INTRODUCING ReStore™

The ReStore Soft Exo-Suit
A Revolution in Post-Stroke Gait Training

Functional
The ReStore soft design combines natural movements with plantar-flexion and dorsiflexion assistance that adaptively synchronize with the patient's own gait to facilitate functional gait training.

Versatile
Individualized assistance and compatibility with supplemental support aids ensure that ReStore has broad applications for patients across the gait rehabilitation spectrum.

Data-Driven
Real time feedback and adjustable levels of assistance enable the therapist to optimize sessions and track each patient's progress.

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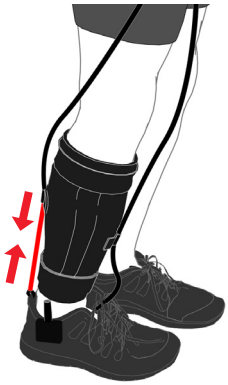
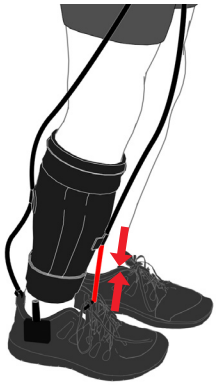
Clinicians:
Scan QR code or Click Here to learn more about the ReStore Exo-Suit

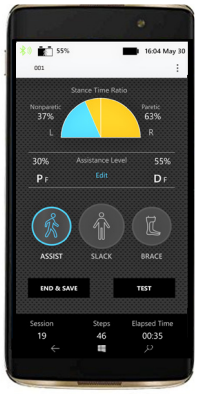
ReWalk® Robotics

ReStore How Does ReStore Work?



Sensors on each foot detect gait events and synchronize timing of assistance





Posterior cable contracts to provide PF assistance for **forward propulsion**

Anterior cable contracts to provide DF assistance for **ground clearance**

Slack and Brace modes enable additional gait training capabilities

ReStore App provides real time feedback and session control to optimize results

Seamless integration with a wide array of functional gait training activities within your clinic

To learn more, visit us at www.rewalk.com or contact us at www.rewalk.com/contact
ReWalk Robotics • 200 Donald Lynch Boulevard, Marlborough, MA 01752

Exo-Suit Published Research Summary

		Walking Speed	Walking Distance	Propulsion Symmetry	Reduced Compensations	Stride Length	Metabolic Effort	Ground Clearance	Paretic Ankle Power	Muscle Activation	Device Safety	User Satisfaction
Awad et al. (2020a)	Awad, Louis N., et al. "The ReWalk ReStore™ soft robotic exosuit: a multi-site clinical trial of the safety, reliability, and feasibility of exosuit-augmented post-stroke gait rehabilitation." *Journal of neuroengineering and rehabilitation* 17.1 (2020): 1-11.	✓									✓	✓
Awad et al. (2020b)	Awad, Louis N., et al. "These legs were made for propulsion: advancing the diagnosis and treatment of post-stroke propulsion deficits." *Journal of NeuroEngineering and Rehabilitation* 17.1 (2020): 1-16.	✓	✓	✓	✓		✓				✓	
Awad et al. (2020c)	Awad, Louis N., et al. "Walking faster and farther with a soft robotic exosuit: Implications for post-stroke gait assistance and rehabilitation." *IEEE Open Journal of Engineering in Medicine and Biology* 1 (2020): 108-115.	✓	✓									
Porciuncula et al. (2019)	Porcuincula et al. "Soft Robotic Exosuits for Targeted Gait Rehabilitation After Stroke: A Case Study" American Society of Neurorehabilitation conference 2019.	✓	✓	✓		✓			✓			
Sloot et al. (2018)	Sloot, L., et al. "O 089-A soft robotic exosuit assisting the paretic ankle in patients post-stroke: Effect on muscle activation during overground walking." Gait & posture (2018).							✓	✓	✓		
Awad et al. (2017a)	Awad, Louis N., et al. "A soft robotic exosuit improves walking in patients after stroke." Science translational medicine 9.400 (2017): eaai9084.			✓			✓	✓	✓			
Awad et al. (2017b)	Awad, Louis N., et al. "Reducing Circumduction and Hip Hiking During Hemiparetic Walking Through Targeted Assistance of the Paretic Limb [3] Using a Soft Robotic Exosuit." American journal of physical medicine & rehabilitation 96.10 (2017): S157-S164.				✓							

