0.044) trunk muscle strengths after 20 training sessions relative to baseline. 2. Anterior trunk muscle strength improved only in the AIS-D subgroup, and posterior trunk muscle strength improved in both the AIS-C and AIS-D subgroups. 3. Improvements in lateral trunk muscle strength

	were measured at baseline, and after 10 and 20 training sessions.	showed a significant positive correlation with great gait speed (10MWT) (r_s = 1.00, *P*<0.01). 4. Older adult participants achieved greater improvement in trunk muscle strength than younger participants.
Tsai et al. (2021); USA Pre-post Level 4 N=8	**Population:** 8 participants with chronic motor complete SCI who were using a wheelchair; 7 males and one female; median age 53 (37-64) years; level of injury T1 (n=1), T2 (n=2), T4 (n=1), T7 (n=1), T8 (n=1), T9 (n=1), and T11 (n=1); AIS A (n=7) and AIS B (n=1); and median time since injury 3.5 (1.5-14) years. 7 participants without SCI (6 males and 1 female) joined in the study for seated balance tests only as a healthy comparative group. **Treatment:** Participants received supervised exoskeleton-assisted walking (EAW) training using a ReWalk including 3–4 sessions (4–6 h) per week (with a median of 30 [7-90] sessions within a median 111 [87-210] days) with the aim of reach an independent walking with the ReWalk and perform certain mobility skills. Each session included device donning and doffing, sit-to-stand and stand-to-sit, standing weight shifting balance skills, balancing with one crutch on each arm, coordinated crutch/walker timing, appropriate weight shifting during walking and stopping. Other mobility training was added when possible (e.g., turns, navigating to rest on a wall, and walking outdoor and up and down a ramp). **Outcome Measures:** Sitting balance* (sitting LOS using computerized dynamic posturography and mFRT) was evaluated pre and post training intervention. *The sitting balance outcomes were added as an amendment to the existing pilot project, so only 5 participants finished pre- and post-mFRT.	1. The majority of participants had improvement in their computerized dynamic posturography seated balance tests after the intervention, with significant increases in total-direction endpoint excursion and maximal excursion (P=0.008 and 0.016 respectively). If the change in each direction is further explored, the participants demonstrated statistically non-significant improvements in endpoint excursion, maximal excursion, and directional control in most of the eight directions. These increases were toward the values measured in the healthy comparative group. 2. After EAW training, mFRT results showed a slight increase but did not reach significant differences compared to before training.
Okawara et al. (2020); Japan	**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	1. There were no AEs. 2. Participants in the low walking ability group showed little

Prospective controlled trial Level 2 N=20	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 (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.	improvement in sitting balance.
Khan et al. (2019b); Canada Pre-post Level 4 N=12	**Population:** 12 participants with chronic, non-progressive SCI, using the wheelchair as the primary mode of mobility and able to use forearm crutches; mean (± SD) age 37.5 (± 13.7) years; level of injury C6 (n=2), C7 (n=1), T3 (n=2), T4 (n=2), T6 (n=1), T7 (n=2), T9 (n=1), T10 (n=1); AIS A (n=6), AIS B (n=2), AIS C (n=3) and AIS D (n=1); and mean (± SD) time since injury 7.7 (± 8.1) years. **Treatment:** Participants used the ReWalk 2.0 exoskeleton for training different activities (such as donning and doffing, sit-to-stand, stand-to-sit, balancing in standing and walking) 4 days per week during 12 weeks of training. *Uninjured (i.e., control) participants were also recruited for comparison of some physiological measures. **Outcome Measures:** 10MWT during continuous walking in the ReWalk, 6MWT, LEMS, and sitting balance (for the LOS and for sway speed which were measured on a force platform) were evaluated before,	1. 10 participants completed the program and 9 of them were assessed at follow-up. 2. AEs and technical issues included two falls (without no injuries sustained by the participants); skin abrasions; and some minor injuries in the trainer. 3. ReWalk training improved the LOS in sitting between baseline and after training (p=0.02, mean change 4.5 ± 4.1 cm). 4. Sway speed in sitting with eyes closed also improved significantly (p=0.03) for many participants.

	during, immediately after, and at follow-up (2–3 months after training).	
[Chisholm et al. (2017)](); Canada Case series Level 4 N=3	**Population:** 3 participants with traumatic SCI: • P1: 41 years of age, male, injury level: T3, AIS A, 23 years post injury. • P2: 42 years of age, male, injury level: C7, AIS B, 18 years post injury. • P1: 39 years of age, female, injury level: T4, AIS A, 25 years post injury. **Treatment:** An alternating treatment design with three intervention phases to compare the Ekso and Lokomat methods of robotic gait training was used. The two groups were Ekso-Lokomat-Ekso (P1 and P3) and Lokomat-Ekso-Lokomat (P2), with 10 training sessions in each intervention phase for a total of 30 sessions and no washout between intervention phases. Participants performed up to 45 min of robotic-assisted gait training (RAGT) 3–4 times per week. • Initial training with the Ekso™ consisted of sit-to-stand, standing balance, weight shifting, and stand-to-sit functions. Training focused on improving walking performance. • Gait training with the Lokomat robotic gait orthosis focused on increasing gait speed. Treadmill speed was set to the fastest speed that the patient could tolerate, and subsequently increased by increments of 0.1 km/h every 10 min. The level of BWS was adjusted to the minimum tolerated by the patient while ensuring appropriate stance phase kinematics. **Outcome Measures:** Seated (static and dynamic) balance control outcome measures (CoP, T-shirt test, and mFRT) were assessed at baseline and at the end of each intervention phase.	1. Improved postural stability after training with Ekso compared to Lokomat during static balance tasks, indicated by reduced CoP root mean square distance and ellipse area, was shown. In addition, Ekso training increased total distance of CoP movements during a dynamic balance task. 2. Clinical measures of seated balance control: All participants slightly reduced their total time during the T-Shirt Test and increased their distance during the mFRT after Ekso training. There was a tendency for greater time taken on the T-Shirt Test and shorter distance during the mFRT after Lokomat training as compared to Ekso training.