USE OF TECHNOLOGIES AND INNOVATIONS IN REHABILITATION
TRAINM OVERVIEW

• For pediatrics and adults
• Very high intensity therapies
• By multi-disciplinary team of medical professionals
• Equipped with robotics, VR, neuro-gaming, brain-computer-interface and non-invasive brain stimulation
INDICATIONS WE TREAT

NEUROLOGICAL DISORDERS

• Acquired brain injury
• Cerebral palsy
• Motor neuron diseases, e.g. ALS
• Multiple sclerosis
• Muscular dystrophies
• Parkinson’s disease
• Spinal cord injury
• Stroke

ORTHOPEDIC & POST-OP

• Paralysis
• Carpal tunnel syndrome
• Hand injuries
• Peripheral neuropathy
• Contractions post-op
• Amputees and prosthetics
• Hip-replacement
• **Personalized high-intensity therapies:**
  ✓ Best-in-class team of doctors and therapists
  ✓ Robotics
  ✓ Non-invasive brain stimulation techniques
  ✓ Virtual reality (VR)
  ✓ Neuro gaming
  ✓ Brain-computer interface (BCI)

• **Combining technologies, human intervention and a motivating environment**

• **TRAINM patients receive 1,000 movements per session, 20x more than conventional therapy**
ACHIEVING MEASURABLE RECOVERIES TOWARDS FUNCTIONAL RECOVERY GOALS

SET GOALS

FEEDBACK
- Accurate performance feedback is analyzed after each session and a plan is generated

AUGMENT
- Augment function based on individually tailored protocols

SENSE
- Objective and subjective measurements
  - Sensors generate precise motor function data

ASSESS
- Medical staff assess data and plan patient-specific augmentation strategy
ENVIRONMENT DESIGNED TO ENHANCE MOTIVATION AND SENSE OF WELL-BEING

1,000M² OF BEAUTIFUL ENVIRONMENT FILLED WITH LIGHT AND MUSIC
FOR PEDIATRICS AND ADULTS

GAIT TRAINING/WALKING: GEO, LOKOMAT, WALKER VIEW

ARM AND SHOULDER: INMOTION, ARMEO, MYRO, DIEGO FINGER, HAND, ARM: PABLO, AMADEO

GYM: FUNCTIONAL, BALANCE, TRUNK CONTROL TRAINING
SCIENCE BEHIND ROBOTICS
"We use interactive robotics so that we can stimulate motor activities in a highly intensive manner within a population that recovers from a brain haemorrhage. The robot therapy ensures a better and larger recovery and we try to add other non-invasive bio-electronic applications so that we can achieve an even better result."

"The outcome is always going to better when people understand both the human aspects of hands on therapy and can combine those conventional approaches with an intensity that can be delivered with the robotics. There are many places that use some time with robots as an adjunct to conventional therapy but I think there is a lot that can be learnt from TRAINMs approach."

"Patients have very real ambitions to get back to their daily activities and to their social roles and often in other settings those ambitions aren’t realised, they are not given the support to do it. Here, at TRAINM people are absolutely supported to go on and realise those ambitions and to improve a long time after the injury."
“The brain is an electrical organ. We try to develop methods that interact with this brain activity and thus have a positive influence on its functioning.”

Dr. Dylan Edwards, PhD, PT
• Director, Moss Rehabilitation Research Institute
• Associate Professor, Neurology, Weill Cornell Medical College
• Co-Director, Intensive Course in TMS, Harvard Medical School

“Rehabilitation robotics are important tools that support therapists so that patients can achieve the highest possible functional outcome and independence. More and more studies show that intensive therapy is crucial. We are convinced that, with the help of robot-assisted rehabilitation, training levels are achieved that would not be possible without this technology. TRAINM offers exclusive therapy and makes them unique in the world.”

Gery Colombo, PhD
• Founder, CEO and Chairman of the Board of Hocoma AG
• President of the international industry society in advanced Rehabilitation Technology

“I believe that the provision of robot technology within rehabilitation is one of the most important developments in the field of rehabilitation. This provides an enormous opportunity so that we can improve limitations and facilitate rehabilitation after a brain haemorrhage. I am extremely honoured that I can provide my advice to TRAINM. TRAINM uniquely embodies what I have already described 10 years ago in a publication: "Robotics in Rehabilitation - Bright lights, Great future.”

Dr. Herman Igo Krebs, PHD
• Principal research Scientist and Lecturer at the Massachusetts Institute of Technology (MIT), Newman Laboratory for Biomechanics and Human Rehabilitation
Dr. Kristaan Deckers, MD
- Head of Physical Medicine and Rehabilitation, GZA Hospitals, Antwerp
- Medical Director, Head of Rehabilitation, TRAINM

“There is an increasing amount of scientific evidence that the use of robot-assisted rehabilitation leads to a much better result in repairing and maintaining various functional parameters. Particularly within neurorehabilitation there are more and more studies that show that robot applications lead to much better results than traditional, conventional therapies. We certainly notice this in the area of gait rehabilitation and meta-analyses also show us important results for the rehabilitation of the upper limbs. It is clear that progressive research in rehabilitation science will teach us more about the impact of robot-assisted techniques on neuroplasticity and motor learning. Ultimately, this will lead to even better results for our patients.”

Pro Peter Feys, PhD, PT
- Professor Peter Feys – Professor Rehabilitation Sciences and Physiotherapy, NIOMED, University of Hasselt

“In traditional therapy there is often mainly a focus on the quality of movement to be able to move again, but sometimes there is not enough attention given to the intensity of movement and the quantity of it as well. We all know that if we need to learn a new task we need to put a lot of time into it. That is also the case when it comes to movement. Traditional therapy if often too short and sometimes not intensive enough to be able to make progress. TRAINM is situated in an unique surrounding and since a few years they are actively offering robot based training for patients with neurological diagnosis.”

