

WE MOVE YOU



**LOKOMAT
THERAPY IS
BACKED UP
BY NEARLY
20 YEARS OF
CLINICAL
RESEARCH!**



SUMMM

- 1** The Lokomat is the best investigated device in robot assisted gait rehabilitation today.
- 2** Research shows that Lokomat training can be safely and effectively conducted in many populations.
- 3** With Lokomat training, you can challenge patients of all functional levels.
- 4** A very high quality systematic review proves that every seventh walking dependency could be prevented with electromechanically assisted gait training.
- 5** Fifty-eight randomized controlled trials report superior results for the Lokomat compared to other gait training methods.
- 6** Lokomat assessments are valid and reliable.
- 7** Augmented Performance Feedback leads to increased patient participation.
- 8** The Lokomat allows for increased training intensity at all functional levels, which leads to improved outcomes.
- 9** Lokomat training is an efficient way to treat patients.



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- 10** Exoskeleton devices have clear advantages over end-effector devices.
- 11** Recommendations and Guidelines
- 12** The Hocoma Knowledge Platform: Find all available literature in one place!



1

THE LOKOMAT IS THE BEST INVESTIGATED DEVICE IN ROBOT ASSISTED GAIT REHABILITATION TODAY



PEER-REVIEWED JOURNAL ARTICLES

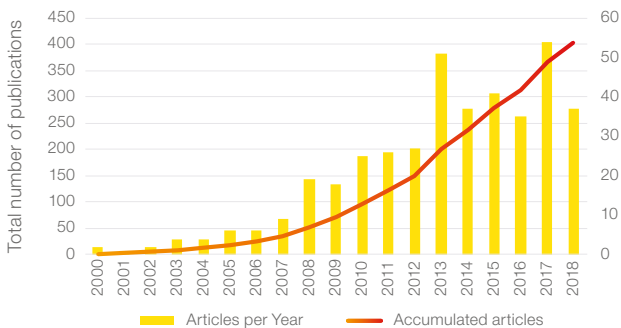
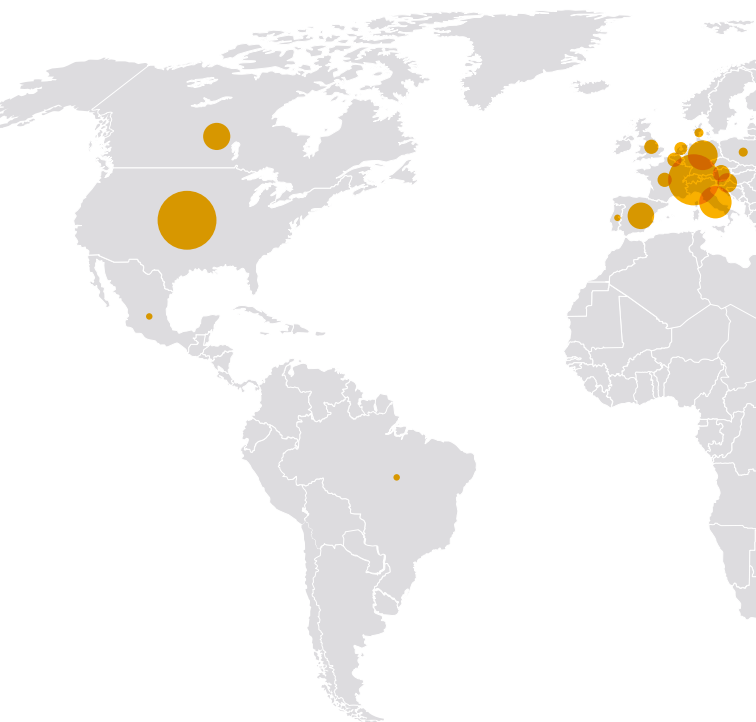


Figure 1 The interest of the research community in the Lokomat is remarkable and still growing.

