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Short Communication

Latest Advances in Neuro Rehabilitation: Editorial

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Abstract

In recent years, there has been a significant shift in neuro rehabilitation, driven by technological advancements. While traditional methods remain valuable, they often struggle to meet the diverse needs of patients with common neurological conditions like stroke, Parkinson's disease, and spinal cord injury. However, the rise of innovative technologies has opened up promising avenues for improving rehabilitation strategies across various disorders.

Keywords: Neuro Rehabilitation; Trends in Rehabilitation; Electro Rehabilitation

Robotic-assisted training has transformed rehabilitation by providing precise, tailored movements that promote motor recovery and functional enhancement. Virtual reality creates immersive environments that engage patients in therapeutic activities, making rehabilitation more interactive and motivating. Functional electrostimulation assists in muscle activation, aiding in motor relearning and movement restoration. Non-invasive brain stimulation methods, such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS), modulate neural activity to enhance neuroplasticity and support recovery [1].

Moreover, the integration of advanced neuroimaging techniques like functional MRI, near-infrared spectroscopy, and high-density EEG allows researchers to understand the neural mechanisms underlying rehabilitation and track brain changes in response to interventions. This not only provides insights into the effectiveness of different approaches but also offers potential markers for assessing treatment efficacy.

Translational and back-translational models play a crucial role in connecting basic neuroscience research with clinical practice. By establishing strong neurobiological foundations for rehabilitative interventions, these models ensure that therapeutic approaches are based on solid scientific evidence, thereby enhancing their effectiveness and real-world relevance [2].

In summary, the integration of advanced technologies and neuroscientific insights into neurorehabilitation holds great promise for enhancing outcomes and quality of life for individuals with neurological disorders. Ongoing research in this field is expected to lead to further innovations that will shape the future of neurorehabilitation. Understanding how central nervous system lesions correlate with clinical features and outcomes forms the foundation for personalized medicine in neurorehabilitation. This approach holds promise in explaining the varying individual responses to treatment and enhancing the quality of care. Developing new strategies for both the acute and chronic phases of neurological diseases, and determining the most suitable timing for interventions, are crucial for optimizing neurorehabilitation efforts [3]. Additionally, there is a growing interest in exploring the effectiveness of combined drug and physiotherapy treatments through new randomized controlled trial designs. Furthermore, while evidence-based medicine has historically been somewhat distant from the field of neurorehabilitation, there is now increasing interest in systematic reviews, meta-analyses, and consensus conferences to inform practice and decision-making.

The Research Topic "New Advances in Neurorehabilitation" featured 20 high-quality manuscripts that provide valuable insights into technological and methodological advancements, as well as novel features and approaches in neurorehabilitation.

Stroke-related motor outcomes have traditionally been a focal point in neurorehabilitation due to the high prevalence of chronic stroke. Schulz., *et al*. investigated the potential relationship between prefrontal-premotor connections and residual motor function in 30 well-recovered chronic stroke patients and 26 controls. They found that prefrontal-premotor tracts were identifiable in both groups. While stroke patients exhibited minimal microstructural alterations in these tracts, primarily in the affected hemisphere, there was no significant correlation between the microstructure of prefrontal-premotor connections and residual motor function following stroke.

Chen., *et al*. conducted a pilot study examining functional cortico-muscular coupling to assess motor function in 8 stroke patients and 8 controls. They investigated the functional connection between electroencephalogram and electromyogram signals from a hand muscle during a steady-state grip task. Their findings suggested that the multiscale and directional characteristics of cortico-muscular coupling may be disrupted in stroke.

In a study involving 63 wheelchair-dependent spinal cord injury (SCI) patients with varying ages and levels/severity of injury, researchers examined the reliability of wearable sensor-derived measures of physical activity. They found that activity counts exhibited consistently high single-day reliability, whereas other measures varied depending on factors such as decreased movement quantity and increased movement quality with rehabilitation progress. These findings offer valuable insights for utilizing sensor-based assessments of physical activity in clinical SCI studies [4].

Neurorehabilitation holds significant importance for patients with multiple sclerosis (MS), who often experience motor, sensory, cognitive impairments, and pharmaco-resistant pain. van Beek., *et al*. outlined a study protocol for a randomized controlled trial (RCT) aimed at investigating the effectiveness of a challenging tablet app-based home-based training intervention to enhance dexterity in MS patients. They hypothesized that the program would lead to short- and long-term improvements in dexterity, with potential generalization to enhanced activities of daily living and quality of life.

Similarly, patients with Parkinson's disease (PD) commonly present with a wide array of motor and non-motor symptoms, necessitating a combination of neurorehabilitation and pharmacological treatments. Berra., *et al*. conducted a review on the efficacy of body weight support combined with treadmill training on PD gait, reporting data from an RCT involving 36 PD patients. Both the active and control groups demonstrated significant improvements in motor and gait outcomes. However, intragroup analysis revealed specific improvements in cadence and stride duration in the active group and in the swing/stance ratio in the control group. Notably, some patients with chronic pain or anxious symptoms may not tolerate body weight support, suggesting its consideration in cases of severe postural instability, balance disorder, and orthostatic hypotension [7].