Dr. Tony Van Havenbergh, MD, PHD
- Chairman, Department of Neurosurgery at GZA hospital Group
- Medical Director, Head of Neuromodulation, TRAINM

“For a decade there has been a growing body of scientific evidence that magnetic or electrical stimulation of the brain can improve neurological recovery. One of the mechanisms is to stimulate the brain to regenerate. That is why it seems logical to combine electrical neuromodulation with intensive training. The scientific studies and my personal clinical experiences support this theory. TRAINM is one of the first centres where expert electrical neuromodulation is combined with intensive robot-assisted rehabilitation. The TRAINM neuromodulation is also used in neurological symptoms such as vision problems, dysphasia after a stroke, within cognitive indications after a traumatic brain injury and degenerative neurological disorders.”
1. Evidence-based rehabilitation for the upper and lower extremities:
   - reproducible,
   - quantifiable,
   - high-intensity, task-specific therapy (over 1,000 movements/60 min session)

2. Significant reduction in impairment of function

3. Positive results are long lasting

4. Therapy for all levels of impairment severity and types: (chronic, subacute, acute)

5. High motivational factor

6. Recovery achieved through neuroplasticity and motor learning

7. Efficient assessment, documentation and reporting
Neuroplasticity allows the nerve cells in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment. (MedicineNet.com. April 7, 2012).

Neuroplasticity is the brain's amazing capacity to physiologically change as the result of our interactions with our environment and experiences.

Neuroplasticity is big a factor in recovery from brain injury.

It is the basis for much of our cognitive and physical rehabilitation practices.

Part of rehabilitation is aimed at trying to rebuild connections among the nerve cells.

This "re-wiring" of the brain can make it possible for a function previously managed by a damaged area to be taken over by another undamaged area.
10 PRINCIPLES OF NEUROPLASTICITY

**USE IT OR LOSE IT**
• Keep doing functional things, and if you’re a caregiver, don’t over-help.

**USE IT AND IMPROVE IT**
• Training that drives brain functions can lead to enhancement of function.

**SPECIFICITY**
• Focus on the specific functional task for optimal results.

**REPETITION MATTERS**
• Must perform a task over and over again. Plasticity requires sufficient repetition.

**INTENSITY MATTERS**
• Plasticity requires sufficient training intensity. Building neural connections takes time.

**TIME MATTERS**
• Different forms of plasticity occur at different times during training and over the course of recovery.

**SALIENCE MATTERS**
• The experience must be relevant, novel, and have meaning.

**AGE MATTERS**
• Plasticity occurs more readily in younger brains.

**TRANSFERENCE**
• Plasticity in response to one training experience can enhance acquisition of similar behaviors.

**INTERFERENCE**
• Plasticity in response to one experience can interfere with the acquisition another.
A French man lives a relatively normal, healthy life - despite missing 90 percent of his brain. The researchers explained how he'd lived most of his life without realizing anything was wrong with him.

He only went to the doctor complaining of mild weakness in his left leg, when brain scans revealed that his skull was mostly filled with fluid, leaving just a thin outer layer of actual brain tissue, with the internal part of his brain almost totally eroded away.

But despite his minimal remaining brain tissue, the man wasn't mentally disabled - he had a low IQ of 75 but was working as a civil servant. He was also married with two children and was relatively healthy.
1. Proper rehabilitating
2. A lot of repetition (not 10s, not 100s, but 1,000s) possible only with robotics
3. Focused learning (don’t tune out): game-based therapies with therapists
4. Active movements are better than passive: sensor and based-robotics with active mode
5. When you can’t do more, passive movements will still help with sensor and motor-based robotics
6. Other interventions:
   - Neuromodulation: tDCS and rTMS
   - Drugs and pharmaceuticals
   - Brain-computer interface
A U.S. based government health care system tracked overall healthcare expenditures of patients using robotics therapy for 36 weeks and found that their healthcare costs were lower than the conventional therapy group by an average of US$6,419/patient.

<table>
<thead>
<tr>
<th>Cost in US$ per patient</th>
<th>Avg total cost at 36 wks*</th>
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<tr>
<td>Usual Care (n=28)</td>
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<td>Robotic Therapy (n=49)</td>
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<td>Difference</td>
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*Includes costs for all healthcare services incurred at the Veterans Affair delivery system, services paid out of pocket, such as homemaker and other assistance, and self-reported services as received outside the VA system.

STROKE STUDIES
OUTCOMES: 12 studies matching criteria identified, of 574. FM, Motor Power, Motor Status and FIM outcomes were pooled.

CONCLUSIONS:
1. Robot assisted Therapy in addition of conventional therapy (CT) are more beneficial than CT alone.
2. Studies across sub-acute stroke patients showed significantly improved motor recovery when robotics used in addition to CT.
3. Studies in chronic stroke patients and at 6-8-months follow-up showed strong results favoring robotics.

“The high number of repetitive movements generated during robotics therapy is probably the key reason for this therapeutic effect.”

OBJECTIVE: Assess the effectiveness of robot-assisted arm training to improve activities of daily living (ADL)

METHODS: Studies Analyzed: 19 randomized controlled clinical trials

RESULTS: “Patients who receive electromechanical and robotics assisted training after stroke are more likely to improve their generic activities of daily living and paretic arm function”

“International benchmark for the independent assessment and assimilation of scientific evidence” - World Health Organization

In a controlled clinical study involving 56 stroke patients, the motor skills of the robot treated group improved significantly more than the control group. Analysis showed that therapy with Robots significantly reduced motor impairment of the treated limbs on the Fugl Meyer scale and Motor Power Scale and improved FIM motor scores by 5.5 points higher than control group.


In a multi-center, randomized controlled trial involving 127 chronic stroke patients with moderate to severe upper-limb impairment, 36 weeks therapy with Robots demonstrated significant improvement in impairment, function and quality of live as measured by the Fugl Meyer (+5), Wolf Motor Function Test (-6.5) and Stroke Impact Scales (+5). Of notice, the control receiving usual care did not improve and the investigators ended the control group for futility. Robotics therapy was better than usual care by 5pts on the FMS.

“The improvements provide evidence of potential long-term benefits of rehabilitation and challenge the widely held clinical belief that gains in motor function are not possible for long term stroke survivors.”

ROBOTIC-ASSISTED GAIT TRAINING: ACUTE STROKE

METHODS: Identified 107 cases of new cerebral stroke: 36 patients were allocated to robotic training (RT) group (robotics 2x/week, CP 3x/week) and 71 patients to the conventional physiotherapy (CP) group (CP 5x/week) lasting at least 30 sessions.

