ECRONICON OPEN ACCESS

EC NEUROLOGY
Review Article

Stroke Rehabilitation: A Role for the New Technologies?

Madalena Bettencourt[1] and João Casaca-Carreira[2]*

[1]Physiotherapist, Insurance Company, Fidelidade, Portugal

[2]Physiotherapy Department, Portuguese Red Cross Health School, Lisbon and Physiotherapy Department, School of Health, Setúbal Polytechnic Institute, Portugal

***Corresponding Author**: João Casaca-Carreira, Physiotherapy Department, Portuguese Red Cross Health School, Lisbon and Physiotherapy Department, School of Health, Setúbal Polytechnic Institute, Portugal.

Received: April 16, 2020; **Published:** May 15, 2020

Abstract

Background: Stroke is a disease of the central nervous system caused by the reduction or interruption of a vessel on the brain. The prevalence of stroke consequences, not only physical but also psychological and social, tend to increase in the years after stroke, being rehabilitation the most important part of the process. With the emergence of new technologies, stroke rehabilitation benefited from important improvements.

Purpose: The purpose of this study is to understand the role of new interventions on the rehabilitation of stroke patients with hemiplegia and body asymmetry.

Results: Standard therapy, Bobath concept, Induced Constraint Movement Therapy, Mirror Therapy, Force Plate Feedback, Virtual Reality and Robot Therapy are described and the evidence supporting each approach is presented. Based on the studies mentioned above, the new approaches that have been more studied and shown more results are the Virtual Reality and the Robot Therapy.

Conclusion: In summary, these studies reveal that the new therapeutic approaches should be used as a complement of the standard therapy.

Keywords: *Stroke; New Technologies; Rehabilitation*

Introduction

Stroke is a disease of the central nervous system caused by the reduction or interruption of a vessel on the brain. This leads to a default of oxygen and nutrients in the brain that causes damage or the death of some brain cells [1,2]. The clinical signs can be focal or global and have a quick development [1] causing motor and sensory dysfunctions [3]. Apparently, there is no cause rather than vascular origin. Stroke can occur due to an interruption (ischemic) or a rupture (haemorrhagic) of a vessel [3,4].

According to the World Health Organization "15 million people suffer stroke worldwide each year and of these, 5 million die and another 5 million are permanently disabled", so for many years stroke has been one of the most common causes of disability and death [2]. "Stroke is still predicted to be a leading cause of disability worldwide by 2030" [5].

Stroke often causes cognitive impairment, being the domains most frequently affected memory, orientation, language and attention, constructional and visuospatial functions [6].

This condition can affect the middle cerebral artery, anterior cerebral artery, posterior cerebral artery and vertebral/basilar artery [3]. The largest artery is the middle cerebral artery stroke and usually the most commonly affected [7]. Stroke frequently gives origin to contralateral hemiparesis and hypesthesia, aphasia, neglect and ipsilateral hemianopsia [3].

Stroke has a huge impact in people all around the world and the existing treatments (conventional/traditional therapy) are not very effective, so despite the positive developments, it is still possible to improve the treatments [8]. Upper limb (UL) paralysis is the most common symptom in stroke, so most therapies focus on UL rehabilitation [1,9].

Another consequence of this condition is the asymmetry of the body, because one side of the body is paralyzed, and this causes problems in movement control and balance skills [10]. The prevalence of stroke consequences, not only physical but also psychological and social, tend to increase in the years after stroke, being rehabilitation the most important part of the process [11].

With the emergence of new technologies, stroke rehabilitation benefited from important improvements. The purpose of this study is to understand the role of new interventions on the rehabilitation of stroke patients with hemiplegia and body asymmetry. In this review, we will discuss the standard methods and the "new" methods such as robot therapy (RT), force plate feedback therapy (FPT) and virtual reality (VR).

Rehabilitation approaches

As a first step to explain the new approaches available for stroke, it is paramount to describe what is commonly defined as standard therapy. The approaches used on standard therapy consist of exercises to improve muscle strength, motor control of lower limb and gait training, balance, activities of daily living, Bobath concept, mirror therapy and constraint-induced movement therapy [11,12].

