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| **Technology-assisted rehabilitative studies** | | | | |
| **Device type** | **Study** | **MAIN GOAL** | **CLINICAL SCALE ASSESSMENT** | **INSTRUMENTAL ASSESSMENT** |
| TBD and OGD: Hip-knee guidance | Chisholm AE., 2017 | To determine how postural control muscles of the trunk are challenged during different methods of robotic-assisted gait performance, and evaluate changes in seated balance control after gait training with robotics. | *Pre vs post 1st period of training*(Ekso for pt. 1-3, Lokomat for pt. 2): T-shirt ↓; mFRT ↑;  *Pre vs post 2nd period of training* (Lokomat for pt. 1-3, Ekso for pt. 2): T-shirt test ↑ (pt. 1-3), T-shirt Test ↓ (pt. 2), mFRT ↓ (pt. 1-3) mFRT ↑ (pt. 2);   *Pre vs post 3rd period of training* (Ekso pt. 1-3, Lokomat pt. 2): T-shirt Test ↓ (pt. 1-3), T-shirt Test ↑ (pt. 2), mFRT ↑ (pt. 1-3), mFRT ↓ (pt. 2) | *EO condition:* *pre vs post 1st period of training* (Ekso for pz 1-3, Lokomat for pz 2): COP: RMS distance ↓ (pz 1-3), RMS distance = (pz 2), RVEL ↓ (pz 1-3), RVEL = (pz 2), AREA-CE ↓ (pz 1-3), AREA-CE = (pz 2) *pre vs post 2nd period of training* (Lokomat for pt. 1-3, Ekso for pt. 2): COP: RMS distance ↑ (pt. 1-3), RMS distance ↓ (pt. 2), AREA-CE ↑ (pt. 1-3), AREA-CE ↓ (pt. 2), RVEL ↓ (pt. 1), RVEL ↑ (pt. 3), RVEL = (pt. 2) *pre vs post 3rd period of training* (Ekso pt. 1-3, Lokomat pt. 2): COP:RMS distance ↓ (pt. 1-3), RMS distance ↑ (pt. 2), AREA-CE ↓ (pt. 1-3), AREA-CE ↑ (pt. 2), RVEL ↓ (pt. 1), RVEL ↑ (pt. 3), RVEL= (pt. 2)  *EC condition:  pre vs post 1st period of training* (Ekso for pz 1-3, Lokomat for pz 2): COP: RMS distance ↓ (pz 1-3), RMS distance = (pz 2), RVEL ↓ (pz 1-3), RVEL ↑ (pz 2), AREA-CE ↓ (pz 1-3), AREA-CE = (pz 2) *pre vs post 2nd period of training* (Lokomat for pz 1-3, Ekso for pz 2): COP: RMS distance ↑ (pz 1-3), RMS distance ↓ (pz 2), RVEL ↓ (pz 1), RVEL ↑ (pz 3), RVEL ↓ (pz 2), AREA-CE ↑ (pz 1), AREA-CE= (pz 3), AREA-CE ↓ (pz 2) *pre vs post 3rd period of training* (Ekso pz 1-3, Lokomat pz 2): COP: RMS distance ↓ (pz 1), RMS distance = (pz 3), RMS distance ↑ (pz 2), RVEL ↓ (pz 1), RVEL ↓ (pz 3), RVEL ↑ (pz 2), AREA-CE ↓ (pz 1), AREA-CE = (pz 3), AREA-CE ↑ (pz 2)   *pre vs post 1st period of training* (Ekso for pz 1-3, Lokomat for pz 2): COP: LOS total distance ↑ (pz 1-3), LOS total distance = (pz 2) pre vs post 2nd period of training (Lokomat for pz 1-3, Ekso for pz 2): COP: LOS total distance ↓ (pz 1-3), LOS total distance ↑ (pz 2) pre vs post 3rd period of training (Ekso pz 1-3, Lokomat pz 2): COP: LOS total distance ↑ (pz 1-3), LOS total distance ↓ |
| TBD: No guidance | Covarrubias-Escudero F., 2019 | To examine the effects of a six-week TMBWS program on COM control and gait independence. | NA | *Healthy vs SCI before training:****COP* RMS\*\*\*↑ SCI**, COP NJ↑ SCI *Healthy vs SCI post training:***COP RMS\*\*\***↑ **SCI, COP NJ\*\*\*↑ SCI** *SCI pre vs post training: COP* RMS↑ (ASIA C, D), **COP NJ\*↓ (ASIA C),** NJ ↓ (ASIA D) |
| TBD: Pelvis guidance | Wu MM., 2019 | To address if practice with TMBWSD may increase COM control performance | NA | *SCI group comparison null 1 vs transition 1:***COM Speed Variability\***↑**, COM Lateral Excursion\*↑** *Healthy group comparison null 1 vs transition 3:* COM Speed Variability=, **COM Lateral Excursion\*↑** |
| TBD: Hip-knee guidance | Piira A., 2019 | To investigate whether a less personnel-demanding robot-assisted training programme would have similar treatment effects as the manually assisted approach in treatment effects as the manually assisted approach in comparison with control groups receiving usual care. | *pre vs post training*: *Lokomat*: **BBS\* ↑, mFRT\* ↑** *UC:* **BBS\* ↑**, mFRT *↑* | NA |
