ICRAN2013

International Conference on Recent Advances in Neurorehabilitation

March 7th - 8th, 2013
Valencia (Spain)

Proceedings

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First Edition, 2013

© Edited by:
Roberto Llorens Rodríguez

© of the present edition:
Editorial Universitat Politècnica de València
www.editorial.upv.es

ISBN: 978-84-9048-022-9 (printed version)
Ref. editorial: 6099

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46013 Valencia (Spain)

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10:10 – 10:50	**Hermano Igo Krebs.** Principal Research Scientist and Lecturer. Mechanical Engineering Department, Massachusetts Institute of Technology Cambridge, MA, USA. ***Robotic therapy after stroke: bright lights and dark shadows***
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11:30 – 12:10	**Catherine Mateer.** Board Certified Clinical Neuropsychologist and Professor of Psychology. Department of Psychology, University of Victoria, British Columbia, Canada. ***Applying principles of neuroplasticity to neurorehabilitation and use of technology***
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15:40 – 16:20	**David B. Arciniegas.** Beth K. and Stuart C. Yudofsky Chair in Brain Injury Medicine and Professor of Psychiatry, Neurology, and Physical Medicine & Rehabilitation, Baylor College of Medicine, and Senior Scientist and Medical Director for Brain Injury Research, TIRR Memorial Hermann, Houston, Texas, USA. ***Neuropsychiatric assessment during inpatient rehabilitation traumatic brain injury***
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11:40 – 12:20	**Evelyn Klinge.** Director of the Handicaps Innovations Technologiques entity. Ecole National Supérieure d'Arts et Métiers, Paris, France. ***Virtual reality for the brain: Cognitive assessment and rehabilitation***
12:20 – 13:00	**Albert "Skip" Rizzo.** Associate Director for Medical Virtual Reality. Institute for Creative Technologies, University of Southern California, California, USA. ***Interfacing with virtual rehabilitation***
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15:10 – 15:20	**Yukihiro Hara.** Dept. of Rehabilitation Medicine, Nippon Medical School, Chiba Hokusoh Hospital, Inzai City, Japan. ***The effects of electromyography-controlled functional electrical stimulation on upper extremity function and cortical per fusion in stroke patients***
15:20 – 15:30	**Rosa Ortiz Gutiérrez.** Dept. of Physiotherapy, Occupational Therapy, Rehabilitation and Physical Medicine. Faculty of Health Sciences. Rey Juan Carlos University. Alcorcón. Madrid-Spain. ***A telerehabilitation program by virtual reality-video games to treat balance and postural control disorders in multiple sclerosis patients***
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Keynotes and Short Oral Communications

Robotic therapy after stroke: bright lights and dark shadows

Hermano Igo Krebs

Massachusetts Institute of Technology, Department of Mechanical Engineering, Newman Laboratory for Biomechanics and Human Rehabilitation, Cambridge, MA, USA

The last two decades has seen a remarkable shift in the neuro-rehabilitation paradigm. Neuroscientists and clinicians moved away from the static perception that the brain is hardwired and of delivering movement therapy because of compassion to a new dynamic understanding that plasticity occurs and might be harnessed to remap or create new pathways. Capitalizing on this new understanding, we introduced a paradigm shift in the clinical practice in 1989 when we initiated the development of the MIT-Manus robot for neuro-rehabilitation and deployed it into the clinic in 1994 (1). Since the publication of the first controlled study with stroke inpatients (2) several studies have been completed with both stroke inpatients and outpatients demonstrating the potential of robotic therapy for the upper extremity. These results were discussed in different meta-analysis (see for example: (3)) and led ultimately to the 2010 American Heart Association (AHA) guidelines for stroke care which recommended that: “Robot-assisted therapy offers the amount of motor practice needed to relearn motor skills with less therapist assistance… Most trials of robot-assisted motor rehabilitation concern the upper extremity (UE), with robotics for the lower extremity (LE) still in its infancy… Robot-assisted UE therapy, however, can improve motor function during the inpatient period after stroke” (4). This is not an isolated opinion. The 2010 Veterans Administration/Department of Defense guidelines for stroke care came to the same conclusion endorsing the use of rehabilitation robots for the upper extremity. Here I will discuss different clinical results on whether robotic therapy has achieved a level of maturity to justify its adoption across the board to augment and magnify a patient’s potential of recovery.

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Applying principles of neuroplasticity to neurorehabilitation and use of technology

Catherine Mateer

Department of Psychology, University of Victoria, British Columbia, Canada.

The way rehabilitation professionals, organizations and institutions engage with clients in providing brain injury rehabilitation is changing quickly. The rate of change will need to accelerate to stay apace of a rapidly evolving neuroscience of rehabilitation and meet the challenge of providing effective and efficient care. Advances in our understanding of neuroplasticity, a vast array of new technologies and changes in way people communicate and share information present tremendous opportunities. Greater understanding of the factors that influence recovery, from genes to behavior, will increase the effectiveness and sophistication of interventions. New technologies and compensatory aids combined with precision outcome measurement and implementation science, will lead to more individualized and tailored interventions and more effective compensation and adaptation to the chronic effects of brain injury. These new developments will undoubtedly shape the future of client, family and community engaged rehabilitation.