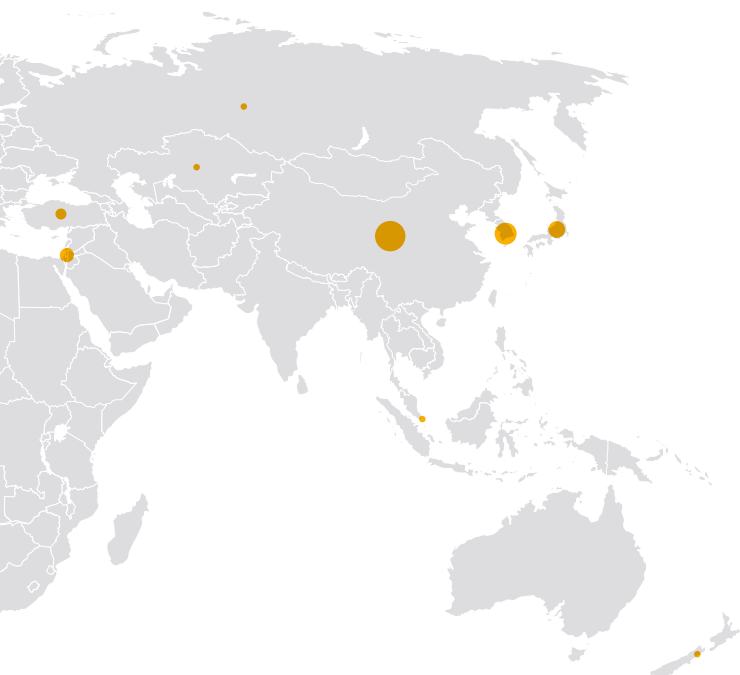


Today, 404 research articles from independent research groups all over the world that include the Lokomat have been published in peer-reviewed journals (as of December 2018). These journals include such high-ranking ones as Brain [1-3], Stroke [4], Multiple Sclerosis [5, 6], Neurorehabilitation and Neural Repair [7, 8], and Archives of Physical Medicine and Rehabilitation [9].

Figure 2 The Lokomat research community is found in many parts of the world. In addition to the single-country studies, there are 31 published papers from international collaborations.



These studies include 88 randomized controlled trials (RCTs), 82 reviews, 70 observational studies, non-randomized controlled trials and case series, 24 single-case studies, numerous cross-sectional studies and several technical papers. The 88 RCTs alone have included a total of over 3600 participants, of which exactly 2000 received Lokomat training during the study!



2

RESEARCH SHOWS THAT LOKOMAT TRAINING CAN BE SAFELY AND EFFECTIVELY CONDUCTED IN MANY POPULATIONS



The Lokomat is intended to assist with gait training of people with gait deficits, regardless of the origin of their disabilities. Studies have therefore also been conducted in many different populations:

- Individuals with spinal cord injuries [8-13]
- Individuals with traumatic brain injuries [14-17]
- Individuals with non-traumatic brain injuries (including stroke) [4, 18-22]. More specifically, Lokomat training has also been found safe and effective in those with stroke and latero-pulsion tendency (pusher behavior) [23-25].
- Children and adults with cerebral palsy [26-31]
- Individuals with Parkinson's disease [32-36]
- Individuals with multiple sclerosis [5, 37-41]
- Individuals with Guillain-Barré syndrome [42-48]
- Individuals post-surgery (meniscus tear, total knee arthroplasty and lumbar discectomy) [49-51]

In addition to the above listed patient populations, which have been treated in line with the intended use of the Lokomat, two studies also trained a group of individuals with heart failure and a group of patients early post cardiac surgery [52, 53]. No adverse events occurred during either of those studies.

3

**WITH LOKOMAT
TRAINING,
YOU CAN
CHALLENGE
PATIENTS
OF ALL
FUNCTIONAL
LEVELS**



The Lokomat provides a safe and permissive environment in which people can train walking even if they are very severely injured or have experienced an injury just recently. Even in individuals with complete spinal cord injury, who have very little to no control over their lower limbs, Lokomat training can lead to neuroplastic changes and secondary benefits such as regulation of bowel and bladder function [54]. On the other end of the spectrum, patients who have already regained considerable walking ability can still be adequately challenged with Lokomat training. For example, using the robot to provide resistance in different gait phases leads to considerable improvements of muscle activation during walking, and cortical plasticity [10, 55-61].

