Summary of Research Studies

1. Picelli et al. "Combined effects of transcranial direct current stimulation (tDCS) and transcutaneous spinal direct current stimulation (tsDCS) on robot-assisted gait training in patients with chronic stroke: A pilot, double blind, randomized controlled trial." Restorative Neurology and Neuroscience 33 (2015) 357–368

The aim of this pilot study was to **compare different stimulation techniques** while having **robot assisted gait training**. 30 chronic stroke patients were enrolled and divided into three groups: anodal tDCS + sham tsDCS (group 1; *n* = 10) or sham tDCS + cathodal tsDCS (group 2; *n* = 10) or tDCS + cathodal tsDCS (group 3; *n* = 10) **The G-EO System was used** to have robotic training of all patients. The intervention with the G-EO System was a training session of 20 minutes every workday for 2 weeks (10 therapies in total for each patient).

The outcome of interest was the walking independence measured by the distance walked during a 6 Minutes Walking Test before intervention, after the intervention and at 2 and 4 weeks follow up. **All the patients who underwent the G-EO treatment could improve their walking independence**. The preliminary findings support the hypothesis that **anodal tDCS combined with cathodal tsDCS may improve the effects of robotic gait training** in chronic stroke.

2. Sale et al., "Effects of robot assisted gait training in progressive supranuclear palsy (PSP) a preliminary report" Front Hum Neurosci. (2014); 8: 207

In a preliminary report investigating the effect of robot assisted gait training in Progressive Supranuclear Palsy (PSP) it was shown how the **training was feasible, acceptable and safe** for all participants who completed the prescribed training sessions. All patients showed an **improvement in the gait spatiotemporal index** (Mean velocity, Cadence, Step length, and Step width) (T0 vs.T1). The positive results on improvement in spatiotemporal parameter of the PSP subject induced by task-specific repetitive robotic approach and the lack of side effects, strongly recommend extending the use of a this approach in the recovery of gait performance.

3. Stoller O, Schindelholz M, Bichsel L, Hunt KJ. „Cardiopulmonary responses to robotic end-effector-based walking and stair climbing." Med Eng Phys. 2014 Apr;36(4):425-31.

The specific aims of this study were: to characterize cardiopulmonary responses from end-effector-based walking and stair climbing exercise, and to assess the technical feasibility of end-effector-based intensity-guided incremental exercise testing for assessment of peak exercise capacity in healthy subjects. **End-effector-based exercise is a promising method for the implementation of cardiovascular exercise**. Five healthy subjects with no known cardiovascular, pulmonary or musculoskeletal problems that may have interfered with or contraindicated exercise testing participated in this study. The end-effector-based robotic device (G-EO system, Reha Tech-nology AG, Switzerland) was used to simulate walking and stairs climbing .Although robotic stair climbing evoked lower cardiopulmonary responses than conventional stair climbing, **active contribution during exercise elicited substantial cardiopulmonary responses within recommended ranges for aerobic training**.

4. Mehrholz J, Elsner B, Werner C, Kugler J, Pohl M. Electromechanical-assisited training for walking after stroke. Cochrane Database Syst Rev. 2013 Jul 25;7 The Cochrane Library 2013, Issue 7

This **Cochrane Review shoes evidence that physiotherapy in combination with electromechanical robotic assisted gait training is more effective when compared to conventional therapy approach in stroke patients**. The review includes **23 randomized controlled clinical trials** comparing electromechanical and robotic assisted gait training **(end-effector based** and exoskeleton) versus conventional approach. The authors of the review focused on the proportion of patients who were able to walk reach independency in walking after the intervention and at follow up. Results have shown significant evidence that stroke patients who receive electromechanical assisted gait training in combination with physiotherapy are more likely to achieve a **higher chance of independency in walking when compared to those patients who has received only conventional therapy approach**. Positive effects were observed in all patients but those patients who were not able to walk within the first three months after the episode seemed to have the most favorable outcome.

5. Sale et al., "Robot-assisted walking training for individuals with Parkinson's disease: a pilot randomized controlled trial" BMC Neurology (2013)

In a **randomized controlled trial** investigating the effects of **end-effector robotic gait training** on 20 individuals with idiopathic Parkinson's disease, analysis showed a **statistically significant improvement** in gait index in favor of the experimental group when compared to the control group (T0 versus T1). In particular, the statistical analysis of primary outcome (gait speed) showed **statistically significant improvements** for the EG as well as for step and stride length. No statistically significant improvements on the CG were found. The **simplicity of treatment**, the **lack of side effects**, and the **positive results** from patient support the recommendation to extend the use of this approach.

