Scientific Resources

2004, Koeneman, E. J., Schultz, R. S., Wolf, S. L., Herring, D. E., & Koeneman, J. B.. A pneumatic muscle hand therapy device.. IEEE.

The development of a pneumatic muscle driven hand therapy device, the Mentor trade mark, reinforces the need for volitional activation of joint movement while concurrently offering knowledge of results about range of motion, muscle activity or resistance to movement. The device is ***well tolerated*** *and has r****eceived favorable comments from stroke survivors, their caregivers, and therapists.***

2005, Bharadwaj, K., Sugar, T. G., Koeneman, J. B., & Koeneman, E. J. Design of a Robotic Gait Trainer using Spring Over Muscle Actuators for Ankle Stroke Rehabilitation. Journal of Biomechanical Engineering, 127(6), 1009. doi:10.1115/1.2049333

The device is a parallel robot that incorporates two pneumatically powered, double-acting, compliant, spring over muscle actuators as actuation links which move the ankle in dorsiflexion/plantarflexion and inversion/eversion. The ***compliant muscles*** *will* ***assist*** *the patient in a* ***reasonable gait pattern without forcing them to follow an exact pattern. *precursor to the Foot Mentor***

2005, He, J., Koeneman, E. J., Schultz, R. S., Huang, H., Wanberg, J., Herring, D. E., ... & Koeneman, J. B.. Design of a robotic upper extremity repetitive therapy device. In 9th International Conference on Rehabilitation Robotics, ICORR (pp. 95-98). IEEE.

The development of a pneumatic muscle (PM) driven therapeutic device, the RUPERT™, has the potential of providing a low cost and safe take-home method of supplementing therapy in addition to in the clinic treatment. The device can also provide real-time, objective assessment of functional improvement from the therapy. ****RUPERT is the precursor to the Hand Mentor***

2006, He, Jiping, E. J. Koeneman, R. S. Schultz, D. E. Herring, John Wanberg, H. Huang, Thomas Sugar, R. Herman, and J. B. Koeneman. "RUPERT: a device for robotic upper extremity repetitive therapy." IEEE.

It is ***wearable*** *and* ***provides assistive forces required to move the arm*** *during performance of several critical tasks of daily living. The robot has four degrees of freedom at shoulder, elbow and wrist. The* ***sensors feedback position and force information*** *for* ***quantitative evaluation of task performance****. It has the potential of providing a take-home method of supplementing therapy. The device can also* ***provide real-time, objective assessment of functional improvement of therapy. *RUPERT is the precursor to the Hand Mentor***

2007, Sugar, T. G., He, J., Koeneman, E. J., Koeneman, J. B., Herman, R., Huang, H., ... & Swenson, P. Design and control of RUPERT: a device for robotic upper extremity repetitive therapy. IEEE transactions on neural systems and rehabilitation engineering, 15(3), 336-346.

We have ***tested the device on stroke survivors*** *performing two critical activities of daily living (ADL):* ***reaching out and self feeding****. The future improvement of the device involves increased degrees-of-freedom and interactive control to adapt to a user's physical conditions.* ****RUPERT is the precursor to the Hand Mentor***

2008, Balasubramanian, S., Wei, R., & He, J. (2008, August). Rupert closed loop control design.IEEE Engineering in Medicine and Biology Society (pp. 3467-3470). IEEE.

An ***adaptive robot control strategy*** *combining a* ***PID-based feedback controller*** *and an* ***Iterative Learning Controller (ILC)*** *is proposed for performing passive reaching tasks. Additionally, a fuzzy rule-base for estimating the learning rate for the ILC is also proposed. The proposed control scheme has the* ***ability to adapt to different subjects*** *for performing different reaching tasks.* ****RUPERT is the precursor to the Hand Mentor***

2008, Rosenstein et al. “Effects of Combined Robotic Therapy and Repetitive-Task Practice on Upper-Extremity Function in a Patient With Chronic Stroke.”

The ***Hand Mentor*** *provides an effective means to* ***improve*** **upper-extremity motor functioning** and **functional performance** in daily tasks followed this client's engagement in distal initiation of movement during an RTP exercise regimen that was **robotically reinforced.**

2010, Kutner et al. “Quality-of-Life Change Associated With Robotic-Assisted Therapy to Improve Hand Motor Function in Patients With Subacute Stroke: A Randomized Clinical Trial.”