Usually, physiotherapy focus on regaining mobility and flexibility of the affected limb to contradict the flexo pattern and promote the use of the non-affected side to compensate on the daily tasks. The fact that the therapists stimulate more the unaffected limb to compensate, it will eventually, reduce the sensorimotor representation on the cortex [11]. Improvement of motor learning and refining of movement occurs in the intact nervous system by the multilevel sensory dynamics, where alternative motor areas can be recruited [5,13]. Such an approach can also be used in the lesioned nervous system, that is why both limbs (affected and non-affected) should be stimulated, to increase somatosensory input in order to augment cortical excitability and facilitate neuroplastic changes [13].

Bobath approach

The Bobath Concept addresses people suffering from a central nervous system impairment that affects motor, cognitive, social and emotional developments. This approach focuses on regulating muscle tonus, balance, mobility and functional extremity movements, especially related to daily living tasks, is based on the ability of the brain to recover and learning principles [14,15]. The Bobath concept consists of facilitating the movement in key areas, giving "a sensory input" to the cortical area and send information to motor control and perception of the limb in space [16].

Although this concept has shown some positive results in the chronic phase mainly on improving selective movement and upper limb function, as well as mobility and balance in the acute phase, overall, it is not more effective in general than other therapies in regaining mobility, motor control, balance and activities of daily living [12,14,16].

Induced constrain movement therapy

Induced constrain movement therapy (ICMT) is a behavioral approach based on "Learned Nonuse" [17]. It consists of restraining the non-affected limb and ask for tasks, intensive and repetitive movements using only the affected side [18]. This approach has shown positive results on ROM improvement of the upper limb during difficult tasks [19]. ICMT is possible to be done at home, without supervision and has shown a good cost-effectiveness relation [20]. This also has a few limitations since it is very specific for upper limb (only) and if the therapy is not applied at an early stage the results tend to be not so positive [19,21].

Mirror therapy

The mirror therapy is a very often used method that therapist apply as a part of the treatment, because provides real-time visual feedback and gets patients motivated and interested, since the patient focus on the unaffected side rather than the affected [1,9,10].

This approach requires the placement of the mirror between the patient limbs. The reflective side faces the non-affected limb to create the illusion to the patient of two unaffected sides [10]. Although the affected limb is not moving in the way that the patient sees it in the mirror, the fact that the patient is imagining the movements dispatch cortical activity [22]. The affected motor-areas and brain cells get stimulated by the feedback they are receiving from the image of the non-affected side moving [19]. It has been proven to be effective in improving motor function especially on ADL performance, mainly in the upper limb [10,19]. However, a disadvantage of this method is the compensations that can be done towards the unaffected side by the patient due to the weakness of the muscles on the affected side. When the patient focus on moving the "normal" limb acquires an asymmetrical posture, which can also be related to the fact the patients trying to see better the image on the mirror [10]. Besides, is a difficult method for patients to do on their own, since the mirror is a heavy object to dislocate [22].

The fact that standard therapies help in the improvement of motor function, only modest benefits have been shown to date and can also be expensive if one thinks that most cases become chronic and need long term rehabilitation [19,23].

Here, in this review we decided to explore novel therapies since they can provide safe environments allowing patients to try challenging and stimulating tasks and also receiving real-time feedback [13].

Force plate feedback (FPF)

One characteristic of hemiplegic patients is the increased postural sway and an asymmetric distribution of the body weight. Usually, the body load is shifted towards the unaffected side, changing the midline of the body making it difficult for the patient to maintain balance [24,25]. So the FPF "addresses these deficits and provides the individual with feedback from a force platform while balance activities are performed". This approach is applied in order to improve postural balance that is defined "as the ability to maintain the center of mass of the body within the base of support with minimal postural sway" [25,26]. As a consequence of the asymmetrical weight distribution the walking performance will be affected [24].

The use of this therapy is important in the sense that provides visual or auditory feedback about the patient's postural symmetry. This method can measure the weight distribution of the body on the platform and the centre of pressure of the body and work on that through visual, vestibular and proprioceptive inputs [11,24,25]. It focuses on doing daily tasks on the platform in order to prevent falls [25]. Although the studies refer to an improvement of the body distribution on a static/stance position, they are not conclusive about the effects on postural sway or gains on gait independence in ADLs [24]. The costs of these equipment's are not as high as they were a few years ago but remain still high which limits the possibility of having one at home [26,27]. Besides this, the FPF therapy requires the maintenance of balance and body orientation while the patient is standing on the platform, which makes it impossible for the patient to do it alone in some cases [27].

