Psychiatria Danubina, 2021; Vol. 33, Suppl. 11, pp 49-51 *Conference paper*

THE ROLE OF ROBOTIC REHABILITATION IN CHILDREN WITH NEURODEVELOPMENTAL DISORDERS

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SUMMARY

In the last years, traditional treatments have been combined with innovative therapies, such as robot-assisted training, an interesting new rehabilitation tool for children with neurologic impairment. The robots deliver a high dose of training and intensity, critical factors for the activation of neuronal plasticity. Despite their increasing use, the effectiveness of robotic devices in the rehabilitation process lacks of an overall and shared framework of reference. The analysis of the literature reveals some positive aspects of the use of robotics in pediatric rehabilitation and others that are critical.

Key words: *neurodevelopmental disorders – robotics - rehabilitation*

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Neurodevelopmental disorders are disabilities associated primarily with the functioning of the neurological system and brain. Cerebral palsy (CP) is the most frequent neurological pathology in pediatric age. CP is defined as a group of permanent disorders of the development of movement and posture, causing activity restriction, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain (Rosenbaum et al. 2007). The motor disorders in CP are often accompanied by sensory, perceptual, cognitive, communication and behavioural disorders, epilepsy and secondary musculoskeletal difficulties. CP is therefore a condition due to alterations of the central nervous system resulting from pre-, peri- or postnatal causes that occurred before the completion of the individual's growth and development; CP is extremely heterogeneous in terms of its aetiology and the type and severity of the disorder itself.

According to the "Recommendations for the rehabilitation of children with cerebral palsy" (Castelli et al. 2016), rehabilitation is a complex process aimed at promoting the best possible participation and quality of life for the child and for the family. Through direct and indirect actions, it focuses on the individual in all his dimensions, physical, mental, emotional, communicative and relational (holistic approach), and it involves the child's family, social and environmental context (ecological approach). It is achieved through the formulation of the rehabilitation plan and of the various treatment programmes.

Various rehabilitation treatments have been applied in order to improve children's functional recovery, quality of life and autonomy. A multidisciplinary approach is decisive.

In the last years, traditional treatments have been combined with innovative therapies, such as robot-assisted training, which has emerged as a new interesting rehabilitation tool for patients with neurologic impairment. In fact, the use of robotic technologies is constantly increasing in rehabilitation, mostly in neurological disability. International Federation of Robotic (World Robotics 2018) expects a further increase of robot's use in rehabilitation.

Robotic rehabilitation is considered a therapeutic option in the treatment of patients with motor disabilities of neurological aetiology based on the following considerations:

- the limitations documented in the literature of the so-called traditional methods of motor rehabilitation;
- the robots deliver a reproducible training, applying the same algorithm of interaction with the patient, an essential aspect for evaluating the rehabilitation effectiveness;
- the robotic systems, by recording the patient's performance, allow the objective measurement of the deficits present and the monitoring of the progressively obtained results;
- the availability of robotic technologies, linked with virtual reality feedback, potentially capable of overcoming the current limits of rehabilitation interventions by implementing integrated and more effective training strategies.

The robots deliver a high dose of training (number of movements) and intensity (movements per unit of time), critical factors for the activation of neuronal plasticity. The latter is the brain capacity to modify functional organization as result of experience; it allows recovery of function after a damage of nervous system. Neuroscience research provides indications on the most effective strategies for activating neuronal plasticity. It requires not only the acquisition of a skill but also the continued performance of that skill over time. Therefore, an effective rehabilitation intervention has to be motivating, intense, repetitive and with a sensorial feedback for self-correction (Novak et al. 2020). These are specific features of robotic devices, which constitute a new opportunity for rehabilitation intervention.

Compared with standard interventions, motivation during robotic training may be greater for children because they are often both accustomed to and interested in technology. Interest and enhanced tolerability may increase practice time and reduce overall treatment durations. Furthermore, children with CP are often tired of the rehabilitation treatment they have practiced since birth. The use of robotic systems is able to re-motivate them, making them active again during training.

The improvement of walking ability is one of the primary rehabilitation goals for children with neurologic impairment. Gait training is a key component of pediatric rehabilitation and one of the major challenges for rehabilitation specialists.

Robot-assisted gait training (RAGT) can provide controlled, intensive, task-specific training that is goal directed and cognitively engaging. These aspects, together with the repetition of steps, promotes a physiological-like movement of limbs able to enhance neuroplasticity and to improve the potential for the recovery of walking after neurologic injury. RAGT devices allow the control of different field of force (viscous, elastic, and gravitational) and personalization of treatment. They also provide sensory-motor feedback that supports in real-time the patient's performance and facilitate the learning of a more efficient motor control. The robot provides optimal difficulty level with variable degrees of body weight support and guidance force. This allows a personalization of the intervention in line with the patient's abilities. The majority of the available data supporting the effectiveness of RAGT relate to adult stroke. The success of studies on adults suggests that robotic assisted rehabilitation may be well suited to the needs of children.

Despite the increase in use of robotic technologies in children with developmental disorders, the effectiveness of robotic devices in the rehabilitation process lacks of an overall and shared framework of reference. The analysis of the literature reveals some positive aspects of the use of robotics in pediatric rehabilitation and others that are critical.

RAGT with Lokomat is the robotic field in which publications are more numerous given the greater diffusion of this tool internationally for several years. It is used most in CP affected children. The outcomes studies show improvement of biomechanics, clinical, spatio-temporal, kinetics, kinematics and electromyography parameters in patients who performed gait analysis (Beretta et al. 2020). An increase of number of child who reaches standing station, an improvement in walking distance travelled, walking speed, endurance and balance is reported in trials that use robotic devices for walking rehabilitation. In some studies, robotic treatment is associated with conventional rehabilitation.

Results appear particularly promising in upper limb rehabilitation too. In fact, an improvement in fluidity and speed of reaching movements is reported.

Robotic devices are useful also to promote improvements in sensorimotor and cognitive process (Liebermann et al. 2006).

Another positive aspect of robotic training is the playful approach of children. It motivates and encourages them to improve their performance. Furthermore, robotic devices allow a repetitive training, with a sensorial feedback for self-correction. These features are known to stimulate neuroplasticity. The absence of side effects is another positive feature.

Critical aspects include the heterogeneity of the studied cases, the variability of measurement instruments of motor performance and of training protocols. It is necessary to increase the number of trials and achieve greater homogeneity between treatment protocols to confirm the positive effects of the use of robotic devices in children rehabilitation. A more careful evaluation of visuo-perceptive and cognitive skills is also needed for a more personalized use of robotic devices; a good cognitive level and an acceptable level of development of visual perception skills are in fact necessary for a correct use of robot's interface.

Schuler (Aurich Schuler et al. 2013) analyse machine-operator-patient interaction: robotic device with therapist interaction seems to be the condition with greater muscle activation. Some trials highlight the importance of the therapist who interfaced the robot with the child, in order to monitor their activity, encourage and guide they during the robotic training.

In conclusion, many works demonstrate the benefits of robotic training in developmental age, but it is necessary to increase the number of trials. In particular, it is crucial to achieve greater homogeneity between treatment protocols and patient groups to confirm the positive effects of robotic devices in children rehabilitation.

Acknowledgements: *None.*

Conflict of interest: *None to declare.*

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