Awad et al. (2020a)

The ReWalk ReStore™ soft robotic exosuit: a multi-site clinical trial of the safety, reliability, and feasibility of exosuit-augmented post-stroke gait rehabilitation

Louis N Awad, Alberto Esquenazi, Gerard E Francisco, Karen J Nolan, Arun Jayaraman

SUMMARY

The aim of this multi-site clinical trial was to determine the safety, reliability, and feasibility of using the ReStore exosuit during post-stroke rehab. 44 users presenting with hemiparesis following a stroke completed 5 days of training with the ReStore, with walking assessments performed prior to and following the training series. Each session with the ReStore device was comprised of up to 20 minutes of treadmill walking and up to 20 minutes of overground walking. The primary endpoint was assessed as the frequency of device-related adverse events during the study (including device-related serious adverse events and falls); Secondary endpoints of clinician safety and device reliability were assessed as the frequency of device-related injuries experienced by physical therapists during the study and device malfunctions during device usage, respectively. There were no device-related falls or serious adverse events reported. A low rate of device malfunctions was reported by clinician-operators. Following the 5 sessions of walking practice with the ReStore exosuit, study participants increased both their device-assisted and unassisted maximum walking speeds. The authors concluded that the ReStore exosuit is safe and reliable for use during gait training on a treadmill and overground in post-stroke rehabilitation.

PMID: 32552775 DOI: 10.1186/s12984-020-00702-5

Awad et al. (2020b)

These legs were made for propulsion: advancing the diagnosis and treatment of post-stroke propulsion deficits

Louis N Awad, Michael D Lewek, Trisha M Kesar, Jason R Franz, Mark G Bowden

SUMMARY

This review was conducted to analyze the relationship between post-stroke propulsion and walking ability. The authors discuss research on propulsion-targeting interventions and technologies, and highlight paretic propulsion as a key determinant of post-stroke walking function. In this review, the authors present the biomechanical and functional consequences of post-stroke propulsion deficits, review advances in understanding of the nature of post-stroke propulsion impairment, and discuss emerging diagnostic and treatment approaches that have the potential for improving rehabilitation paradigms for addressing paretic propulsion, including a discussion of the ReStore Exo-suit. The authors conclude that post-stroke propulsion deficits are diverse, current diagnostic and treatment paradigms do not adequately address these deficits, and that emerging clinical and technological advances have shown substantial promise to help reshape the management of post-stroke propulsion deficits. The authors suggest that future work in this area will lead to development of a new rehabilitation paradigm favoring a propulsion-restorative approach over one based on compensatory recovery.

PMID: 33087137 DOI: 10.1186/s12984-020-00747-6

Awad et al. (2020c)

Walking Faster and Farther With a Soft Robotic Exosuit: Implications for Post-Stroke Gait Assistance and Rehabilitation

Louis N. Awad, Pawel Kudzia, Dheepak Arumukhom Revi, Terry D. Ellis, Conor J. Walsh

SUMMARY

This article evaluates the effects on mechanics and energetics of walking after stroke when using a soft robotic exosuit. Six individuals aged 40-60y in the chronic phase of stroke (3-5y post-stroke) were included in this study. Assessments on day 1 included 10-meter and 6-minute walk tests both without the exosuit worn and with the exosuit worn but powered off. Day 2 included the same assessments with the unpowered exosuit, as well as with the suit set to provide assistance during dorsiflexion and plantarflexion phases of the gait cycle. A comparison of the unworn exosuit condition with the worn-but-unpowered condition yielded no significant changes in participants' walking speed, distance, or energy expenditure, despite the additional weight of the <5kg exosuit. In contrast, study participants walked a median 0.14 ± 0.06 m/s faster during the 10-meter walk test and traveled 32 ± 8 m farther during the six minute walk test with the suit powered on, compared with the unworn condition. The authors concluded that individuals post-stroke can achieve clinically meaningful increases in speed and distance when using the soft exosuit to provide both dorsiflexion and plantarflexion assistance.

