Wearable Devices and Virtual Reality for Neurorehabilitation: An Opportunity for Home Rehabilitation

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Abstract. In the present research we provide an overview of new solutions and problems of wearable and virtual reality devices for neurorehabilitation. A lot of commercial devices currently help physiotherapist to provide rehabilitation for reaching, grasping, walking and balance recovery, adapting cognitive load and providing challenging exercises. The present review highlighting the positive step made by the translational research and the unsolved problems. In particular, a critical step over to increase usability should be made in the future because wearable devices and virtual reality should represent a promising option to ensure a prolonged home rehabilitation.

1 Introduction

Clinicians and in particular neurorehabilitation are demonstrating a growing interest in the adoption of wearable technology when monitoring individuals in the home and community settings to optimize outcomes of rehabilitation interventions. It is widely accepted that timely access to rehabilitation is a key factor in the recovery for people who have survived a stroke. Therapy-based rehabilitation appears to improve independence in personal activities of daily living according to evidence based guidelines [1]. Solutions with inertial sensors is developed to be a cost-effective and accessible tool to the greatest possible number of service providers and patients. It is also recognized that an innovative use of technology may enable providers of stroke services to realistically meet the growing demographic demands of their services and facilitate acceptable or improved care outcomes for stroke patients in Europe. Several solutions with inertial sensors or virtual reality (VR) seek to achieve this specifically by

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optimizing the recovery of physical function and personal independence in order to reduce the overall socioeconomic burden of this disease. For these reasons, there is significant benefit in using a solution with inertial sensors to enhance the cost-effective provision of rehabilitation for this patients' population. In add they are low cost and easy to use technologies, and they can be useful in home rehabilitation. In this brief unsystematic review, we report some examples of technologies that currently help physiotherapist to provide inpatient and at home rehabilitation.

2 Materials and Methods

This is a brief unsystematic review of the technology used for rehabilitation in the hospital and at home

3 Results

Virtual Reality has emerged as a new approach to treatment in stroke rehabilitation settings over the last ten years. By simulating real-life activities, stroke patients are able to work in a more ecological setting than the hospital environment. It is possible to enrich the rehabilitation of cognitive motor content adapted to patient's cognitive levels [1]. There are two main types of VR: immersive: in immersive VR, the virtual environment is delivered by equipment worn by the user or the person is situated within a virtual environment. This fully immersive system gives the user a strong sense of presence through the use of head-mounted displays, special gloves, and large, concave projections to create the sense of immersion. Non-immersive VR is usually two-dimensional and delivered through a computer screen. The user can control what is happening on screen by using a device such as a, mouse, or sensor. After a stroke, mass practice, task-oriented arm training of the upper and lower limbs can help the brain "re-program" itself and form new neural connections. These new connections stimulate recovery of motor skills in patients following stroke. VR is the new must-have technology tool for gaming, training, or just trying to immerse yourself in a new and virtual environment. VR shows considerable promise as a safe, engaging, interactive, patient-centered and relatively inexpensive medium for neurehabilitation training [2, 3]. From the other side a VR based approach only based on commercial gaming platform founded that non-immersive virtual reality as an add-on therapy to conventional rehabilitation was not superior to a recreational activity intervention in improving motor function [4]. Whereas positive results were founded when VR devices were designed specifically for neurorehabilitation with a combination of technologies (wearable IMUs and VR) [5]. Furthermore, VR shows a lot of promise is motor and cognitive recovery of subjects affected by a central nervous system pathology. Most applications relate to indirect virtual reality, such as feedback, in addition to electromechanical devices and robots such as exoskeletons and end effectors. The scientific paradigms underpinning the system are in particular those of the "augmented feedback" principles that support the consolidated experience of the promotion of motor learning (knowledge of results and the performance). Finally, Virtual Reality application regards

the use of the Leap motion that can track the fine movements of both hands and fingers [6]. A wearable sensor based approach enables to detect a goal-directed limb or balance movements during an exercise or during a performance of ADL. An online reliable feedback can be provided to encourage the use of the affected limb. Commercial devices provide an interactive therapy solution to delivers functional exercises and tests for neurological patient, for orthopedic patients and athletes recovering from sports injuries. The game-based rehabilitation system offers engaging therapeutic exercises, stimulates the proprioceptive system, and uses audio and visual feedback to motivate patients to stick with their neuromuscular training. The inertial sensors to accurately measure body movements and track patients' performance in real time (biofeedback). The most important field of application of wearable technology are: gait analysis, stabilometry, instrumented clinical tests, upper body mobility assessment, daily-life activity monitoring and tremor assessment; with the focal point on the assessment of the outcomes of therapeutic interventions (i.e. physical and occupation therapy) with potential for gathering information suitable to adjust the intensity and modality of the prescribed therapeutic exercises. [7, 8]

4 Discussion

Virtual reality and biofeedback training has already been used in stroke rehabilitation, and previous studies supported that such technology could be effective. The mechanism we want to use even is multi-sensory feedback and repeated practices that could facilitate motor learning and brain neuroplasticity. Compared to conventional rehabilitation Virtual reality and biofeedback training could increase subject's motivation and satisfaction. Due to simple characteristics as easy to use by patients and their caregiver, the relative low costs, compared with other medical devices, wearable devices and virtual reality should represent a promising option to ensure a prolonged home rehabilitation. This is the case of virtual reality system employing infrared capture to translate the position of the hand into game play. [9] Virtual reality gives us the possibility to perform treatments even at home with adequate cognitive involvement, and to adapt the scenario of the exercise to the specific neuropsychological deficit (see executive functions, alert, AND NEGLECT). [2–10] Wearable based technologies allow to assess the quality of motor performance during in home rehabilitation exercises so that appropriate feedback can be generated for patients and physiotherapist to promote high-quality exercise. [11] During home rehabilitation a user-centered design is mandatory. This process should analyze usability concerns, user characteristics, environment, tasks and workload. [12] In add safety concern in particular during trunk, balance and leg training should be better explored with solutions that be adaptable according to patient's ability and the relative variability of skills. In fact, all neurological patients are at high risk of falls and a home training might increase this risk. In add a rigorous remote control of the quality and of the amount of therapy is needed if wearable and virtual reality based technologies would help patients and clinicians regarding home rehabilitation. Finally, it is important a daily monitoring of some neuropsychological aspects of the trained subjects (i.e. mood, motivation, participation, frustration), during rehabilitation provided through new technologies. [13]

5 Conclusion

The assessment of the impact of rehabilitation interventions on the daily life of individuals is essential for developing protocols that maximize the impact of rehabilitation on the quality of life of individuals. Wearable technology has the potential to overcome limitations of existing methodologies to assess the impact of rehabilitation interventions on the real life of individuals. Easy to use and non-invasive sensors can provide clinicians with quantitative measures of subjects' status in the home and community settings thus facilitating making clinical decisions concerning the adequacy of ongoing interventions and possibly allowing prompt modification of the rehabilitation strategy if needed.

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