Chapter 15
Motor Recovery in Stroke Rehabilitation Supported by Robot-Assisted Therapy

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ABSTRACT

This chapter discussed the potential usefulness of robot-assisted therapy for motor recovery after a stroke. An overview of the available literature was performed providing up-to-date information about the use of robot-assistive technology in rehabilitation practice. The chapter discussed the rationale for the use and the different machines in terms of basic engineering principles and the related rehabilitation possibilities. Finally, clinical and rehabilitative implications of the findings were critically discussed.

INTRODUCTION

Stroke is the second leading cause of death and the third leading cause of disability in the world (Johnson, Onuma, Owolabi, & Sachdev, 2016). The global burden of stroke continues to grow, with the stroke prevalence in 2013 reaching almost double than the 1990 prevalence rate (Stinear, 2017). According to the World Health Organization (WHO), cerebrovascular disease is the *'incoming epidemic of the 21st century'* (Sarikaya, Ferro, & Arnold, 2015). Moreover, epidemiological evidence suggests that the incidence of ischaemic stroke has increased in the last years in young adults. These patients have a long-life expectancy after stroke and the costs of long-term care pose huge challenges to health-care systems (Ekker, Boot et al., 2018). The WHO defined stroke as *'rapidly developed clinical signs of focal (or global) disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than of vascular origin'*. Although still widely used, the WHO definition relies heavily on clinical symptoms and is now considered outdated by the American Heart Association and American

DOI: 10.4018/978-1-7998-7430-0.ch015

Stroke Association (AHA) due to significant advances in the 'nature, timing, clinical recognition of stroke and its mimics, and imaging findings that require an updated definition' (Coupland, Thapar, Qureshi, Jenkins, & Davies, 2017). In the last edition - Eleventh Revision - of *WHO International Classification of Diseases* (WHO ICD-11), the definition of stroke, based on tissue definition, has been integrated in addition to clinical symptoms (Feigin, Norrving, Sudlow, & Sacco, 2018). This information clarifies that a cerebrovascular accident to be classified like a stroke if there is a death of brain cells -due to lack of oxygen when the blood flow to the brain is lost by blockage or rupture of an artery to the brain- that involves in permanent clinical symptoms (Johnson, Onuma, Owolabi, & Sachdev, 2016). As defined, the tissue damage can be translated into clinical symptoms that include motor impairment on the right or left side of the body, sensory loss, speech/language problems, behavioural diseases, memory loss and vision problems. Due to the wide range of signs and symptoms, stroke is a highly invalidating disease. For this, impairment due to stroke affects all the domains investigated in The International Classification of Functioning, Disability and Health (ICF). Specifically, a stroke can determine an alteration in more than hundred categories of ICF core set, in regard to the body functions and structures, activities and participation, and in the environmental factors (Geyh, Cieza et al., 2004). The most common and widely recognised impairment caused by stroke is motor impairment, which can result either in a loss or limitation of muscle control or movement or in a limitation of functional mobility (Langhorne, Coupar, & Pollock, 2009). Motor impairment after stroke typically affects the control of movement of the arm, and leg of one side of the body (hemiparesis). Approximately 65% of the hospitalised stroke survivors experience initial motor impairment (Hendricks, van Limbeek, Geurts, & Zwarts, 2002), and the majority of these do not recover to their functional baseline (Claflin, Krishnan, & Khot, 2015). The ability to live independently after stroke critically depends on the recovery of motor function (Stinear, Byblow, & Ward, 2014). It follows that motor recovery is crucial for regaining independence and improving the patients' quality of life (Lieshout, van de Port, Dijkhuizen, & Visser-Meily, 2020; Martino Cinnera, Bonnì et al., 2020). Therefore, much of the focus of stroke rehabilitation, and in particular the work of medical doctors, physiotherapists and occupational therapists, is on the recovery of impaired movement and the associated functions (Langhorne, Coupar, & Pollock, 2009). In view of the high number of patients with permanent motor impairment, it is necessary to research novel neurorehabilitation treatments to minimize long-term disability (Claflin, Krishnan, & Khot, 2015). To maximize motor recovery, alongside conventional therapy, new methods, based on new technologies available, have been developed in the last few decades. Among the new treatments, the potential of using robotic devices to assist patients in motor recovery was explored.

The aim of this chapter is to support the reader with a selective review of the newest evidence-based studies available on the usefulness of robot-assisted therapy for upper and lower limb impairment after a stroke. Specifically, an overview will be provided on the characteristics and therapeutic indications of the various robotic devices and on the new potential in combining robotic therapy with new technologies. This information could be useful to clinicians to expand the possibilities of treating motor disorders due to a stroke.

1 BACKGROUND

The recovery of motor functions after a stroke is mainly due to the modification of the activity and of the structure of the neurons, which takes the name of neuronal plasticity or neuroplasticity. These phe-

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