Virtual reality (VR)

VR is defined as a "computer-based technology that allows users to interact with the multisensory simulated environment and receive 'real-time' feedback on performance" [28]. There are different types of VR devices used in rehabilitation. The most common are the immersive and non-immersive. As the name suggests in the immersive, the person is completely involved in the VR environment, it is more realistic [29]. It is not often used because of the price, although it is not as expensive as in the past, the price is still around 100.000$. Also, it can be harder for patients to set up the equipment alone, which can cause them motion-like sickness and requires some space around [29,30].

The non-immersive VR as a better cost-effective relation [29]. It is based on video games, so it is also more accessible for patients to even have it at home, but still mainly affordable for clinical use [23,29]. Even though it's easier to find cheaper equipment for non-immersive VR, it's important to have in mind, that not all video games are suitable for the motor recovery treatment of these patients [31]. A big disadvantage is the fact that the environment cannot be manipulated to full engagement of the patient and also it can't make corrections related to the visual impairments, since with the immersive system one can make corrections on the movement regarding the differences between visual and vestibular feedback [13,29].

VR is mostly used in upper limb rehabilitation, where the best results were achieved. However, VR has broader recovery purposes as gait, balance, cognitive functions, and ADL through feedback- based mechanisms [13,31].

In summary, VR allows the possibility of personalized tasks, goal-orientated actions, extra motivation, improvement of patient's attention on the most relevant details to the task, all of that in a safe environment [13,22,32]. Evidence is still lacking regarding the effects of VR in stroke patients compared to conventional therapy, however, it is proven that the use of VR combined with conventional therapy is effective in restoring upper limb function on ADLs [13,31,32].

Robot therapy (RT)

What is defined as the robotic intervention is "the application of electronic, computerized control systems to mechanical devices designed to perform human functions" [4]. There are different types of robotic devices to help in the rehabilitation of stroke patients, and they can focus more on the lower limb (especially on gait training) or on the upper limb (usually robotic arms to help on ADLs) [33].

The use of robot equipment makes it possible to see the contribution of the different muscles separately during the daily living tasks and see the compensations and give feedback to avoid them [5]. Like the approaches mentioned above, none of the patients submitted to these interventions, should have suffered from the posterior cerebral artery stroke, since it can cause cortical blindness or visual agnosia, making it incompatible for patients to receive visual feedback [3].

Since one of the most common consequences of stroke is the hemiplegia and 30% to 66% of those remain with limitation on the arm function after 6 months, the studies about RT focus more on the upper limb which has shown better results [12,34]. If the patients do not have access to the proper treatment and stimulus they will be dependent on their daily activities which can lead to depression and low quality of life [6,35]. Besides the emphasis given to the upper limb, studies also have shown more results in two different stages of the condition: subacute and chronic [36,37].

In the subacute phase, best results have been shown with weight supported training to increase arm function [9]. If standard therapy and RT are administrated independently the results favours the patients treated with standard therapy. However, if RT is added to standard therapy the results are better than standard therapy alone [4,34,38].

Although RT allows patients to train independently, it is not viable to have robot equipment at home, since the prices remain high (we need to take into consideration not only the price of the equipment itself but also the maintenance costs). Evidence shows that RT alone is not enough for patients, and for that reason should be combined with other approaches, which makes it unaffordable [34,39].

Although RT already showed good results on the improvement of motor function of the upper limb, robots are not a substitution of therapists. In addition is still important to find a way that makes it sustainable and effective in more rehabilitation outcomes (balance, strength, cognitive) and that does not overload the work of health professionals, since it is a long term rehabilitation therapy [34,36].

Since all the approaches above (RT, VT and FPF) have a direct relation with visual feedback, we need to consider that they are only applicable to patients with no visual impairment.

Conclusion

Based on the studies mentioned above, the new approaches that have been more studied and shown more results are the VR and the RT. Both have shown results, specifically, on the improvement of the upper limb in motor function. These therapies rely on the attempt of taking advantage of the neuroplasticity process during the recovery period from the brain injury, what is especially important in the primary stage of the recovery.

The task-specific and context-specific training should be included in the rehabilitation, as well as intensity and repetition which are basic principles of neuroplasticity. Another important factor is the cognitive and emotional engagement, key elements in motor recovery. These aspects are paramount to motivation, since stroke recovery is a long-term process.