Electronic ISSN: 2644-1276 DOI: 10.1109/OJEMB.2020.2984429

Porciuncula et al. (2019)

Soft Robotic Exosuits for Targeted Gait Rehabilitation After Stroke: A Case Study

Franchino Porciuncula, Teresa C. Baker, Dheepak Arumukhom Revi, Jaehyun Bae, Regina Sloutsky, Lauren Baker, Terry Ellis, Conor J. Walsh, Louis N. Awad

SUMMARY

This case study is the first comparison study examining the therapeutic effects of exosuit-augmented gait training versus conventional gait training with an individual post-stroke. The study participant, a 58 year-old male with chronic (54 mo) left-sided hemiparesis resulting from stroke, participated in two bouts of gait-training intervention. Each intervention consisted of six sessions of training provided over a 2-week period, with a 7-week washout period separating the two bouts. For both interventions, a physical therapist provided progressive, task specific, high intensity gait training with an emphasis on walking speed. Outcomes were assessed via the 10-Meter Walk Test, 6-Minute Walk Test, and biomechanical analyses performed without the exosuit before and after each intervention. Exosuit-augmented gait training produced clinically meaningful changes in fast walking speed and walking distance, as well as increased paretic ankle angle at push-off, stride length, paretic ankle plantarflexion moment, and paretic propulsion. Alternately, training without the exosuit resulted in only modest increases in fast walking speed and walking distance, and failed to demonstrate changes in ankle angle at push-off, stride length, and ankle plantarflexion moment – and produced a reduction in forward propulsion. The authors conclude that these these results demonstrate that exosuit-augmented gait

training uniquely retrains a propulsion-based walking strategy that is not observed after gait training without an exosuit.

Link to Abstract

Sloot et al. (2018)

A soft robotic exosuit assisting the paretic ankle in patients post-stroke: Effect on muscle activation during overground walking.

Lizeth H. Sloot, Jaehyun Bae, Lauren Baker, Kathleen O'Donnell, Nicolas Menard, Franchino Porciuncula, Dabin Choe, Terry Ellis, Louis N. Awad, Conor J. Walsh

SUMMARY

This study analyzes muscle activation and gait mechanics during walking with and without a soft exosuit for individuals with stroke. The researchers recorded EMG of bilateral tibialis anterior, gastrocnemius and soleus muscles of 8 hemiparetic individuals. Exosuit assistance produced an 8% increase in paretic propulsion (p=0.03), an 11% increase in maximum ankle moment during push-off (p=0.048), and a 9° improvement in ground clearance during swing (p=0.003). In the subset of participants presenting with forefoot landing patterns (n =4), exosuit assistance produced a heel strike pattern and reduced their abnormally high muscle activity during early stance. The authors found no statistical changes in TA activity during swing or calf muscle activity during push-off, indicating that the exosuit assistance is complementary to the participants' own effort.

PMID: 29983296 DOI: 10.1016/j.gaitpost.2018.06.124

Awad et al. (2017a)

A soft robotic exosuit improves walking in patients after stroke.

Louis N. Awad, Jaehyun Bae, Kathleen O'Donnell, Stefano M. M. De Rossi, Kathryn Hendron, Lizeth H. Sloot, Pawel Kudzia, Stephen Allen, Kenneth G. Holt, Terry D. Ellis, Conor J. Walsh