The mirror mechanism and its clinical implications

Giacomo Rizzolatti

Dipartimento di Neuroscienze, Università di Parma, Italy

Humans are an exquisitely social species. Our survival critically depends on our ability to thrive in complex social situations. In the first part of my my talk I will present evidence that, in our central nervous system, there is a specific mechanism (mirror neuron mechanism) that allows us to understand the actions done by others, their intentions, and emotions. The mirror mechanism produces, in our brain, motor representations that reflect actions and emotions observed in others. Because we know the outcome of our motor representations, we have, through the mirror mechanism, an immediate, direct knowledge of what the others are doing and feeling. In the second part of my talk I will discuss the implications of these finding for understanding some neurological and psychiatric disturbances (autism in particular) and for rehabilitation.

Outcome After Mild Traumatic Brain Injury: Genes, Biomechanics, and Injury Context

Thomas W. McAllister, M.D.

Millennium Professor of Psychiatry and Neurology, Geisel School of Medicine at Dartmouth, Lebanon, New Hampshire, U.S.A

Clinical outcome following neurotrauma can be quite variable. Although injury severity correlates well with outcome measures such as mortality, correlations are less robust with other outcome measures. For example following a mild traumatic brain injury (TBI) the vast majority of individuals will recover, yet the rate of recovery varies and there is a small subgroup of injured individuals who show a surprising number of ongoing injury related symptoms and disability. This suggests factors other than injury severity play important roles in outcome.

This presentation will offer a neuro-biopsychosocial framework for understanding variation in outcome after mild TBI. Five critical domains will be discussed. First, structural and functional imaging studies in mild TBI will be presented as a means of understanding the nature and recovery trajectory of cognitive complaints and deficits after brain injury. Second, the interactive relationship between TBI and psychiatric illness will be discussed. The interaction of psychological and biomechanical stress in military personnel, as well as the shared neurobiological underpinnings of TBI symptoms and post traumatic stress disorder (PTSD) will serve as an illustrative example of the role that neurotrauma can play in the etiology of psychiatric disorders. Third, concepts important to understanding genetic influences on outcome after TBI will be presented, along with data suggesting a role for polymorphisms in several candidate genes. Fourth, the role of individual differences in the psychological domain will be presented. Finally, data from ongoing studies of collision sport athletes wearing helmets that monitor the characteristics of head impacts will be presented to highlight the importance of individual and injury-specific biomechanical factors in determining outcome after injury. Consideration of the full array of these factors is important for accurate clinical assessment and treatment.

Neuropsychiatric assessment during inpatient rehabilitation after traumatic brain injury

David B. Arciniegas, MD

Beth K. and Stuart C. Yudofsky Chair in Brain Injury Medicine
Executive Director, Beth K. and Stuart C. Yudofsky Division of Neuropsychiatry
Professor of Psychiatry, Neurology, and Physical Medicine & Rehabilitation
Baylor College of Medicine, and Senior Scientist and Medical Director for Brain Injury Research
TIRR Memorial Hermann

Cognitive, emotional, and behavioral problems are common among persons with traumatic brain injuries (TBI) in the early post-injury period. These neuropsychiatric disturbances complicate rehabilitation and may delay community re-entry and participation. Early identification and management of post-traumatic neuropsychiatric disturbances therefore is an important element of the rehabilitation process. TBI specialty rehabilitation centers have developed and promulgated a host of clinical and research measures with which to evaluate posttraumatic cognitive, emotional, and behavioral disturbances. Most of these measures yield detailed assessments of a limited subset of neuropsychiatric disturbances experienced by persons with TBI. Administration of the complement of measures needed to perform comprehensive neuropsychiatric assessment is logistically impractical in many inpatient rehabilitation settings. This impracticality is compounded by the relative paucity of neuropsychologists and/or neuropsychiatrists in community-based hospitals available to administer them as well as the relatively modest proportions of variance in functional status and rehabilitation outcomes for which they account. It therefore is important to identify highly informative methods of neuropsychiatric assessment that clinicians working in community-based rehabilitation hospitals can use easily and efficiently in their daily work with persons with TBI. Ideally, these methods will capitalize on training received by most clinicians during their early post-graduate years and involve the use of assessment tools that are applicable to a wide variety of conditions and clinical settings. We identified several bedside neurobehavioral assessments used commonly in other fields whose properties may meet the needs of clinicians working in both specialty and community-based TBI rehabilitation settings. This lecture will outline the background leading to their identification and present data demonstrating the feasibility, functional relevance, and predictive value of the brief bedside neurobehavioral assessment battery we constructed. The relationship between the elements of this battery to the TBI-related Common Data Elements initiatives in North America and

Europe as well as the Common Data Elements initiatives for other neurological conditions will be discussed. Finally, the opportunities to apply this battery in the service of community-based TBI clinical care, specialty care-level TBI research, and cross-condition clinical trial development will be considered.