The ***Hand Mentor*** *is an effective adjunct to deliver* ***intensive rehabilitation important in upper limb functional recovery****. The* ***Hand Mentor*** *therapy group had a greater increase in rating of mood and a greater increase in rating of social participation. The* ***Hand Mentor*** *therapy group had significant improvements in stroke recovery rating Robotic-assisted therapy may be an effective alternative or adjunct to the delivery of intensive task practice interventions to enhance hand function recovery in patients with stroke.*

2011, Zhang, H., Austin, H., Buchanan, S., Herman, R., Koeneman, J., & He, J. Feasibility studies of robot-assisted stroke rehabilitation at clinic and home settings using RUPERT. In 2011 IEEE International Conference on Rehabilitation Robotics (pp. 1-6). IEEE.

The system was tested in two studies. The first study involved receiving therapeutic training during three time weekly clinic visits for 4 weeks. The second study set up the robot-assisted rehabilitation system at the patients' homes, where the therapeutic training was

practiced on a daily base. Patients' performances were assessed using clinical evaluation tools, including Wolf Motor Function Test and Fugl Meyer Assessment (FMA), both before and after the training. Both two patients in the home-application setting demonstrated functional improvement after the training. They also demonstrated significant increase in the movement smoothness on reaching some target. Both clinical tests and objective statistical tests from robot sensory data agree on the functional improvement. ***RUPERT is the precursor to the Hand Mentor***

2011, Zhang, H., Austin, H., Buchanan, S., Herman, R., Koeneman, J., & He, J.. Feasibility study of robot-assisted stroke rehabilitation at home using RUPERT. In The 2011 IEEE/ICME International Conference on Complex Medical Engineering (pp. 604-609). IEEE.

*The therapeutic effect of repetitive therapy is **best realized by long term and multiple intensive sessions per day**. Our approach provides valuable information on determining therapy intensity and repetitions and monitoring progress. After one week, participants **increased the practice intensity to twice a day** with evidence of **competency** in **motor control** for more demanding tasks.*

2013, Linder et al. “Incorporating robotic-assisted telerehabilitation in a home program to improve arm function following stroke: a case study”

*The **Hand Mentor** robotic-assisted therapy paired with a HEP can be successfully delivered within a home environment to a person with stroke.When combined with a home exercise program, the **Hand Mentor** provides similar or greater improvements in upper limb function that home exercise alone. Robotic assisted therapy is an efficacious adjunct to a HEP program to elicit substantial improvements in upper extremity motor function especially in those persons with stroke who lack access to stroke rehabilitation centers.*

2014, Butler et al. “Expanding Tele-rehabilitation of Stroke Through In-home Robot-assisted Therapy”

*Individuals were able to make functional improvements in the use of their impaired extremities poststroke using the **Hand Mentor** telerehabilitation device in the home. The in-home service delivery regimen reduced the cost of therapy while expanding access to a rehabilitation modality for individuals who would not otherwise have received services.*

2014 Lynskey,“Home-based robot-assisted ankle rehabilitation for chronic stroke survivors.”

*This study provides preliminary evidence that home-based rehabilitation provided by the **Foot Mentor** is a viable alternative for the treatment of distal lower extremity dysfunction in chronic stroke survivors.*

2015, Wolf et al. “The HAAPI Trial: A Novel Robotics Delivery Approach in Stroke Rehabilitation.”

*The **Hand Mentor** improves upper limb function to the same extent **as traditional therapy interventions** (home exercise program). The device is portable and has a wireless and Web-based capability of transmitting data from a home to a secured base station. As a result, the TR component may be a practical and valuable approach to delivering poststroke care when limited resources, manpower shortages, long distances, or compromised patient mobility restrict or limit access to other treatment locations; however, a more detailed selection of users will be required before this approach could become better than a home-based exercise program.*

2015, Cherry et al. “Expanding stroke telerehabilitation services to rural veterans: a qualitative study on patient experiences using the robotic stroke therapy delivery and monitoring system program.”