| TBD: Hip-knee guidance | Labruyère R., 2014 | To describe the rehabilitation outcome of a patient treated with TMBWS training. | *pre vs post training:  Lokomat:*BBS ↑ *ST:***BBS\* ↑** *post training vs FU:* BBS nc | *pre vs post training and post training vs FU: Lokomat:* COP mediolateral amplitude ↑*ST:*COP mediolateral amplitude *↑* |
| TBD: Hip-knee guidance | Martinez SA., 2019 | To compare the effects of MME versus TM for increasing of volitional lower extremity motor scores and corticospinal neurotransmission. | *pre vs post training:  Lokomat:*BBS ↑ *MME:* BBS *↑* | *Lokomat vs MME*: COP maximal excursion ↑ (for Lokomat) |
| TBD: Hip-knee guidance | Okawara H., 2020 | To quantify the effect of BWSTT with Voluntary Driven Exoskeleton according to the severity of SCI, evaluated using baseline walking ability. | *pre vs post training:  low walking ability group:***TUG\* ↓, BBS\* ↑** *high walking ability group:***TUG\* ↓, BBS\* ↑)** | NA |
| TBD: Hip-knee guidance | Hornby TG., 2005 | To describe the use of a TMBWSD in the clinical setting in an attempt to augment voluntary recovery of motor function and ambulation. | *pre vs post training*:  TUG (pt. 1 and 3 not able), TUG ↓ (pt. 2), FRT sitting=, FRT standing ↑ (pt. 1 and 2), FRT standing ↓ (pt. 3) | NA |
| TBD: Hip-knee guidance | Moreh E., 2009 | To compare gait-related outcomes of lower extremity ST and task-specific locomotor training. | *pre vs post training*: BBS *↑* | NA |
| TBD: Lower leg guidance | Wu M., 2012 | To test whether robotic resistance training could improve locomotor function. | *pre vs post training*:  **BBS\* ↑, ABC\* ↑** | NA |
| OGD: Hip-knee guidance | Khan AS., 2019 | To determine the training dosage required for walking proficiency, the sensory and motor changes in the nervous system with training, and the functionality of the device in a home-like environment. | NA | *pre vs post training*: **COP** **LOS\* ↑, COP sway speed\* ↓,** *post training vs FU:*COP LOS ↓, COP sway speed ↓ |
| OGD: Hip-knee guidance | Bach Baunsgaard C., 2018 | To assess safety, feasibility, training characteristics and changes in gait function using OGD. | *Pre vs Post training and Pre vs FU:* **TUG \*\*↓, BBS\*\* ↑** | NA |
| OGD: Knee guidance | Bishop L., 2012 | To document the use and practicality of gait training for an individual with asymmetric lower limb motor deficits using a novel OGD. | *pre vs post training*: BBS ↑, TUG ↑ | NA |
| OGD: Knee guidance | Font-Llagunes J.M., 2020 | To present the mechanical design and the control architecture of the developed robotic orthosis and to perform a pilot biomechanical assessment of the walking kinematics of a single patient using that device. | NA | *test 1 vs test 2*: COM lateral displacement *↓* |
| TTD: Foot guidance | Daunoraviciene K., 2018 | To estimate and quantify changes in the postacute stage, mainly related to heart rate and blood pressure in functional recovery, postural parameters, walking ability and psychoemotional reactions, during training using averticalization TT robot. | *pre vs post training:  stroke:***BBS\* ↑, Tinetti\* ↑ (walking speed, sit down-stand up time, walking distance)** *SCI:***BBS\* ↑,**Tinetti (not fully applicable) | NA |

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| **Technology-assisted assessment studies** | | | | | |
| **Device type** | **Study** | **MAIN GOAL** | **CLINICAL SCALE ASSESSMENT** | **INSTRUMENTAL ASSESSMENT** | **CORRELATION between clinical and instrumental outcomes** |
