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Experiences and devices in Robot-assisted rehabilitation of Posture and Gait disorders. Robotic Rehabilitation: How it interacts with Recovery Mechanisms

Parkinson's disease and Multiple Sclerosis are two common neurodegenerative diseases of adulthood that cause gait disorders. These are characterised by the appearance of reactive microglial and astroglial cells, a process referred to as neuroinflammation. Activation of glia cells can induce an increase in the levels of pro- and anti-inflammatory cytokines and reactive oxygen species, which can lead to the modulation of neuronal function and neurotoxicity observed in several brain pathologies. There is no conclusive evidence that can classify the inflammation as a cause or a consequence of the disease onset. However, therapeutic approaches specifically targeting neuroinflammation and neuroplasticity may represent an effective strategy to interfere with the disease progression and consequently for preventing or treating the related symptoms. Exercise is known to effectively modulate inflammation and has been reported to change the inflammatory state to become anti-inflammatory or neuroprotective. Moreover, exercise increases synaptic plasticity by directly affecting synaptic structure and potentiating synaptic strength, and indirectly by strengthening the underlying systems that support plasticity including neurogenesis, metabolism and vascular function. More studies are needed to elucidate the likely range of intensity, duration, frequency, and type (aerobic or task oriented, overground or robotic) of exercise that is required to induce such important target responses. Robotic gait training is a relatively new approach of motor impairment that, in addition to providing a specific repetitive aerobic activity for gait and multisensory input, is able to capture and maintain the attention of the subjects, to motivate them and therefore optimize the compliance with the treatment. Our recent studies showed that robotic assisted gait training seems to be able to improve symptoms that are unresponsive or that poorly respond to pharmacological treatment like gait disorders in Parkinson's disease and Multiple Sclerosis, probably due to its effect on improving neuroplasticity. In fact, robotic assisted gait training provides all parameters that are essential for promoting activity-dependent neuroplasticity ensuring the efficacy and the effectiveness lasting over time (high intensity such as high repetition, velocity, complexity, specificity, difficulty, relevance and complexity of practice). In particular, the end effector device like GEO system in which movements are generated from the most distal segment of the extremity, is a suitable tool for rehabilitation in Parkinson's disease. GEO system provides continuous proprioceptive cues, enhances the spinal control of locomotion, improves postural control, promotes aerobic recondition and muscle strengthening of lower limbs, forces to provide an alternate gait pattern with a physiological joint amplitude and steady spatio-temporal features, like step length, symmetry and cadence. At the same time it allow the patient to be more free to control the proximal muscles districts. All these features represent key elements for gait disturbances rehabilitation in Parkinson disease. Instead, in the exoskeleton system like EKSO, there is a one-to-one correspondence between robots and human joints, and each single joint is guided along a preprogramed trajectory making it suitable for the rehabilitation of Multiple Sclerosis.

Among the tools used to test neuroplasticity in humans and so to study the effects on the brain of a rehabilitation treatment, Paired Associative Stimulation Protocol is the most reliable. It involves applying pairs of peripheral and central stimuli repeatedly. Low-frequency peripheral stimulation of somatosensory afferents over median nerve is synchronously paired with TMS over the motor cortex. The direction of excitability changes induced by PAS critically depends on the interstimulus interval (ISI) between the peripheral and cortical stimulus. If ISI is approximately 25 ms PAS facilitates the excitability of corticospinal output neurons, conversely, PAS at shorter interstimulus intervals (ISI is 10 ms) produces a long-lasting suppression of corticospinal excitability. Quartarone A et al., proposed a very rapid method of conditioning the human M1 cortex known as rapid PAS. In this protocol sub-motor threshold 5 Hz repetitive electrical peripheral nerve stimulation of

the right median nerve is synchronized with submotor threshold 5 Hz rTMS of the left M1 at a constant interval for 2 min to provide 600 pairs of stimuli. The results reflect the changes in synaptic efficacy brought about via long-term potentiation-(LTP) like process.

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