*The **Hand Mentor** provides a valuable rehabilitation tool to **extend effective, evidence-based** and **specialized rehabilitation** services for **upper** and **lower limb rehabilitation** especially for those with **difficulty accessing** therapy services because they had **exhausted their benefits** or because **traveling** to outpatient therapy was too cumbersome due to distance were able to perform therapeutic activities in the home daily (or at least multiple times per week). Participants who were still receiving formal therapy services either in-home or in the clinic were able to perform therapeutic activities in the home on the days they were not attending/receiving formal therapy.*

2015, Linder et al. “Improving Quality of Life and Depression After Stroke Through Telerehabilitation.”

*The **Hand Mentor** improves quality of life and depression symptoms when utilized in the stroke survivor's home.*

The results of this study provide several relevant contributions to the field of occupational therapy:

Robot-assisted therapy with the **Hand Mentor**, **improved QOL and depression measures** in people <6 mo after stroke. An 8-wk program was sufficient time to observe changes in the QOL and depression measures for this client population. Use of a robot-assisted device in the home provided an **objective way for therapists to remotely monitor** people after stroke through an electronic database system and a weekly phone conversation. For people after stroke with **limited access** to **traditional therapy**, home-based interventions may be a **valuable intervention for continued nonmotor recovery.**

2015, Andrew J. Butler, Justiss Kallos, Stephen N. Housley, Michelle C. LaPlaca, Stephen F. Traynelis, and Steven L. Wolf, “Randomized, Placebo-Controlled, Double-Blind Pilot Study of D-Cycloserine in Chronic Stroke.”

*A relatively short duration of **Hand Mento**r rehabilitation (18 hours) provides significant improvement in **upper limb function, grip strength, quality of life** and **depressive symptoms.***

2016, Ostadabbas, “A Tongue-Controlled Robotic Rehabilitation: A Feasibility Study in Stroke Survivors.”

*The **Hand Mentor** can be successfully adapted with other assistive technologies to provide new hybrid rehabilitation paradigms.*

2016, Housley, “Improving upper extremity function and quality of life with a tongue driven exoskeleton: a pilot study quantifying stroke rehabilitation.”

Significant improvements in tracking performance translated into improvements in the **UE portion of the Fugl-Meyer Motor Assessment**, **range of motion**, and all **subscores for the Stroke Impact Scale**. Regression modeling found **daily training time** to be a **significant positive predictor of decreases** in tracking error, indicating the presence of a potential dose-response relationship. The results of this pilot study indicate that the TDS-HM system can elicit **significant improvements in moderate to severely impaired stroke survivors**. This pilot study gives preliminary insight into the **volume of treatment time required to improve outcomes.**

2016, Housley, “Increasing Access to Cost Effective Home-Based Rehabilitation for Rural Veteran Stroke Survivors.”

*Home-based, robotic therapy provided by the **Hand Mentor** reduced costs (65%), while expanding access to a rehabilitation modality for people who would not otherwise have received care. Those who participated made clinically meaningful improvements in the use of their impaired extremities using a robotic device in the home.*

2016, Bajaj, S., Housley, S. N., Wu, D., Dhamala, M., James, G. A., & Butler, A. J. (2016). Dominance of the unaffected hemisphere motor network and its role in the behavior of chronic stroke survivors. Frontiers in human neuroscience, 10, 650.

*Results of the present study uncovered an important brain-behavior relationship that can be induced by the **Hand Mentor** intervention between the connectivity in the unaffected brain hemisphere and the motor behavior of the affected hands in stroke patients. Findings reported in this study strengthened our understanding of stroke conditions and brain plasticity in stroke survivors.*

2018, Housley, Stephen N., Kathleen Fitzgerald, and Andrew J. Butler. "Telerehabilitation Robotics: Overview of approaches and clinical outcomes." Rehabilitation Robotics. Academic Press, 2018. 333-346.

*Telerehabilitation robotics is one of the newest additions to technologically mediated health care that combines established features of robot-assisted rehabilitation and telehealthcare to provide rehabilitation services at a distance. Several studies have documented clinically and statistically significant improvements in upper and lower extremity functioning, while several feasibility studies have documented improvements in high-fidelity kinematics. Telerehabilitation robotic delivery has also been shown to expand access to rehabilitation services. The only fully deployed telerehabilitation robotics platform is the **Hand Mentor**.*