| Force plate | Harel J., 2013 | To improve assessment of seated balance in individuals with paraplegia. | *healthy vs SCI groups:* BBS (domain 3): healthy > SCI **mFRT: healthy > SCI\*\*** | *healthy vs SCI groups:* CTSIB: healthy > SCI **COG LOS: healthy > SCI (End point excursion\*\*; Maximum excursion\*\*; Directional control\*)** | **COG LOS directional control: highest correlation with lesion level\***; mFRT: weakest correlation with lesion level |
| Force plate | Shin S., 2013 | To investigate VTC analysis of seated postural control in individuals with SCI. | *healthy vs high lesion vs low lesion groups:* **mFRT**: healthy > low lesion; **healthy > high lesion\***; low lesion > high lesion | *healthy vs high lesion vs low lesion groups:* COP velocity: healthy < low lesion < high lesion COP RMS: healthy < low lesion < high lesion **COP Functional boundary:** healthy > low lesion; **healthy > high lesion\***; low lesion > high lesion **COP VTC mean: healthy > low lesion\*; healthy > high lesion\*\*; low lesion > high lesion\* COP Instability index: healthy < low lesion\*\*; healthy < high lesion\*\*; low lesion < high lesion\*\*** |  |
| Force plate | Lemay J.F., 2013 | To analsye Smart Balance Master (SBM) tests for balance assessement in individuals with AIS D. | *paraplegia vs tetraplegia groups:* BBS: paraplegia ↓ tetraplegia | *paraplegia vs tetraplegia groups: open eyes:* Static test: para > tetra (COG sway areas)COG LOS test: para < tetra (movement time; path sway) Weight-shifting tests: para > tetra (medio-lateral), para < tetra (forward-backward) *closed eyes:* Static test: para > tetra (COG sway area) | **BBS: inverse correlation with open/closed eyes static test\*, with COG LOS test\*\*, with weight-shifting test (foward-backward\*\***, medio-lateral) |
| Stabilometric plate | Tamburella F., 2014 | To determine the reliability, validity, and responsiveness of COP parameters under various test conditions (open/closed eyes, open(cloesd feet) and define the protocol suitable for specifically assessing balance in individuals with incomplete motor SCI. |  |  | **Reliability: the most repeatable parameters were COP L\*\*\*, V\*\*\* and VLL\*\*\* for OF-OE and OF-CE conditions;  Validity: the most valid parameteres in the correlation with BBS and Tinetti scale were COP L\*\*\*, V\*\*\* and VLL\*\*\* mainly in OF-OE condition;  Responsiveness: the most responsive parameters were COP L\*, V\*, VLL\* and VAP\* mainly in OF-OE and CF-CE conditions.** |

Results of the clinical and instrumental outcome measures related to balance, grouped as rehabilitation or assessment studies. Upward/downward arrows (↑/↓) indicate increase/decrease of the related metrics. Asterisks indicate statistically significant variations (\* p<0.05, \*\* p< 0.01 \*\*\* p<0.001).

[ABC: Activities-Specific Balance Confidence; AREA-CE: confidence ellipse area; ASIA: American Spinal Injury Association Impairment Scale; BBS: berg balance scale; BWSTT: body weight support treadmill training; CE: closed eyes; CF: closed feet; COG: centre of gravity; COM: centre of mass; COP: centre of pressure; FRT: Functional Reach Test; FU: follow-up; LOS: limits of stability; mFRT: modified Functional Reach Test; MME: multimodal exercise; nc: not calculable; NJ: normal jerk; OGD: overground device; OE: open eyes; OF: open feet; p: p-value; pt: patient; RMS: root mean square; RVEL: root mean velocity; SCI: spinal cord injury; ST: strength training; TBD: treadmill based device; TM: treadmill exercise; TMBWSD: Treadmill Body Weight Supported Device; TTD: tilt table device; TUG: time up and go; UC: usual care; VTC: virtual time to contact].