CONCLUSIONS: RT combined with CP produced better improvements in the Functional Independence Measure (FIM), Berg Balance Scale (BBS), and Mini-Mental State Examination (MMSE).

(Dundar U. et al., A Comparative Study of Conventional Physiotherapy Versus Robotic Training Combined with Physiotherapy in Patients with Stroke, Topics in Stroke Rehabilitation, 10 (2014) 2106-453)

METHODS: A prospective single-blinded, randomized controlled study of 37 patients receiving inpatient rehabilitation was performed within 1 month after stroke onset. RT group (n=20) received 40 minutes of robotics gait training and 60 minutes of conventional physical therapy each day, whereas the control group (n=17) received 100 minutes of conventional physical therapy daily.

CONCLUSIONS: Compared with the control group, the robotic group showed 12.8% improvement in peak VO₂ after training (P>.05) and improvement in the Fugl-Meyer Assessment Scale (FMA-L) score (P>.05).

OBJECTIVES: to investigate the effect of automated electromechanical- and robot-assisted gait training devices for improving walking after stroke.

METHODS: 36 trials involving 1472 participants were included in this review.

CONCLUSIONS: People who receive electromechanical-assisted gait training in combination with physiotherapy after stroke are more likely to achieve independent walking than people who receive gait training without these devices.


OBJECTIVES: to assess the effectiveness of electromechanical and robot-assisted arm training for improving activities of daily living, arm function and motor strength after stroke.

METHODS: 11 trials with 328 participants were included in this review.

CONCLUSIONS: Electromechanical and robot-assisted arm training after stroke might improve the activities of daily living, arm functions and arm muscle strength.

METHODS: Thirty non-ambulatory patients with subacute stroke were allocated to two groups each receiving 60 min sessions 5 days/week for 4 weeks: 1) experimental group received 30 min of robot training and 30 min of physiotherapy and 2) the control group received 60 min of physiotherapy.

CONCLUSIONS: The improvements were significantly larger in the robotic group with respect to Functional Ambulation Categories (FAC), Rivermead Mobility Index (RMI), velocity and leg strength during the intervention. The FAC gains were 2.4±1.2 (robotics) vs. 1.2±1.5 (control). At the end of the intervention, 7 robotics and 1 control group patients had reached an FAC score (0-5) of 5, indicating an ability to climb up and down one flight of stairs. At follow up, the gains had persisted.


METHODS: Twenty patients who were dependent ambulators with chronic stroke were divided into two groups who received: 1) robot-assisted gait training 3x/week for 4 weeks followed by conventional PT for 4 weeks or 2) same treatments in reverse order.

CONCLUSIONS: “The present study showed that robot-assisted gait training is not only effective in improving balance and gait performance but also improves trunk balance and motor skills required by high-severity stroke patients to perform activities daily living.”

METHODS: The study divided 17 patients with limited finger movement and weakened and impaired hand function > 3 months post stroke into two groups: 1. 20 sessions (4 weeks) of active robot-assisted intervention (FTI) or two weeks (10 sessions) of early passive therapy followed by two weeks (10 sessions of active robot-assisted intervention (HTI).

CONCLUSIONS: Both the FTI and HTI groups showed improved results with greater degree of improvement for the FTI compared to the HTI group, for example, in Jebsen Taylor test (65.9±36.5 vs. 46.4±37.4) and wrist and hand sub portion of the Fugl-Meyer arm motor scale (4.3±1.9 vs 3.4±2.5) after 8 weeks.

Hwang CH., et. Al Individual Finger Synchronized Robot-Assisted Hand Rehabilitation In Subacute to Chronic Stroke: A Prospective Randomized Clinical Trial of Efficacy, Clinical Rehabilitation, 1-9 (2012)

METHODS: Study with 7 patients with subacute to chronic stroke with moderate to high grade distal paresis of the movements.

CONCLUSION: The Motricity Index improved from 59.4 pre to 67.2 post (p<.05) and grip force increased from 7.26 pre to 11.87 post (p<.05). On fMRI, active movement of the affected hand resulted in contra-lesion (i.e. ipsilateral) activation on the primary sensorimotor cortex prior to rehabilitation. After rehabilitation, activation appeared “normalized” including the ipsi-lesion primary sensorimotor cortex and supplementary motor area.

TRAUMATIC BRAIN INJURY STUDIES
Combined robotic-aided gait training and physical therapy improve functional abilities and hip kinematics during gait in children and adolescents with acquired brain injury.

OBJECTIVES: To evaluate the combined effect of robotic-aided gait training (RAGT) and physical therapy (PT) on functional abilities and gait pattern in children and adolescents exiting acquired brain injury (ABI), through functional clinical scales and 3D-Gait Analysis (GA).

METHODS: A group of 23 patients with ABI underwent 20 sessions of RAGT in addition to traditional manual PT. All the patients were evaluated before and after the training by using the Gross Motor Function Measures (GMFM) and the Functional Assessment Questionnaire. Ambulant children were also evaluated through the 6 Minutes Walk Test (6MinWT) and GA. Finally, results were compared with those obtained from a control group of ABI children who underwent PT only.

RESULTS: After the training, the GMFM showed significant improvement in both dimensions 'D' (standing) and 'E' (walking). In ambulant patients the 6MinWT showed significant improvement after training and GA highlighted a significant increase in cadence, velocity and stride length. Moreover, hip kinematics on the sagittal plane revealed a statistically significant increase in range of motion (ROM) during the whole gait cycle, increased hip extension during terminal stance and increased ROM during the swing phase.

CONCLUSIONS: The data suggest that the combined programme RAGT + PT induces improvements in functional activities and gait pattern in children and adolescents with ABI and demonstrated it to be an elective tool for the maintenance of the patients' full compliance throughout the rehabilitative programme.

A randomized comparative study of manually assisted versus robotic-assisted body weight supported treadmill training in persons with a traumatic brain injury.

OBJECTIVES: (1) To compare the effects of robotic-assisted treadmill training (RATT) and manually assisted treadmill training (MATT) in participants with traumatic brain injury (TBI) and (2) to determine the potential impact on the symmetry of temporal walking parameters, 6-minute walk test, and the mobility domain of the Stroke Impact Scale, version 3.0 (SIS).