6. Mehrholz J, Pohl M., "Electromechanical-Assisted Gait training after stroke: a systematic review comparing end effector and exoskeleton devices. J Rehabil Med (2012); 44: 193–199

In a systematic review, end effector and exo-skeleton approaches were compared with the aim of analyze the effects of different electromechanical gait trainings after stroke. The review was made using the following sources: Cochrane Stroke Group Trials Register, CENTRAL, MEDLINE, EMBASE, CINAHL, AMED, SPORTDiscus, PEDro, COMPENDEX and INSPEC.

18 clinical trials were included involving 885 patients. **Significantly higher rates of independent walking in end-effector compared with exoskeleton-based training were shown.**

The results suggest that the **type of electromechanical-assisted device might influence** the outcome of gait rehabilitation after stroke.

7. **Hesse S, Tomelleri C, Bardeleben A, Werner C, Waldner A.. "Robot-Assisted Practice of Gait and Stair Climbing in Non-Ambulatory Stroke Patients". JRRD Volume 49, Number 4, 2012, p. 613–622.**

In a randomized controlled clinical trial involving 30 non-ambulatory stroke survivors on the robot-assisted practice of gait and stairs climbing, the functional ambulation ability (FAC score) of the robot-treated group improved significantly more when compared to the control group. Analysis showed that task-specific repetitive robotic approach significantly lead towards **independency in the ability to walk and to climb stairs.** Because of the **higher training intensity**, the experimental group patients reached a **superior gait and stair climbing ability** after the intervention and at the follow up showing **long lasting improvements**.

8. **Tomelleri C, Waldner A, Werner C & Hesse S. "Adaptive Locomotor Training on an End-Effector Gait Robot. Evaluation of the Ground Reaction Forces in Different Training Conditions". IEEE International Conference on Rehabilitation Robotics (ICORR), 2011.**

This study analyzed the force interaction between the foot and the ground during real floor walking on a treadmill, floor walking on the G-EO system and end-effector robotic gait trainer during passive and adaptive modes among 8 healthy volunteers. The results showed different ground reaction forces across all three conditions while the adaptive mode has shown **ground reaction force patterns and intensities comparable to real floor walking**.

9. **Smania N, Bonetti, P & Gandolfi M. (2011). "Improved Gait After Repetitive Locomotor Training in Children with Cerebral Palsy." Am J Phys Med Rehabil 2011;90: p.137-149.**

In this **randomized controlled trial**, 18 ambulatory **children with diplegic or tetraplegic cerebral palsy** randomly assigned to an experimental with received 30 minutes of repetitive locomotor training with an applied technology (Gait Trainer GT I) plus 10 minutes of passive joint mobilization and stretching exercises and the control group received 40 minutes of conventional physiotherapy for a total of 10 treatment sessions over a 2-wk period. The experimental group showed **significant 1 month post-treatment improvement** on the 10-min walk test, 6-min walk test, hip kinematics, gait speed, and step length **while no significant changes in performance parameters were observed in the control group.**

10. **Hesse S., Waldner A, & Tomelleri C. (2010). "Innovative Gait Robot for the Repetitive Practice of Floor Walking and Stair Climbing Up and Down in Stroke Patients.". Journal of NeuroEngineering & Rehabilitation 7:30.**

The study intends to compare lower limb muscle activation patterns of hemi paretic subjects during real floor walking and stairs climbing up, and during the corresponding simulated conditions on the G-EO System. The muscle activation pattern of seven lower limb muscles of six hemi paretic patients during free and simulated walking on the floor and stair climbing was measured via dynamic electromyography. In addition a non-ambulatory sub-acute stroke patient was trained on the G-EO-Systems every workday for five weeks. Findings demonstrates that the **muscle activation patterns were comparable during the real and simulated conditions, both on the floor and during stair climbing up** and demonstrate a significant gait improvement on the single case analyzed after the G-EO training.

11. **Pohl M et al. "Repetitive locomotor training and physiotherapy improve walking and basic activities of daily living after stroke." Clinical Rehabil 2007;21(1):17-27**

This **randomized controlled clinical trial** was design with the intention to evaluate the effect of **repetitive locomotor training** on an **electromechanical end effector gait trainer** plus physiotherapy in subacute stroke patients. Primary outcome variables were gait ability and basic ADL, assessed before study onset, at the end of the four-week treatment period and at follow-up six months after study end. The Functional Ambulation Category, a reliable and valid score, helped to assess gait ability. Over a period of 21 months, 155 patients entered the trial, 77 in the experimental group and 78 in the control group. Results have shown that **intensive robotic assistive training plus physiotherapy resulted in a significantly better gait ability and daily living competence when compared to physiotherapy alone**. Consistency in the results obtained was also shown at follow up time.