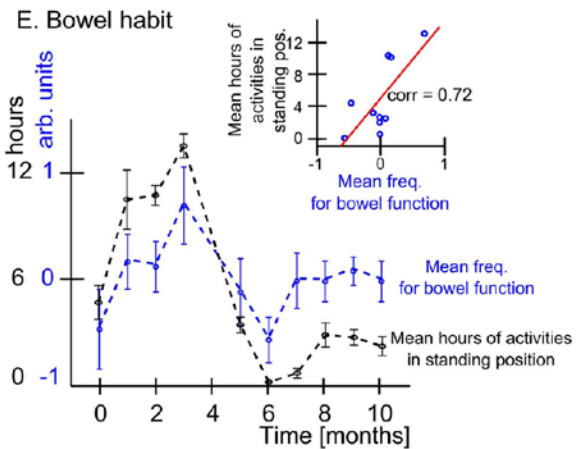


Figure 3 Bowel function was directly related to the intensity of training in 8 patients with chronic complete spinal cord injury (from Donati et al 2016, <https://www.nature.com/articles/srep30383> [54]; copyright, licensed under creative commons license 4.0 <https://creativecommons.org/licenses/by/4.0/legalcode>).

4 **A VERY HIGH QUALITY SYSTEMATIC REVIEW PROVES THAT EVERY SEVENTH WALKING DEPENDENCY COULD BE PREVENTED WITH ELECTRO- MECHANICALLY ASSISTED GAIT TRAINING**

This review [62] included 36 randomized controlled trials involving a total of 1472 patients training on twelve different electromechanical gait trainers. Seventeen of these studies (involving 649 patients) investigated the Lokomat!

The study shows that every seventh walking dependency could be prevented if all patients received electromechanically assisted gait training in addition to their regular therapy! Being able to walk independently is one of the most important goals for many individuals who have suffered from a stroke [63], and reducing the number of people who need assistance would considerably reduce costs of long-term care!

This review also shows that the treatment effect is particularly striking for patients who were more severely impaired at the beginning of the study and those who were treated within the first three months after their stroke!

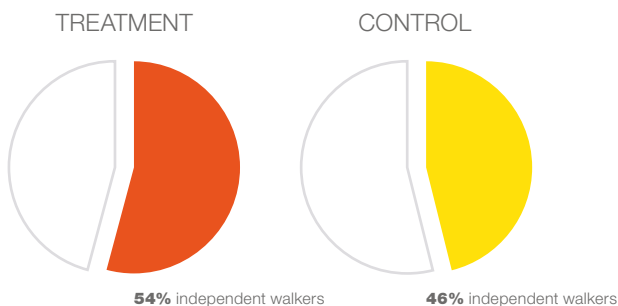


Figure 4 When patients receive electromechanical gait training in addition to their regular therapy, 54% become independent walkers compared to 46% of those who receive traditional gait therapy alone (data from 1472 patients was available for this analysis).

5

**FIFTY-EIGHT
RANDOMIZED
CONTROLLED
TRIALS REPORT
SUPERIOR
RESULTS FOR
THE LOKOMAT
COMPARED
TO OTHER
GAIT TRAINING
METHODS!**

Beyond question, most of the RCTs comparing the effectiveness of Lokomat training to other gait training approaches have found and defined clear advantages for Lokomat training (for example see [4, 8, 9, 24, 30, 64, 65]).