METHODS: Randomized prospective study. A total of 16 participants with TBI and a baseline over ground walking self-selected velocity (SSV) of ≥0.2 m/s to 0.6 m/s randomly assigned to either the RATT or MATT group. Gait training for 45 minutes, 3 times a week with either RATT or MATT for a total of 18 training sessions.

RESULTS: Between-group differences were not statistically significant for any measure. However, from pretraining to post-training, the average SSV increased by 49.8% for the RATT group (P = .01) and by 31% for MATT group (P = .06). The average maximal velocity increased by 14.9% for the RATT group (P = .06) and by 30.8% for the MATT group (P = .01). Less staffing and effort was needed for RATT in this study. Step-length asymmetry ratio improved during SSV by 33.1% for the RATT group (P = .01) and by 9.1% for the MATT group (P = .73). The distance walked increased by 11.7% for the robotic group (P = .21) and by 19.3% for manual group (P = .03). A statistically significant improvement in the mobility domain of the SIS was found for both groups (P ≤ .03).

CONCLUSIONS: The results of this study demonstrate greater improvement in symmetry of gait (step length) for RATT and no significant differences between RATT and MATT with regards to improvement in gait velocity, endurance, and SIS. Our study provides evidence that participants with a chronic TBI can experience improvements in gait parameters with gait training with either MATT or RATT.

PARKINSON'S DISEASE STUDIES
METHODS: Twenty cognitively intact participants with mild Parkinson’s disease and gait disturbance were divided into two groups, each receiving 40 min treatments 5x/week for 4 weeks: 1) robot-assisted gait training (EG) and 2) treadmill training (CG).

CONCLUSION: A statistically significant improvement in gait index was found in favor of the robot-assisted group but not the treadmill group. In particular, gait speed using the Friedman test showed statistically significant improvements for the robotics group.

Sale P. et al, Robot-Assisted Walking Training For Individuals with Parkinson’s Disease: A Pilot Randomized Controlled Trial, BMC Neurology, (2013) 1471-2377/13/50

METHODS: Thirty-four patients with PD at Hoehn & Yahr stage 3-4 were randomly assigned into two groups. All patients received 12, 40 min treatment sessions, 3 days/week, for 4 weeks. The Robotic Training group (n = 17) underwent robot-assisted gait training, while the physical Therapy group (n = 17) underwent a training program not specifically aimed at improving postural stability.

CONCLUSIONS: A significant improvement was found in favor of the Robotic Training Group (Berg: 43.44±2.73; Nutt: 1.38±0.50) compared to the Physical Therapy group (Berg: 37.27±5.68; Nutt: 2.07±0.59) after treatment on the Berg Balance Scale and the Nutt’s rating. All improvements were maintained at the 1-month follow up evaluation.

OBJECTIVES: To study the effects of long-term brain-machine interface (BMI) training on inducing clinical recovery in severely paralyzed patients.

METHODS: Eight chronic (3-13 yrs post) patients with complete SCI trained twice a week for a year using a brain-computer interface to control either an avatar seen through VR goggles or a robotic exoskeleton. During the study, patients wore caps that recorded their brain waves, or EEG signals, which they used to direct movements of a human figure displayed on a headset. Patients then graduated to operating a robotic exoskeleton that moved their legs, helping them stand up or walk on a treadmill.

CONCLUSIONS: Following the training, patients were able to voluntarily move their legs for the first time in years. They also regained some sensation of feeling in their lower limbs. By the end of the study, half the patients were upgraded from a clinical diagnosis of complete spinal cord injury to “incomplete” paraplegics.

OBJECTIVES: the aim of the study was to assess the effects of Robot-assisted gait training (RAGT) on improvement in walking-related functional outcomes in patients with incomplete SCI compared with other rehabilitation modalities according to time elapsed since injury.

METHODS: This review included 10 trials involving 502 participants.

CONCLUSIONS: Robot Assisted Gait Training improves mobility-related outcomes to a greater degree than conventional over ground gait training for patients with incomplete SCI.

METHODS: A total of 88 adults within 6 months of spinal cord injury onset (incomplete upper motor neuron (UMN) or lower motor neuron (LMN)) graded by the American Spinal Injury Association Impairment Scale as C or D allocated to either robotic training plus over ground therapy (LKOGT) or conventional over ground training (OGT) for an hour/day, 5 days/week for 8 weeks.

CONCLUSIONS: Robotic-assisted step training yielded better results in 6-minute walk test and the Lower Extremity Motor Score in both UMN and LMN patients.

CEREBRAL PALSY STUDIES
**METHODS:** 12 children ages 5-12 with Cerebral Palsy and upper-limb hemiplegia received robotic therapy twice a week for 8 weeks.

**CONCLUSIONS:** The children showed significant improvement in total Quality of Upper Extremity Skills Test (QUEST) and Fugl-Meyer Assessment Scores.


**OBJECTIVES:** The objective of this study was to investigate the feasibility of game-based robotic training of the ankle in children with cerebral palsy (CP).

**METHODS:** 3 children with CP (ages 7-12), received 36 sessions (12 weeks 3x/week) of Rutgers Ankle CP system, playing two custom VR games while participants were seated, and trained one ankle at-a-time for strength, motor control, and coordination.

**CONCLUSIONS:** Gait function improved substantially in ankle kinematics, speed and endurance. Quality of life increased was greater than a minimal clinical important difference. This feasibility study supports the assumption that game-based robotic training of the ankle benefits gait in children with CP.

OBJECTIVES: To systematically examine the effects of robotic therapy on upper extremity (UE) function in children with cerebral palsy (CP)

METHODS: Nine articles using three different robotic systems were included.

CONCLUSIONS: The systematic review summarizes the current literature showing that robotic therapy has a potential benefit in improving UE function in children with CP.

OBJECTIVES: To evaluate gross motor function, activity and participation in patients with bilateral spastic cerebral palsy after Robot-enhanced repetitive treadmill therapy (ROBERT).

METHODS: Participants trained for 30-60 min in each of 12 sessions within a three-week-period. Outcome measures were assessed three weeks in advance (V1), the day before (V2) as well as the day after, and 8 weeks after ROBERT (V3 + V4).