SUMMARY

This study evaluates the immediate effects of walking with a lightweight soft exosuit providing mechanical assistance during plantarflexion and dorsiflexion of the paretic limb with individuals in the chronic phase of stroke recovery. For the primary analysis in this study, nine individuals with chronic stroke participated in bouts of walking on an instrumented treadmill with a tethered exosuit connected to an off-board actuation unit. Biomechanical analysis was performed at the participant's preferred overground walking speed under two conditions – with the exosuit providing mechanical assistance during plantarflexion and dorsiflexion (powered) and with the suit not transmitting any forces to the wearer (unpowered). Compared to walking without assistance from the exosuit, study participants increased paretic ankle dorsiflexion by 5.33 ± 0.91° during the swing phase and improved paretic propulsion by 11 ± 3% ($P < 0.05$). These improvements contributed to an overall 20 ± 4% reduction in propulsion asymmetry and a 32 ± 9% reduction in the metabolic burden of post-stroke walking. Two complementary studies are also described in supplementary sections: a passive exosuit study and a study of overground gait assistance with an untethered (body-mounted) version of the exosuit. The

authors suggest that exosuit-induced improvements in post-stroke walking function may increase the opportunity for walking practice with higher intensity and variability, and the ability to facilitate walking practice with more normal gait mechanics also has the potential to promote locomotor restoration instead of compensation.

PMID: 28747517 DOI: 10.1126/scitranslmed.aai9084

Awad et al. (2017b)

Reducing Circumduction and Hip Hiking During Hemiparetic Walking Through Targeted Assistance of the Paretic Limb Using a Soft Robotic Exosuit.

Louis N. Awad, Jaehyun Bae, Pawel Kudzia, Andrew Long, Kathryn Hendron, Kenneth G. Holt, Kathleen O'Donnell, Terry D. Ellis, Conor J. Walsh.

SUMMARY

This single-visit 8-person comparison study examines the effect of an ankle-assisting soft exosuit on typical gait compensations post stroke. Eight participants with hemiparetic gait in the chronic phase of stroke walked on an instrumented treadmill to evaluate their walking during two conditions: with an exosuit powered and providing assistance to ankle dorsiflexion and plantarflexion; and with the same exosuit worn but unpowered. No verbal or other external cues were provided to the participants during the two bouts of walking. When walking with assistance from the exosuit, participants demonstrated a 27± 6% reduction in paretic hip hiking, and a 20±5% reduction of paretic circumduction (p=0.004). The powered exosuit also resulted in a significant increase (p=.002) in the nonparetic step length. Data analysis demonstrated that exosuit-induced increases in swing phase knee flexion contributed to reductions in hip hiking during exosuit assisted walking. The authors suggest that the rapid and substantial kinematic changes observed in the strategy used to advance the paretic limb in response to exosuit assistance speaks to the potential value of exosuits during gait retraining, particularly during early phases of stroke recovery before individuals develop such compensatory walking strategies resulting from paretic ankle dysfunction.

PMID: 28777105 DOI: 10.1097/PHM.0000000000000800

Multiple Solutions in Neurorehabilitation

ReWalk Robotics offers a comprehensive family of rehabilitation solutions for use under the care of a therapist in a clinic or via telehealth, or for personal ownership.

Diagnostic Group	In-Clinic Rehabilitation	Home Use / Telehealth
Stroke	• ReStore Exo-Suit • MediTouch Movement Biofeedback • MYOLYN MyoCycle Pro FES bike	• MediTouch Movement Biofeedback • MYOLYN MyoCycle Home FES bike
Spinal Cord Injury	• ReWalk Exoskeleton • ReWalk Clinic Day Program • MediTouch Movement Biofeedback • MYOLYN MyoCycle Pro FES bike	• ReWalk Personal 6.0 Exoskeleton • MediTouch Movement Biofeedback • MYOLYN MyoCycle Home FES bike
Other Neurologic Disorders (including MS and TBI)	• MediTouch Movement Biofeedback • MYOLYN MyoCycle Pro FES bike	• MediTouch Movement Biofeedback • MYOLYN MyoCycle Home FES bike

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Scan QR Code or Click Here to request information about ReWalk's newest solutions for neurorehabilitation or to arrange a demonstration at your facility.

Note – ReWalk Robotics distributes the MediTouch Movement Biofeedback Devices and the MYOLYN FES Bikes in the United States only; for clinics or individuals outside the United States, we will be happy to refer you to the respective companies.