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Guest Editorial

Integrating robot-assisted interventions into standard of care

The best way to introduce this special issue on rehabilitation robotics is to borrow from the 2012 update of the Veterans Health Administration Research and Development Strategic Plan. That document, created under the auspices of Secretary Eric Shinseki and Chief Research and Development Officer Joel Kupersmith, describes in crystal clear terms the present stage of development of upper extremity rehabilitation robotics:

> "Objective 2.6 Robot-Assisted Interventions. Develop and implement robot-assisted interventions as standard clinical practice for patients who have suffered neurological injury due to conditions such as stroke, spinal cord injury, or multiple sclerosis."

Rehabilitation robotics for the upper extremity has matured quite a bit since we started developing the MIT-Manus at the end of 1989. It crawled from a few academic engineering laboratories to a few academic rehabilitation hospitals. It wobbled between these two communities while it grew and collected some basic evidence. It tested the accumulated evidence further and matured to adolescence and early adulthood, at least for the upper extremity (G. Kwakkel, 2008). This is clearly stated in the 2010 American Heart Association (AHA) guidelines for stroke care which recommended that: "Robot-assisted therapy offers the amount of motor practice needed to relearn motor skills with less therapist assistance... Most trials of robot-assisted motor rehabilitation concern the upper extremity (UE), with robotics for the lower extremity (LE) still in its infancy..." (E. L. Miller, 2010). This is not an isolated opinion. The 2010 Veterans Administration/Department of Defense guidelines for stroke care came to the same conclusion, endorsing the use of rehabilitation robots for the upper extremity but not for the lower extremity (The Management of Stroke Rehabilitation Working Group, 2010).

Putting the lower extremity robotics to the side for now, we need to do quite a bit to make upper extremity robot-assisted interventions the standard of care. The key to marching forward and making progress is to stop thinking about the devices and start thinking about rehabilitation processes. The goal is to rehabilitate a person following a stroke or a child with cerebral palsy, and the devices are sophisticated tools which would enable and assist clinicians in facilitating this objective. However, if not properly inserted and integrated into the rehabilitation process, they will lead to mediocre results and disappointment. We should not only augment the clinicians' repertoire of interventions, but should do that while preserving the evidence that we learned in terms of high intensity repetition, motor interference, generalization, consolidation, type and quality of feedback, etc. It is my firm belief that in order to insert robotics and thereby accelerate improvements in the effectiveness of patient standard of care, we have to change the way physical and occupational therapy, physical medicine, motor control, and rehabilitation engineering interact and are taught. I am not alone: the American Physical Therapy Association (APTA) includes the following 2012 addition to its strategic plan for 2020: "Increase PTs' awareness and understanding of the potential application of new models and advances in more effective PT care delivery, including technologies that will influence physical therapy

practice." Specifically, I believe that in this rapidly advancing era of rehabilitation technology, clinicians need specialized training in the fundamental principles of technology-assisted rehabilitation as they pertain to motor learning and motor control.

The same recipe should be applied to the lower extremity robotics. I understand some of my colleagues' frustration but we have to recognize that mistakes are bound to take place when pushing state-of-the-art technology, and that not everyone placed all his/her chips on horses trotting in rhythmic training fashion post-stroke (B. Dobkin and P. W. Duncan, 2012). I am an optimist and firm believer that through research we will ultimately succeed in changing this landscape.

This issue includes a selected collection of papers that are intended to afford a vision of the state-of-the-art in rehabilitation robotics. I took John Godfrey Saxe's well known poem to heart in viewing the field from different perspectives. Not surprisingly, we can cluster papers around upper (Bishop, Cortes, Dodakian, Duret, Giacobbe, Ladenheim, Mazzoleni) and lower extremity (Forrester, Hesse, Danzl, Tanabe). Of the three papers on neurorecovery following a stroke involving the lower extremity, Hesse investigates not only rhythmic training but also the ability to simulate going up or down steps, Forrester's paper researches training an impaired ankle under both seated (discrete) and walking (rhythmic) conditions, and Danzl employs a device designed for rhythmic training in a novel fashion at the slowest possible speed to simulate discrete stepping. But there are other potential clusters of a) different conditions: stroke (Bishop, Dodakian, Duret, Forrester, Giacobbe, Hesse, Mazzoleni, Danzl), spinal cord injury (Cortes, Tanabe), cerebral palsy (Ladenheim, Hesse), Parkinson (Hesse); or b) different logistical questions: how long therapy should last (Duret), what training sequence (Giacobbe, Mazzoleni), what form of feedback (Dodakian, Ladenheim). If we think of a rehabilitation process, a two-step procedure would be involved: first, to consider how to insert robot-assisted therapy into the clinic and second, to then examine how it interacts with other approaches to augment patient's recovery potential. To that effect, there are five papers dealing with neuro-imaging (Dodakian), neurostimulation in the form of transcranial direct current stimulation (tDCS) or transcranial magnetic stimulation (TMS) (Cortes, Giacobbe, Danzl), and with assistive technology when our neurorehabilitation efforts might hit a wall (Tanabe).

I will conclude reminding us of the opening statement paraphrasing the Veterans Health Administration Research and Development Strategic Plan. The mission of translating robot-assisted interventions into standard of care is crystal clear. The burden is on us to make it happen and I hope this issue will assist all of us to see where we were, are, and need to be.

Guest Editor
Hermano Igo Krebs, PhD
Massachusetts Institute of Technology
Newman Laboratory for Biomechanics and
Human Rehabilitation
Cambridge, MA, USA
E-mail: hikrebs@mit.edu

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