Other advantages of these interventions are the fact that they can be delivered at home, alone or in complement to other therapies, which assumes extreme importance due to the long-term recovery associated with stroke. In case therapy happens at home, the number of visits to the clinic can be reduced substantially, which can diminish the costs, travel time, and be more comfortable and convenient for the patient and their families.

Long-term recovery processes are often punctuated by lack of motivation, reduced compliance to home-exercise. The use of new technologies could counteract this aspect, as new therapies are frequently personalized, safe and enjoyable for the patients.

Although the benefits of these new approaches are not superior in several parameters to standard therapies, the studies described above show several benefits related to motor recovery of the upper limb.

In summary, the evidence reveals that the new therapeutic approaches (RT, MT, VR, FPF) should be used as a complement of the standard therapy. More studies need to be done to understand if there is a possibility to develop an intervention protocol that allows only the use of these technologies, which defines the intensity of the use, the stage that it is more effective, the amount and the type of programs/devices to use.

Bibliography

1. Lee D., *et al*. "Asymmetric training using virtual reality reflection equipment and the enhancement of upper limb function in stroke patients: A randomized controlled trial". *Journal of Stroke and Cerebrovascular Diseases* 23.6 (2014): 1319-1326.
2. WHO. Stroke, Cerebrovascular accident. Who, Health Topics.
3. Tadi P LF. "Acute Stroke (Cerebrovascular Accident)". Stat Pearls (FL) TI (2020).

4. Norouzi-Gheidari N., *et al*. "Effects of robot-assisted therapy on stroke rehabilitation in upper limbs: Systematic review and meta-analysis of the literature". *Journal of Rehabilitation Research and Development* 49.4 (2012): 479-496.

5. I Badia SB., *et al*. "Combining virtual reality and a myoelectric limb orthosis to restore active movement after stroke". *International Journal on Disability and Human Development* 13.3 (2014):153-166.

6. Kauhanen M-L. "Quality of life after stroke: Clinical, functional, psychosocial and cognitive correlates" (1999): 88.

7. S SDBKCTG. Middle Cerebral Artery Stroke. Med Scape.

8. Meretoja A., *et al*. "Trends in treatment and outcome of stroke patients in Finland from 1999 to 2007. PERFECT Stroke, a nationwide register study". *Annals of Medicine* (2011): 43.

9. Högg S., *et al*. "Upper limb strength training in subacute stroke patients: Study protocol of a randomised controlled trial". *Trials* 20.1 (2019): 1-11.

10. Kim J., *et al*. "Kinematic analysis of head, trunk, and pelvic motion during mirror therapy for stroke patients". *The Journal of Physical Therapy Science* 29.10 (2017): 1793-1799.

11. NHS. Recovery Stroke (2019).

12. Díaz-Arribas MJ., *et al*. "Effectiveness of the Bobath concept in the treatment of stroke: a systematic review". *Disability and Rehabilitation* (2019): 1-14.

13. Levin MF., *et al*. "Emergence of Virtual Reality as a Tool for Upper Limb Rehabilitation: Incorporation of Motor Control and Motor Learning Principles". *Physical Therapy* 95.3 (2015): 415-425.

14. Güçlü Gündüz A., *et al*. "The effects of early neurodevelopmental bobath approach and mobilizatioquadriceps muscle thickness in stroke patients". *Turkish Journal of Medical Sciences* 49.1 (2019): 318-326.

15. M Rsmll-E. "Bobath Concept - Theory and Clinical Practice in Neurological Rehabilitation". Blackwell Publishing (2009).

16. Pumprasart T., *et al*. "The effect of the Bobath therapy programme on upper limb and hand function in chronic stroke individuals with moderate to severe deficits". *International Journal of Therapy and Rehabilitation* 26.10 (2019).

17. Taub E and Uswatte G. "Constraint-Induced Movement therapy: Answers and questions after two decades of research". *Neuro Rehabilitation* 21.2 (2006): 93-95.

18. Morris DM., *et al.* "Constraint-induced movement therapy: characterizing the intervention protocol". *Europa Medicophysica* 42.3 (2006): 257-268.