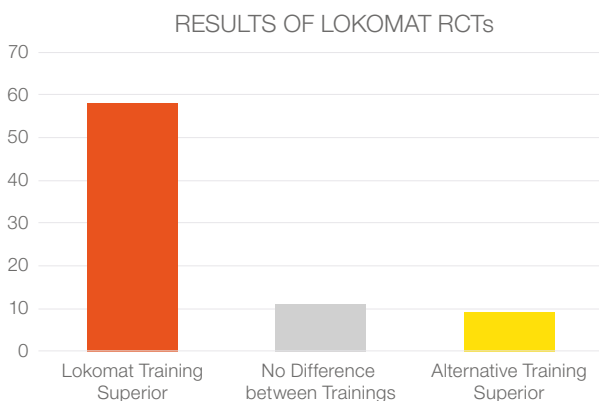


Figure 5 Most RCTs that compare Lokomat training to another form of gait training found advantages for Lokomat training. There are also a number of studies that found that at matched training intensities, the different treatment options were equal. Only very few studies found advantages uniquely for the alternative training method tested (9 papers, of which 4 stem from the same project/data). In those with advantages uniquely for alternative training methods, in general patients already able to walk were included and more assist than necessary was provided (100% guidance force), likely leading to insufficient patient challenge.

The advantages of Lokomat training are far reaching. Specifically, researchers confirmed that Lokomat training compared to other gait training methods leads to superior results in the following important factors:



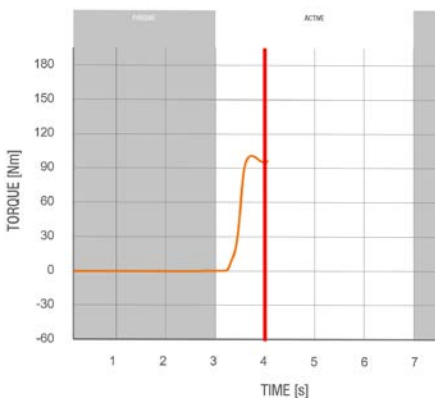
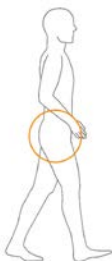
- **walking ability and walking independence**
[8, 11, 22, 27, 64, 66-68].
- **walking speed**
[11, 69, 70].
- **walking endurance**
[8, 9, 11, 22, 37, 38].
- **spatiotemporal and biomechanical parameters such as step length and symmetry**
[4, 15, 27, 39, 71, 72],
hip function [39, 73]
or others [69]
- **balance**
[5, 26, 31, 38, 67, 71]
- **muscle tone regulation and spasticity reduction**
[12, 27, 73-76]
- **lower extremity muscle strength**
[9, 37]
- **cardiovascular effects**
[7, 77]
- **body composition**
[4, 73]
- **quality of life**
[5]

6

LOKOMAT ASSESSMENTS ARE VALID AND RELIABLE

ASSESSMENT: L-FORCE

HIP LEFT FLEXION

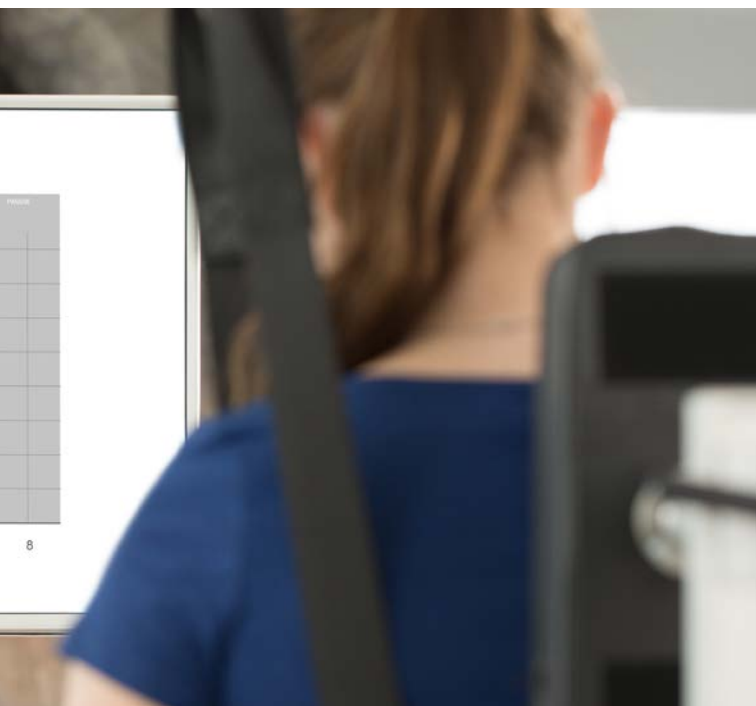


The Lokomat offers the possibility of measuring patient performance in an objective, valid and reliable way in order to document the effect of the training [78].