CONCLUSIONS: This prospective controlled cohort study showed significant and clinically meaningful improvements of function in ICF domains of ‘activity’ and ‘participation’ in patients with bilateral spastic cerebral palsy.


OBJECTIVES: To identify the effects of robotic gait training practices in individuals with cerebral palsy.

METHODS: Studies were included if they fulfilled the following criteria: (1) they investigated the effects of robotic gait training, (2) they involved patients with cerebral palsy, and (3) they enrolled patients classified between levels I and IV using the Gross Motor Function Classification System. Ten studies met the inclusion criteria.

CONCLUSIONS: The results obtained suggest that this type of training benefits people with cerebral palsy, specifically by increasing walking speed and endurance and improves gross motor function.

Carvalho I, et al., Robotic Gait Training for Individuals With Cerebral Palsy: A Systematic Review and Meta-Analysis, Archives of physical medicine and Rehabilitation, (2017)
ORTHOPAEDIC INJURIES STUDIES
OBJECTIVES: To provide a systematic review of studies that investigates the effectiveness of robot assisted therapy on ankle motor and function recovery from musculoskeletal or neurological ankle injuries.

METHODS: Use of 13 electronic databases finding articles from January 1980 until June 2012 using specific key words. Resulting in 29 articles being selected for review that focused on effects of robot-assisted ankle rehabilitation.

CONCLUSIONS: All showed improvements in ankle performance/gait function after a period of robot-assisted training.

OBJECTIVES: To determine the clinical effects of a training robot that induced eccentric tibias anterior muscle contraction by controlling the strength and speed/investigating the effects of walking training with the use of a device.

METHODS: A clinical study (cross-over comparative experimental design) where elderly patients trained four times within 1 month, in sets of eight, twice in one session with resting intervals. A robotic device was used in combination with visual bio-feedback during the training of the tibias anterior muscle.

CONCLUSIONS: Positive improvement trend on the 5m walking test and a significant difference was observed when training and control phases in all elderly subjects. Possibilities shown that device may improve walking ability though eccentric contraction training of the tibias anterior muscle preventing foot drop.

OBJECTIVES: To examine the efficacy of postural strategy training using a balance exercise assist robot (BEAR) as compared with conventional balance training for frail older adults.

METHODS: Cross over trial of 65-85y community dwelling frail or prevail elderly residents that volunteered. An robot system that assisted in balance exercises was compared to conventional balance training combining muscle-strengthening, postural strategy training and applied motion exercises over a 6 week period. All were randomly allocated.

CONCLUSIONS: In frail/pre-frail older adults, robotic exercise was more effective for improving dynamic balance and lower extremity muscle strength than conventional exercise.

OBJECTIVES: To examine the long-term interventions effects of RAT (Robot-assisted therapy) rehabilitation on functional activity levels after ACL reconstruction.

METHODS: The normal rehabilitation carried out traditional physiotherapy such as muscle strength training, joint mobilization, balance training and endurance training. The walking training used a RAT robot (MBZ-CPM1, ManBuZhe [Tian Jin] Rehabilitation Equipment Co., Ltd., China). Walking ability was measured using 10MWT, TUG, Functional reach test and sEMG (surface electromyography).

CONCLUSIONS: Walking ability and muscle strength can be improved by robotic walking training as a long term intervention.

CASE 1: TARS PEETERS

- Male
- DOB: 26/07/1992
- Traumatic brain injury (car accident at 17y) – locked in syndrome
- Medication: Bachlofempump, Porta-Cath, Kepra
- Coma for 8 months; had multiple near fatal pulmonary infections
- Able to understand, unable to respond/make voluntary movements

GOALS ACHIEVED – SINCE START OF TRAINM APRIL 2017:

- Independently driving his electric wheelchair (hand/arm improvement)
- Has not been hospitalized since start of TRAINM
- Gait training on robotics has improved
- Current goal: commute to/from TRAINM independently

TREATMENT PROTOCOL

Functional training: 30 mins (2 sessions/week)
- Lokomat®

Upper-body training: 30-60 mins (3 sessions/week)
- Armeo®Power
- InMotion ARM™
- Tyro-motion®
CASE 1: TARS PEETERS WALKING IMPROVEMENTS

Lokomat (gait training) - data of 2-month intervals since December 2017:

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<th>Distance (m)</th>
<th>Duration (mins)</th>
<th>Speed (km/h)</th>
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<td>Apr-19</td>
<td>959</td>
<td>30</td>
<td>1.9</td>
<td>38%</td>
<td>90%</td>
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</tr>
<tr>
<td>Jun-19</td>
<td>1,063.90</td>
<td>35</td>
<td>1.8</td>
<td>38%</td>
<td>95%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Percentage Change: 21% 17% 6% -5% -5% -5%
CASE 1: TARS PEETERS WALKING IMPROVEMENTS

**BODY WEIGHT SUPPORT**

- Week 1: 45 KG
- Week 107: 34 KG
- Decrease: -24.4%

**DURATION**

- Week 1: 20 MIN
- Week 107: 45.5 MIN
- Increase: +102%

**DISTANCE**

- Week 1: 300 M
- Week 107: 1465.5 M
- Increase: +388.5%

**SPEED**

- Week 1: 0.9 KM/H
- Week 107: 1.9 KM/H
- Increase: +78%
CASE 1: TARS PEETERS - BEFORE TRAINM: 33 HOSPITALIZATIONS & 36 AMBULANCES, NO HOSPITALISATIONS SINCE START – TRAINM (2 YEARS)