19. Ju Y and Yoon IJ. "The effects of modified constraint-induced movement therapy and mirror therapy on upper extremity function and its influence on activities of daily living". *The Journal of Physical Therapy Science* 30.1 (2018): 77-81.

20. Barzel A., *et al*. "Comparison of two types of Constraint-Induced Movement Therapy in chronic stroke patients: A pilot study". *Restorative Neurology and Neuroscience* 27.6 (2009): 673-680.

21. Szaflarski JP., *et al*. "Cortical Reorganization Following Modified Constraint-Induced Movement Therapy: A Study of 4 Patients with Chronic Stroke". *Archives of Physical Medicine and Rehabilitation* 87.8 (2006): 1052-1058.

22. Fuentes MA., *et al*. "Combined Transcranial Direct Current Stimulation and Virtual Reality-Based Paradigm for Upper Limb Rehabilitation in Individuals with Restricted Movements. A Feasibility Study with a Chronic Stroke Survivor with Severe Hemiparesis". *The Journal of Medical Systems* 42.5 (2018): 87.

23. Henderson A., *et al*. "Virtual reality in stroke rehabilitation: A systematic review of its effectiveness for upper limb motor recovery". *Topics in Stroke Rehabilitation* 14.2 (2007): 52-61.

24. Van Peppen RPS., *et al*. "Effects of visual feedback therapy on postural control in bilateral standing after stroke: A systematic review". *Journal of Rehabilitation Medicine* 38.1 (2006): 3-9.

25. Hsieh HC. "Use of a Gaming Platform for Balance Training After a Stroke: A Randomized Trial". *Archives of Physical Medicine and Rehabilitation* 100.4 (2019): 591-597.

26. Barclay-Goddard R., *et al*. "Force platform feedback for standing balance training after stroke". *Stroke* 36.2 (2005): 412-413.

27. Silva MG., *et al*. "Development of a low cost force platform for biomechanical parameters analysis". *Research on Biomedical Engineering* 33.3 (2017): 259-268.

28. Saposnik G and Levin M. "Virtual reality in stroke rehabilitation: A meta-analysis and implications for clinicians". *Stroke* 42.5 (2011): 1380-1386.

29. Holden MK and Dyar T. "Virtual environment training: A New Tool for Neurorehabilitation". *Reports in Neurological* 26.2 (2002): 62-71.

30. Tieri G., *et al*. "Virtual reality in cognitive and motor rehabilitation: facts, fiction and fallaciesv". *Expert Review of Medical Devices* 15.2 (2018): 107-117.

31. Turolla A., *et al*. "Virtual reality for the rehabilitation of the upper limb motor function after stroke: A prospective controlled trial". *Journal of NeuroEngineering and Rehabilitation* 10.1 (2013): 1-9.

32. Laver KE., *et al*. "Virtual reality for stroke rehabilitation". *Cochrane Database Syst Rev* 11 (2017).

33. Bryce TN., *et al*. "Framework for assessment of the usability of lower-extremity robotic exoskeletal orthoses". *American Journal of Physical Medicine and Rehabilitation* 94.11 (2015): 1000-1014.

34. Kwakkel G., *et al*. "Effects of robot-assisted therapy on upper limb recovery after stroke: A systematic review". *Neurorehabilitation and Neural Repair* 22.2 (2008): 111-121.

35. Lo AC., *et al*. "Robot-assisted therapy for long-term upper-limb impairment after stroke". *The New England Journal of Medicine* 362.19 (2010): 1772-1783.

36. Hadjidj A., *et al*. "Wireless Sensor Networks for Rehabilitation Applications: Challenges and Opportunities". To cite this version: HAL Id: hal-00762929 Wireless Sensor Networks for Rehabilitation Applications: Challenges and Opportunities (2013).

37. Yoo DH and Kim SY. "Effects of upper limb robot-assisted therapy in the rehabilitation of stroke patients". *The Journal of Physical Therapy Science* 27.3 (2015): 677-679.

38. Uivarosan D., *et al*. "Effects of combining modern recovery techniques with neurotrophic medication and standard treatment in stroke patients". *Science of the Total Environment* 679 (2019): 80-87.

39. Todd H Wagner., *et al*. "An Economic Analysis of Robot-Assisted Therapy for Long Term Upper-Limb Impairment After Stroke". *Stroke* 42.9 (2011): 2630-2632.

Volume 12 Issue 6 June 2020