The L FORCE assessment measures isometric muscle strength and has been shown to have good inter-, and intra-rater reliability [46] and is sensitive to change over time [79].

The L STIFF assessment, measuring resistance to passive movement, has been shown to agree with clinical spasticity measurements (Modified Ashworth Scale) [80, 81] and is feasible, objective and reliable [82].

The Lokomat has been further used to measure proprioceptive abilities by several authors [83, 84]



7 AUGMENTED PERFORMANCE FEEDBACK LEADS TO INCREASED PATIENT PARTICIPATION



Figure 6 BBS: Berg Balance Scale, TUG, Timed up and Go. Individuals either trained with the LokomatNanos (no augmented performance feedback) or the LokomatPro (with augmented performance feedback).

The goal of Lokomat gait therapy is to support the patient as much as needed, but as little as possible. Patient activation is of utmost importance in order to induce neuroplasticity. Many studies have shown that when using the LokomatPro with Augmented Performance Feedback, patient motivation and active participation in terms of muscle activation, cardiovascular exertion or cortex activation can be considerably increased [28, 85-91].

Training with the LokomatPro and Augmented Performance Feedback lead to better therapy adherence, more walking time and higher distances walked during each session [92] compared to regular Lokomat training. In a group of patients with Multiple Sclerosis, adding Augmented Performance Feedback to the Lokomat training lead to a more positive attitude [41] and at least a trend to more improvements in balance [18, 41], more improvements in gait speed [18] and more cognitive improvement (problem solving) [41]. For illustrations see next pages.

Conclusion:

“VR may strengthen RAGT thanks to the entrainment of different brain areas involved in motor planning and learning.”

Calabro 2017

8 **THE LOKOMAT ALLOWS FOR INCREASED TRAINING INTENSITY AT ALL FUNCTIONAL LEVELS, WHICH LEADS TO IMPROVED OUTCOMES**

It is generally accepted that training intensity is a crucial factor in rehabilitation, with more intensive training paradigms leading to superior outcomes [93-98].

One of the great advantages of the Lokomat when compared to other gait training methods is that the intensity of training can be increased considerably. Studies have confirmed that this increase

in Lokomat training intensity is also associated with better patient outcomes [99, 100]. Hereby, even in very chronic stages of the injury, plasticity can be induced with an intensive training protocol [54, 101]. A systematic review investigating electromechanically assisted gait training found that studies with more intense interventions achieved better results than those with less intense interventions [102].

Researchers have also shown that the Lokomat can be successfully used to optimally challenge patients at a higher level by providing resistance during walking [10, 56-61].

Further studies investigating a dose-effect relationship are currently ongoing (clinicaltrials.org).

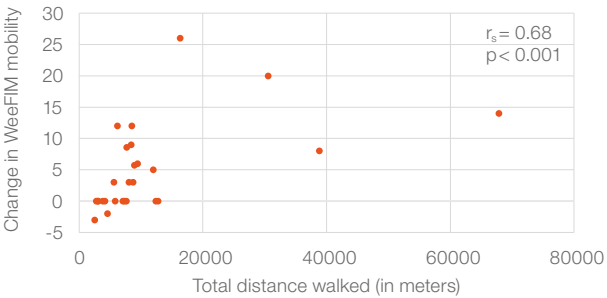


Figure 9 There is a positive correlation between the total distance walked with the Lokomat and the improvement in walking independence in children with cerebral palsy (GMFCS level III and IV). Unpublished data, with permission from PD Dr. Hubertus van Hedel, Rehabilitation Center for Children and Adolescents, Affoltern am Albis, Switzerland.

LOKOMAT TRAINING IS AN EFFICIENT WAY TO TREAT PATIENTS!