- 27/09/2010 opgenomen AZ sint Augustinus in Veurne
- 11/09/2010 overgebracht naar het Middelheim in Berchem
- 18/11/2010 overgebracht naar de Mick – revalidatie in Brasschaat
- 28/11/10 tem 06/12/10 opgenomen in het Middelheim in Berchem
- 31/01/11 tem 17/02/11 opgenomen in het Middelheim in Berchem
- 06/09/2011 tem 03/12/2012 opgenomen in Woon en zorg De Mick in Brasschaat
- 10/01/12 tem 18/01/12 opgenomen in het Middelheim in Berchem – operatie blaassteen
- 29/05/2012 tem 06/12/2012 opgenomen in het CHU in Luik – Prf.S. Lauryes
- 03/12/2012 tem 25/02/2014 revalidatie in UZ Gent K7
- 10/01/2013 tem 27/01/2013 bandwondencentrum in Gent bij plaatsgebrek intensieve
- 05/08/13 tem 05/08/2013 mobilisatie onder narcose van onderste en bovenste ledematen UZ GENT
- 03/12/2013 tem 04/12/2013 operatie achillespeesverlenging in UZ GENT
- 14/02/2014 operatie polsen in UZ GENT
- 25/02/2014 tem 12/11/2014 opgenomen in Woon en zorgcentrum De Mick in Brasschaat
- 14/09/2014 tem 15/09/2014 opgenomen Middelheim in Berchem
- 30/09/2014 tem 15/10/2014 opgenomen Middelheim in Berchem
- 15/10/2014 tem 04/11/2014 opgenomen Middelheim in Berchem
- 12/11/2014 tem 07/06/2016 opgenomen in de Regenboog in Zwijndrecht
- 24/12/2014 tem 23/01/2015 opgenomen Middelheim in Berchem
- 16/04/2015 tem 11/05/2015 opgenomen in Middelheim in Berchem
- 09/11/2015 tem 11/03/2016 opgenomen revalidatie in Gent
- 20/11/2015 tem 21/11/2015 opgenomen intensieve in Gent
- 23/11/2016 tem 08/12/2015 opgenomen intensieve in Gent
- 01/01/2016 tem 07/01/2016 opgenomen intensieve in Gent
- 25/02/2016 tem 20/02/2016 opgenomen intensieve in Gent
- 06/03/2016 tem 07/03/2016 opgenomen UZ Gent 24 uren EEG
- 17/05/2016 tem 03/06/2016 opgenomen Middelheim in Berchem
- 07/06/2016 tem HEEDN Nursing Hof Ter Scheide
- 06/09/2016 tem 23/09/2016 opgenomen Middelheim in Berchem
- 07/10/2016 tem 24/11/2016 opgenomen Middelheim in Berchem
- 18/01/2017 tem 22/02/2017 opgenomen Middelheim in Berchem
- 23/06/2017 tem 05/07/2017 opgenomen Middelheim in Berchem
- 12/03/2019 tem 19/03/2019 opgenomen Middelheim in Berchem
- Ambulant
- 07/01/2011 Ambulant Middelheim
- 31/01/2011 Dag hospitaal – Middelheim
- 25/05/2011 Ambulant Middelheim
- 28/09/2011 Ambulant Middelheim
- 17/10/2011 Neurologie UZA Edegem
- 18/10/2011 Dag hospitaal – Middelheim
- 09/05/2012 Ambulant Middelheim
- 29/08/2012 Ambulant Middelheim
- 02/10/2012 Kliniek Brasschaat
- 10/09/2012 Kliniek Brasschaat
- 01/12/2012 Ambulant Middelheim
- 16/12/2012 Ambulant Middelheim
- 22/12/2012 Ambulant Middelheim
- 02/02/2015 Ambulant Middelheim
- 25/08/2015 Ambulant Middelheim
- 18/02/2016 TANDARTS GENT 12 TANDEN VERZEGELD ONDER VOLLEDIGE NARCOSE
- 19/04/2016 Ambulant Middelheim
- 09/08/2016 Ambulant Middelheim
- 29/09/2016 Ambulant Middelheim
- 17/01/2017 Ambulant Middelheim
- 16/02/2017 Ambulant Middelheim
- 03/04/2017 Ambulant Middelheim
- 21/05/2017 Ambulant Middelheim
- 23/06/2017 Ambulant Middelheim
- 03/07/2017 Ambulant Middelheim
- 02/01/2018 Ambulant Middelheim
- 06/03/2018 Ambulant Middelheim
- 16/05/2018 Tandarts UZ Gent
- 24/08/2018 Sleep Middelheim
- 28/08/2018 Ambulant Middelheim
- 12/09/2018 Ambulant Gent
- 21/11/2018 Tandarts Gent
- 27/11/2018 Ambulant Middelheim
- 14/12/2018 pijnkliniek
- 28/11/2019 Outgarts Gent
CASE 2: RIGHT HEMIPLEGIC CVA (STROKE) AND DYSARTHRIA

- Male
- 72 year old
- Stroke in May 2018
- Joined TRAINM in September 2018

GOALS ACHIEVED – IN 5 MONTHS:

- Gait improved (10MWT speed improved 44%; 6MWT distance improved 82%; DGI improved 40%)
- Arm function improved (ARAT improved 475%, B&B was unable before and able after)

TREATMENT PROTOCOL

Functional training: 30 mins (2 sessions/week)

- Lokomat®
- G-EO1 system
- Tecnobody equipment

Upper-body training: 30-60 mins (3 sessions/week)

- Armeo®Power
- InMotion ARM™
- Tyro-motion®
CASE 2: RIGHT HEMIPLEGIC CVA (STROKE) AND DYSARTHRIA

**ACTION RESEARCH ARM TEST**

- Score: Week 1 = 4, Week 38 = 23
- Improvement: +475%

**10 METRE WALK TEST**

- Speed: Week 1 = 0.36 m/s, Week 38 = 0.64 m/s
- Improvement: -44%

**DYNAMIC GAIT INDEX**

- Score: Week 1 = 10, Week 38 = 14
- Improvement: +40%

**6 MINUTE WALK TEST**

- Score (Metres): Week 1 = 145, Week 38 = 263.2
- Improvement: +82%

**SPEED**

- Speed (Km/h): Week 1 = 1.7, Week 40 = 2.5
- Improvement: +35%

**BODY WEIGHT SUPPORT**

- Body Weight Support (Kg): Week 1 = 35, Week 40 = 22
- Improvement: -32%

**DISTANCE**

- Distance (Metres): Week 1 = 600, Week 40 = 1900
- Improvement: +219%

**DURATION**

- Duration (Minutes): Week 1 = 20, Week 40 = 45
- Improvement: +125%
CASE 3: TRAUMATIC BRAIN INJURY (TBI)

