Table 22. Robotic Upright Stand Trainer (RobUST)

Author Year Country Research Design Score Total Sample Size	**Methods**	**Outcome**
Bowersock et al. (2023); USA Post-test N=4	**Population:** N=4 (3 motor complete and 1 incomplete). Mean age: 37.5 years; 3M, 1F; Level of injury: C4 (n=2), T1 (n=1), T2 (n=1). AIS A (n=2), AIS B (n=1), AIS C (n=1). **Treatment:** RobUST device with aluminum frame with 12 mounted motors and cables that provide controlling forces for participants. **Outcome Measures:** Motor force, kinematic data, force plates data, ground reaction forces, trunk displacement, and EMG of trunk and lower limb muscles	1. Stable standing with force field-free hands was observed in two participant and did not require RobUST FF activation meanwhile the other two needed assistance with trunk control. 2. Stable standing with RobUST FF and free hands resulted in 8.5% larger weight bearing (d = 1.19), larger trunk mean velocity (d = 0.96), and larger activation of representative trunk muscles.
Bowersock et al. (2024); USA Post-test N=5	**Population:** N=5, all motor complete. Mean age: 35 years 4M, 1F Level of injury: C4 (n=3), C7 (n=1), T2 (n=1) AIS: AIS A (n=2), AIS B (n=3) **Treatment:** total of 16 hands-on and 16 free-hand perturbations were attempted. RobUST trunk motors exerted a low-level constant force (30 N) that provided appropriate cable tension to remove any slack in the cables before perturbations without hindering or promoting trunk movement. Perturbations were characterized by a trapezoidal force with 0.15 sec rise time, 0.8 sec constant time, and 0.15 sec fall time. Perturbation magnitude was selected during an acclimation session and was relative to the participant's body weight. Perturbation magnitudes equal to 10, 15, and 20% BW. **Outcome Measure:** Successful perturbation control, motor force, trunk kinematic data, force plate data, and EMG.	1. Lower limb postural responses were generally more frequent, larger in magnitude, and appropriately modulated during the free-hands condition. This was associated with trunk displacement and lower limb loading modulation that were larger in the free-hands condition.
Rejc et al. (2024a);	**Population:** Six individuals with chronic SCI who were already implanted with a spinal	1. Robotic postural training re-enabled and/or largely

USA Pre-post Level 4 N=6	cord epidural stimulation (scES) unit for the recovery of motor function. Mean age: 34.7 years 5M, 1F Level of injury: C3 (n=1), C4 (n=3), C7 (n=1), and T2 (n=1) AIS: AIS A (n=3) and AIS B (n=3) * Prior to enrollment in this study, these individuals had already undergone an average of 112 – 92 overground stand training sessions with Stand-scES using assistive devices (i.e., a standing apparatus or walker) as part of other interventional studies, and had demonstrated the ability to stand with bilateral independent knees extension. **Treatment:** A novel RobUST with scES, performed with free hands, to restore upright postural control was implemented on average 80±10 training sessions (1 h/day; 5 days/week). Robotic upright postural training was always performed with Stand-scES in the RobUST frame. * The RobUST is a motorized cable-driven device that can provide assistance as needed and deliver controlled perturbation forces at the trunk and pelvis. **Outcomes Measures:** Steady upright postural control and proactive upright postural control (in which self-initiated trunk movements and upper limb reaching movements were attempted while standing) were collected immediately prior to the beginning of robotic postural training (Pre), after 45 – 7 (Mid), and after 80 – 10 robotic postural training sessions.	improved the participants' ability to control steady standing, self-initiated trunk movements and upper limb reaching movements while standing with free hands, receiving only external assistance for pelvic control. These improvements were associated with neuromuscular activation pattern adaptations above and below the lesion. 2. Note: a second Rejc (2024b) study also tested the RobUST and sitting outcomes with the same protocol; neither statistically significant differences nor large effect sizes were found.