Studies have reported that Lokomat training has led to reduced staffing costs and that less manual effort from therapists was required while simultaneously increasing therapy intensity for the patients [15, 103]. An example from a well-established rehabilitation hospital in the USA shows that the time to break-even after the purchase of a Lokomat is around two years and that the Lokomat is more financially efficient than manual therapy in their setting after 2-3 years [104].



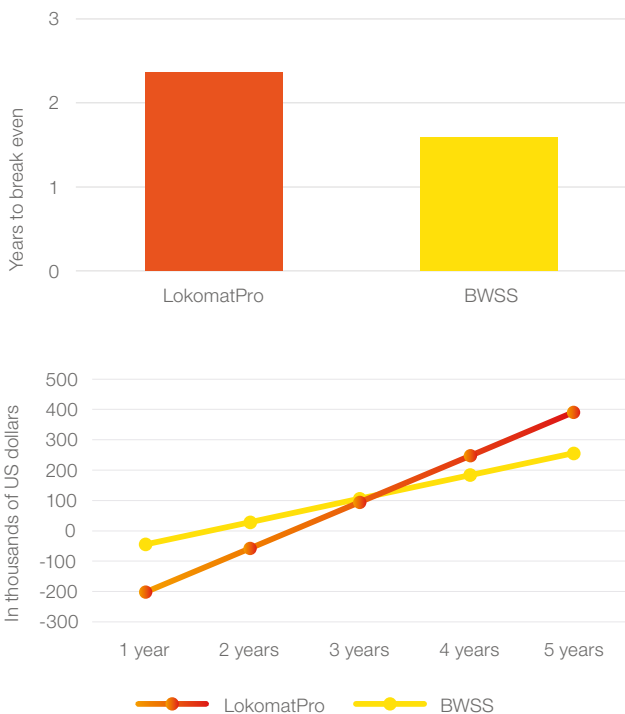


Figure 10

A) Time to break-even is only slightly longer for a LokomatPro than for a commercially available body weight support system for manual locomotor training on a treadmill.

B) After three years of consistently reduced staff requirements, the LokomatPro started to provide a higher return on investment than the body weight support system for this institution. Data from Morrison [104].



10 **EXOSKELETON DEVICES HAVE CLEAR ADVANTAGES OVER END- EFFECTOR DEVICES**

Discussions over the advantages of end effector and exoskeleton devices in the literature are usually based on a review published in 2012. At the time of this review, no study had been published that directly compared the two device types and the authors were forced to draw conclusions from secondary analysis of very heterogeneous studies. They concluded that their method may have introduced considerable bias [105].

In the meantime, several authors have directly compared end effector devices to exoskeletons and found that gait patterns are more symmetrical [106] and potentially safer [107] while walking in an exoskeleton, that the use of the FreeD further normalizes the gait pattern [106] and that individuals with traumatic brain injury training with the Lokomat improved their gait velocity more than those training with an end-effector [108]. Training with the Lokomat uses less human resources than training with an end-effector device [14]. A European multicenter study comparing the Lokomat to an end-effector device has been stopped in 2015 because the end effector was not considered state of the art anymore by the investigators (www.strokecenter.org).

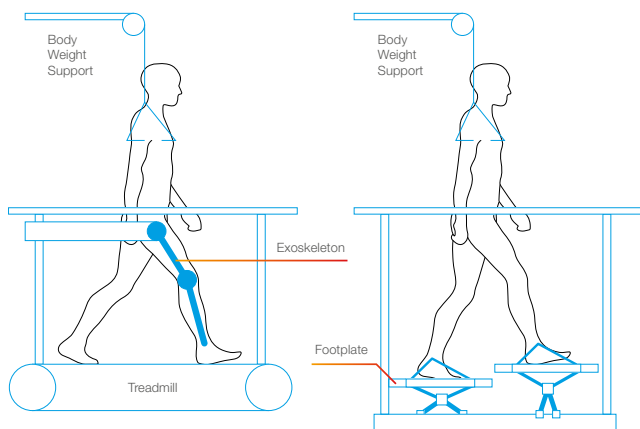


Figure 11 An electromechanically assisted gait trainer of the exoskeleton type is attached to the whole lower extremity of the patient, allowing control over knees and hips. This leads to increased safety and training possibilities. An electromechanically assisted gait trainer of the end-effector type is attached to the feet of the patients, not allowing to control knee or hip joints. Therapists have to manually assist at those joints to assure safety in patients unable to control their joints appropriately.