Meanwhile, Pazzaglia and Galli presented a rehabilitative perspective, focusing on the potential of action observation as a therapeutic approach for patients with apraxia. They discussed the implications of reinforcing perceptual-motor coupling on neurorehabilitation and brain repair. This perspective may pave the way for future interventions centered around action observation in patients with apraxia.

A mini-review was conducted on diffusion tensor tractography studies focusing on the mechanisms of recovery after injury to the anterior cingulum, a vital component of the limbic system associated with various cognitive functions such as memory, attention, learning, motivation, emotion, and pain perception. While most of the reviewed studies were case reports, they suggested that diffusion tensor tractography could be valuable for the neurorehabilitation of patients with anterior cingulum injury.

In another study, Fabbri et al. presented a study protocol for a randomized controlled trial (RCT) aimed at investigating the effects of a multi-dimensional tele-rehabilitation program delivered through a user-friendly web application. The trial focuses on patients with mild cognitive impairment and vascular cognitive impairment, aiming to assess the impact of the intervention on cognitive function and overall rehabilitation outcomes.

Pain is commonly encountered among patients undergoing neurorehabilitation, yet its influence on rehabilitative procedures and optimal treatment strategies remains largely unexplored. Castelnuovo., *et al*. conducted a review on the role of the placebo effect in pain relief within the context of neurorehabilitation, as part of the recommendations from the Italian Consensus Conference on Pain in Neurorehabilitation. Their findings indicated that placebo treatments exhibited varying effects across different pain conditions, ranging from weak effects in central neuropathic pain to moderate effects in postherpetic neuralgia, diabetic peripheral neuropathy, HIV-associated pain, fibromyalgia, and migraine. Additionally, they noted weak short-term effects in complex regional pain syndrome. The authors recommended understanding placebo mechanisms to enhance the doctor-patient relationship, reduce reliance on analgesic drugs, and empower patients to actively participate in their therapy.

A systematic review and meta-analysis of randomized controlled trials (RCTs) aimed to evaluate the effectiveness of manual trigger points treatment compared to minimal active or no active interventions in adults with primary headaches. Drawing from 7 RCTs, the authors concluded that manual trigger points treatment of head and neck muscles may alleviate the frequency, intensity, and duration of attacks in tension-type headache and migraine. However, they noted that the quality of evidence was very low due to the limited number of studies, a high risk of bias, and imprecision of the results.

Meanwhile, patients with lesions of the peripheral nervous system often require neurorehabilitation, with those experiencing brachial plexus lesions facing particularly severe impairments. Ramalho., *et al*. investigated bilateral sensory function in 17 patients with unilateral brachial plexus lesions. They discovered a reduced touch threshold not only in the limb with the brachial plexus injury but also in the unaffected contralateral upper limb. The authors interpreted these findings as indicative of a broader model of representational plasticity occurring bilaterally in the brain following a unilateral peripheral injury.

Recent literature suggests that combining traditional rehabilitation techniques with new technological approaches, such as neuromodulation, biofeedback recordings, and innovative robotic and wearable assistive devices, may enhance the recovery process compared to traditional treatments. Several contributions in the Research Topic focused on robotic rehabilitation for upper limb stroke and multiple sclerosis (MS) patients [8,9].

One study presented the protocol for a multi-center parallel group prospective, randomized, open-label, blinded endpoint trial involving 120 chronic stroke patients with upper limb motor impairment. Patients were randomly assigned to three different rehabilitation protocols: robotic therapy, standard rehabilitation combined with self-training, or robotic therapy combined with constraint-induced movement therapy.

In another study, Wu., *et al*. introduced an admittance-based patient-active control scheme for real-time intention-driven control of a powered upper limb exoskeleton. They provided details on the mechanical structure, real-time control system of the robot, dynamic characteristics of the human-exoskeleton system, and an integrated audiovisual game-like interface. Additionally, they reported data from an experimental investigation involving three healthy subjects and eight stroke patients to validate the feasibility of the proposed scheme for patient-active rehabilitation training.

In a study exploring the potential of robotic arm rehabilitation for chronic stroke patients with hemiparesis and aphasia, researchers paired intensive robot-assisted therapy with either sham or active transcranial direct current stimulation (tDCS). The study, involving 17 individuals, aimed to assess the impact of this combination on speech and language function. Results showed significant improvements in motor speech production following robot therapy, but there were no additional gains associated with active tDCS compared to sham tDCS. This suggests the need for further investigation into the role of tDCS in the relationship between limb and speech/language rehabilitation [10].

Conflict of Interest

NIL.

Source of Interest

NIL.

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