- Male
- 25 year old
- Accident at age of 19
- Joined TRAINM for over 2 years in 2017; at age 23

GOALS ACHIEVED:
- Able to lift his arm for first time since accident
- Can now independently drive a forklift again
- Walk independently w/o assistive devices

TREATMENT PROTOCOL

Functional training: 30 mins (2 sessions/week)
- Lokomat®
- G-EO1 system

Upper-body training: 30-60 mins (3 sessions/week)
- Armeo®Power
- InMotion ARM™
- Tyro-motion®
CASE 4: EX PREMATURE WITH GLOBAL DEVELOPMENT DELAY

GOALS ACHIEVED:
• Increased independent functional capacity
• Improved motor function

TREATMENT PROTOCOL

Functional training: 30 mins (2 sessions/week)
• Paediatric Lokomat®
• Bobath therapy
• Tecnobody – gym

• Female
• 5 year old
• Trains boot camp style
• Joined TRAINM for 1 week boot camp in 13/04/2019 – 20/04/2019
CASE 4: EX PREMATURE WITH GLOBAL DEVELOPMENT DELAY

**GROSS MOTOR FUNCTION (GMFM)**
- Score: Week 1 = 56.8, Week 2 = 52
- Improvement: +8.5%

**GUIDANCE FORCE**
- Force (%): Week 1 = 100, Week 14 = 50
- Reduction: -41%

**SPEED**
- Speed (km/h): Week 1 = 0.5, Week 14 = 1
- Improvement: +43%

**BODY WEIGHT SUPPORT**
- Weight (kg): Week 1 = 6, Week 14 = 2
- Reduction: -53%

**DISTANCE**
- Distance (metres): Week 1 = 600, Week 14 = 1300
- Increase: +115%

**DURATION**
- Duration (minutes): Week 1 = 32, Week 14 = 58
- Increase: +52%
CASE 5: ACQUIRED BRAIN INJURY (ABI)

- Female
- 61 year old
- Injury occurred on 30/11/2017
- Joined TRAINM in 2019; 2 years after

GOALS ACHIEVED –

- Improved sensation in hands
- Improved proprioception of shoulder and elbow
- Improved quality of gait

TREATMENT PROTOCOL

Functional training: 30 mins (2 sessions/week)

- Lokomat®
- G-EO1 system
- Tecnobody equipment

Upper-body training: 30-60 mins (3 sessions/week)

- Armeo®Power
- InMotion ARM™
- Tyro-motion®
CASE 5: ACQUIRED BRAIN INJURY (ABI)

 ACTION RESEARCH ARM TEST

 10 METRE WALK TEST

 DYNAMIC GAIT INDEX

 BOX & BLOCK TEST

 TRUNK IMPAIRMENT SCALE

 BERG BALANCE SCORE
CASE 6: TRAUMATIC BRAIN INJURY (TBI) – L HEMIPLEGIA

Female
18 year old
Injury occurred in 2014
Comes to TRAINM from France
Now completed 3rd boot camp since July 2018

GOALS ACHIEVED –
• Significant improvement in manual dexterity activities
• Improved accuracy and control in hand functioning

TREATMENT PROTOCOL

Functional training: 30 mins (2 sessions/week)
• Lokomat®

Upper-body training: 30-60 mins (3 sessions/week)
• Armeo®Power
• InMotion ARM™
• Tyro-motion®
## CASE 6: TRAUMATIC BRAIN INJURY (TBI) – L HEMIPLEGIA

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point to Point (x, y m)</strong></td>
<td><strong>Point to Point (x, y m)</strong></td>
</tr>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
<tr>
<td>Smoothness 0.507 Reach Error 0.009</td>
<td>Smoothness 0.565 Reach Error 0.009</td>
</tr>
<tr>
<td>Mean Vel 0.115 Max Vel 0.231</td>
<td>Mean Vel 0.100 Max Vel 0.178</td>
</tr>
<tr>
<td>Path Error 0.008 Init Time 0.005 s</td>
<td>Path Error 0.007 Init Time 0.012 s</td>
</tr>
<tr>
<td><strong>Circle (x, y m)</strong></td>
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<td><img src="image3.png" alt="Graph" /></td>
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<tr>
<td>Smoothness 0.093 Independence 0.793</td>
<td>Smoothness 0.021 Independence 0.894</td>
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</tr>
<tr>
<td><strong>Playback Static (x, y m)</strong></td>
<td><strong>Playback Static (x, y m)</strong></td>
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<td><img src="image5.png" alt="Graph" /></td>
<td><img src="image6.png" alt="Graph" /></td>
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<tr>
<td><strong>Round Dynamic (x, y m)</strong></td>
<td><strong>Round Dynamic (x, y m)</strong></td>
</tr>
<tr>
<td><img src="image7.png" alt="Graph" /></td>
<td><img src="image8.png" alt="Graph" /></td>
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</tbody>
</table>
CASE 6: TRAUMATIC BRAIN INJURY (TBI) – L HEMIPLEGIA

10 METER WALK TEST

- Week 32 compared to Week 1:
  - Speed: +16.6%

DYNAMIC GAIT INDEX

- Week 32 compared to Week 1:
  - Score: +50%

6 MINUTE WALK TEST

- Week 32 compared to Week 1:
  - Score: +20.1%

BOX & BLOCKS TEST

- Week 32 compared to Week 1:
  - Score: +17.1%

9 HOLE PEG TEST

- Week 32 compared to Week 1:
  - Speed: +21.4%

BODY WEIGHT SUPPORT

- Week 32 compared to Week 1:
  - Body Weight Support: -20%

DISTANCE

- Week 32 compared to Week 1:
  - Distance: +62%

DURATION

- Week 32 compared to Week 1:
  - Duration: +42%
CASE 7: C5 INCOMPLETE LESION (SCI)

- Male
- 55 year old
- Accident occurred in 2013
- Now completed 3\textsuperscript{rd} boot camp since July 2018

**GOALS ACHIEVED**

- Before TRAINM could not complete 10MWT or BBS but after first evaluation with TRAINM was able to complete with positive outcomes