11 **RECOMMEN- DATIONS AND GUIDELINES**

The American Heart and Stroke Association recommends the use of robot assisted gait training in combination with conventional therapy for rehabilitation after stroke. These guidelines also conclude that combining training with virtual reality has a positive effect on patients [109]. The Australian Clinical Guidelines for Stroke Management also recommend electromechanically assisted gait training after stroke[110].

For children with cerebral palsy, all the available research has been combined into recommendations on how to use the Lokomat in everyday clinical practice in order to produce the best results for these children [111]. A summary of these guidelines can be found on the Hocoma Knowledge Platform (<http://knowledge.hocoma.com/research/lokomat/html>).



THE HOCOMA KNOWLEDGE PLATFORM: FIND ALL AVAILABLE LITERATURE IN ONE PLACE



PRODUCTS

CLINICAL PRACTICE

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Device 1



Study Design



Pathology

Author

Title

Dundar U., Toktas H., Solak
O., Ulasli A.M., Eroglu S.

A Comparative Study of Conventional Physiotherapy
Combined with Physiotherapy in Patients with
Top Stroke Rehabil.21; (6):453-61

Esclarin-Ruz A.,
Alcobendas-Maestro M.,
Casado-Lopez R., Perez-
Mateos G., Florido-
Sanchez M.A., Gonzalez-
Valdizan E., Martin J.L.

A Comparison of Robotic Walking Therapy in
Individuals with Upper Versus Lower Motor Neuron Lesions:
A Controlled Trial
Arch Phys Med Rehabil.95; (6):1023-31

Zimmerli L., Jacky M.,
Lunenburger L., Riener R.,
Bollmann M.

Increasing Patient Engagement During Virtual Reality-Based
Arch Phys Med Rehabil.94; (9):1737-46

A full overview of all papers published on the Lokomat as well as a lot of other interesting information can be found on the Hocoma Knowledge Platform (<http://knowledge.hocoma.com/research/lokomat.html>).

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siotherapy Versus Robotic Training with Stroke	Journal Article	2014
y and Conventional Walking Therapy in r Neuron Lesions: A Randomized	Journal Article	2014
tual Reality-Based Motor Rehabilitation	Journal Article	2013

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CURRENT RESEARCH FOCUS:

Hocoma would like to thank all their research partners and the many researchers who independently showed interest and studied our devices for their hard work and dedication. Together, we're pushing the field forward and improving therapy for our patients!

Hocoma, along with our partners, currently focuses on the following research topics:

- What are the economic advantages of our devices? How can we increase the efficiency of delivering therapy with Hocoma devices? We join forces with research-experienced clinical partners who are interested in collaborating with health economists on this topic.
- What is the real advantage of Augmented Performance Feedback? We join forces with research-experienced clinical partners who are interested in investigating the effects of using Augmented Performance Feedback in a longitudinal study.
- What are the additional benefits of training with the Lokomat FreeD or with the path control software? We are looking for research-experienced clinical partners who are interested in investigating the effects of those new Lokomat features.

If you have clinical expertise and a good idea on how to highlight the clinical potential of the Lokomat in a research project, please fill in the collaboration request at <https://www.hocoma.com/services/clinical-research/>.

If you have engineering expertise and want to contribute to the technical innovation of the Lokomat, please contact us at info@hocoma.com with the keyword "Technical innovation" in the subject line.

INTENSITY = REPETITION × EFFORT

This is what drives us at Hocoma: a strong motivation to help people with technologies and ideas that look at functional movement therapy from a **completely new perspective**. Because these technologies enable people to exercise **intensively**. Because they maximize **motivation**. Because they encourage patients to make possible what they've been told was impossible.

We improve the lives of millions by providing functional and efficient solutions that set new standards in the field of human movement therapy.

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