**TREATMENT PROTOCOL**

**Functional training: 30 mins (2 sessions/week)**

- Lokomat\textsuperscript{®}
- Walker-view
- Tecnobody equipment/gym

**Upper-body training: 30-60 mins (3 sessions/week)**

- Armeo\textsuperscript{®}Power
- Tyro-motion\textsuperscript{®}
CASE 7: C5 INCOMPLETE LESION (SCI)

**ACTION RESEARCH ARM TEST**
- Week 1: 41
- Week 22: 48
- Improvement: +17%

**TRUNK IMPAIRMENT SCALE**
- Week 1: 8
- Week 22: 16
- Improvement: +100%

**BOX & BLOCKS TEST**
- Week 1: 34
- Week 22: 41
- Improvement: +21%

**SPEED**
- Week 1: 1.7
- Week 27: 2.5
- Improvement: +32%

**DISTANCE**
- Week 1: 850
- Week 27: 1150
- Improvement: +34%

**BODY WEIGHT SUPPORT**
- Week 1: 32
- Week 27: 30
- Improvement: -18%

**GUIDANCE FORCE**
- Week 1: 102
- Week 27: 93
- Improvement: -7%
CASE 8: STROKE (L) AND ATAXIA

- Male
- 56 year old
- Dutch
- Intense treatment program for 1 month

GOALS ACHIEVED – 4 WEEKS
- Increased ROM (1D,2D and 3D)
- Increased movement coordination
- Increased grasping function
- Continuous change in goals with increasing functionality and complexity

TREATMENT PROTOCOL

Functional training: 30 mins (5-6 sessions/week)
- Lokomat®
- Walker-view
- Tecnobody equipment/gym
- G-EO1 system

Other treatment: 2 sessions/week
- Neuromodulation
CASE 8: STROKE (L) AND ATAXIA

**SPEED**
- Week 1: 2 km/h
- Week 11: 2.4 km/h
- Increase: +16%

**DISTANCE**
- Week 1: 1000 metres
- Week 11: 2000 metres
- Increase: +99%

**BODY WEIGHT SUPPORT**
- Week 1: 40 kg
- Week 11: 25 kg
- Decrease: -36%

**DURATION**
- Week 1: 30 minutes
- Week 11: 52 minutes
- Increase: +71%
**CASE 9: CEREBRAL PALSY – DIPLEGIC WITH BILATERAL AFOS (ANKLE-FOOT ORTHOSES)**

- Female
- 6 year old
- At TRAINM for only 7 months

---

**GOALS ACHIEVED –**

- Stand independently
- Improved posture and stance
- Less muscle tension

---

**TREATMENT PROTOCOL**

- Functional training: 30 mins (2-3 sessions/week)
  - Paediatric Lokomat®
  - Tecnobody equipment/gym
CASE 9: CEREBRAL PALSY – DIPLEGIC WITH BILATERAL AFOS (ANKLE-FOOT ORTHOSES)

**Body Weight Support**
- **Week 1: 12 KG**
- **Week 30: 1 KG**
- **Decrease: 87%**

**Duration**
- **Week 1: 19 MIN**
- **Week 30: 45 MIN**
- **Increase: 148%**

**Speed**
- **Week 1: 1 KM/H**
- **Week 30: 1.5 KM/H**
- **Increase: 49%**

**Distance**
- **Week 1: 300 METRES**
- **Week 30: 1150 METRES**
- **Increase: 262%**
INTERNATIONAL PATIENTS
BOOTCAMP
CASE STUDIES
### INTERNATIONAL CASE 1: VASILEIOS PROVOPOLOUS

**GOALS ACHIEVED – SINCE START OF TRAINM**
- Building up muscle tone in the upper & lower extremity
- Improve fine motor skills – hand
- Improve balance & coordination

**TREATMENT PROTOCOL**

**Functional training:**
- Gym using D-Wall
  1 hour/day (6 sessions/week for a month)
- Lokomat® Paediatric
  2 hour/day (6 sessions/week for a month)

**Upper-body training:** 60 mins (3 sessions/week for a month)
- Armeo®Power
- InMotion ARM™
- Tyro-motion®

- Male
- DOB: 12/11/2008
- Cavernous hemangioma in lower pons (19/05/19)
- Came to complete boot camp training TRAINM from Greece
**INTERNATIONAL CASE 2: CHARLOTTE O’REILLY**

- Female
- 18 year old
- Traumatic brain injury occurred in 2014
- Comes to TRAINM from France
- Now completed 3\textsuperscript{rd} boot camp since July 2018

**GOALS ACHIEVED –**

- Independent walking
- Able to use upper extremity pain free
- Decrease lower back pain

**TREATMENT PROTOCOL**

**Functional training:**
60 mins each (2 sessions/day for 2 weeks)

- Lokomat\textsuperscript{®}
- Gym using D-Wall
- GEO
- Walker-view

**Upper-body training:**
60 mins (2 sessions/day for 2 weeks)

- Armeo\textsuperscript{®}Power
- InMotion ARM\textsuperscript{™}
- Tyro-motion\textsuperscript{®}
INTERNATIONAL CASE 2: CHARLOTTE O’REILLY

**TRUNK IMPAIRMENT SCALE**

Week 0: 15
Week 2: 20
 Increase: +33%

**ACTION RESEARCH ARM TEST**

Week 0: 48
Week 2: 57
 Increase: +18.8%

**DYNAMIC GAIT INDEX**

Week 0: 16
Week 2: 22
 Increase: +37.5%

**10 METRE WALK TEST**

Week 0: 0.025
Week 2: 0.03
 Increase: +20%

**6 METRE WALK TEST**

Week 0: 358
Week 2: 370
 Increase: +3.4%
INTERNATIONAL CASE 2: CHARLOTTE O’REILLY

**Before**

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</tbody>
</table>

- Smoothness 0.507
- Reach Error 0.009
- Circle Size 0.093
- Independence 0.793
- Mean Vel 0.115
- Max Vel 0.231
- Path Error 0.008
- Init Time 0.005 s

**After**

<table>
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<tr>
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</table>

- Smoothness 0.565
- Reach Error 0.009
- Circle Size 0.021
- Independence 0.894
- Mean Vel 0.100
- Max Vel 0.178
- Path Error 0.007
- Init Time 0.012 s
Thank You