Neuroimaging and rehabilitation outcome

Bigler, E.

Department of Psychology and Neuroscience Center, Brigham Young University, Provo, Utah, USA.

To date neuroimaging findings have provided only minimal information for the rehabilitation clinician in terms of making treatment decisions predicting outcome. Brainstem pathology is associated with poor outcome where size and location of pathology predict outcome but otherwise, even determining such metrics as lesion burden, location and size of abnormalities or volumetrics for brain pathology outside the brainstem have yielded inconsistent results in terms of predicting outcome. To date the problem has been that although neuroimaging could identify a lesion, measures that determined location and volumetrics provided only a modicum of information about the pathways affected and how neural networks were influenced. Contemporary neuroimaging utilizing magnetic resonance imaging (MRI) offer an array of image analysis tools that include automated image analyses for performing whole brain region of interest (ROI) volumetrics including cortical thickness, diffusion tensor imaging (DTI), functional MRI (fMRI) including resting state fMRI (rsfMRI) and perfusion abnormalities using arterial spin labeling techniques. Combining these tools provides methods for assessing the patency of networks and how and to what degree various forms of damage disrupt the network. Once the brain is injured dynamic patterns of change in the underlying neuropathology occur in ways that inform the ultimate outcome if sequential neuroimaging can be performed, where a baseline scan is obtained as close to the time of injury followed by repeat scanning. Techniques of neuroimage analysis and integration with neurorehabilitation outcome will be presented. Often since advanced research level neuroimaging is not an option for many undergoing neurorehabilitation, practical solutions on how to utilize what neuroimaging methods are available to the rehabilitation clinician will be offered.

Virtual rehabilitation applications: Making it work wherever the need is

Patrice L. (Tamar) Weiss

Laboratory for Innovations in Rehabilitation Technology, Dept. of Occupational Therapy, University of Haifa

People who have sustained neurological impairment have a lessened ability to cope with daily life challenges. The framework of the World Health Organization's International Classification of Functioning has encouraged a widespread shift from the traditional medical model to a social model of disability where complex physical, cognitive and social difficulties are recognized as impeding fulfillment of social roles (participation) due to health-related (body structures and functions) and socially-induced (environmental factors) limitations. In recognition of the importance of participation and empowerment in the rehabilitation process, clinicians aim to evaluate and treat clients under conditions that elicit realistic responses. However, for reasons of convenience, cost and safety, it is often not feasible to provide truly life-like opportunities for clients to perform in. Thus, neuro-rehabilitation clinicians seek to gain access to tools and techniques that go beyond conventional approaches yet retain their feasibility and validity.

Techniques based on virtual reality (VR) simulations have aimed to provide this capability for the past 15 years. Virtual reality includes the use of interactive simulations created with computer hardware and software to present users with opportunities to engage in environments that appear and feel similar to real world objects and events. Users interact with displayed images, move and manipulate virtual objects, within the simulated environment thereby engendering a feeling of “presence” in the virtual world. VR enables objective and accurate measurement of behavior in challenging, ecologically-valid and safe environments, while controlling delivery of stimulus and maintaining standardization of measurement protocols. Although the evidence is not yet conclusive, numerous studies indicate the strong relationship between performance within virtual and real environments as well as transfer of skills learned via VR to those need in real-life settings.

The aim of this presentation is to demonstrate how recently developed technologies have extended the repertoire of virtual tools now available to the clinician. We use Paul Milgram’s *virtuality* continuum, which describes a range of environments, from the purely real to the purely virtual, to frame a discussion of how varying degrees of mixed reality can add significantly to therapy for clients with neurological dysfunction. Clinical examples of *aug-*

mented reality, in which virtual data enhance real settings (e.g., via wearable technologies) and *augmented virtuality*, in which the real objects augment interactions with virtual environments (e.g., Tangible User Interfaces), will be provided.

Virtual Reality for the brain: Cognitive assessment and rehabilitation

Evelyne KLINGER, Ph.D., Eng

Arts et Metiers ParisTech, LAMPA – EA 1427, Angers-Laval, France

Following a Central Nervous System (CNS) trauma, there is an urgent need for efficient cognitive evaluation and rehabilitation. This process is often long and arduous, and the therapists face the challenge of finding effective and motivating interventions for the recovery of autonomy, notably in both Activities of Daily Living (ADL) and Instrumental Activity of Daily Living (IADL). Virtual Reality (VR) offering new paradigms for human-computer interaction, VR-based cognitive rehabilitation appears to provide an answer to this challenge. Functional virtual environments seem to be a possible way to overcome the limitations of the traditional approaches. The literature shows the importance of these virtual experiments for the development of skills and know-how (1,2,3). In fact, VR is able to provide opportunities to respond to and perform tasks in less complex ways that entail a simplified cognitive load, greater repetition, and progressive training in comparison to real-world tasks.

The talk will aim at offering an overview of concepts and research in the field of cognitive rehabilitation. After a critical review of the traditional approaches, the rationale for using VR in neuropsychological rehabilitation will be presented, more specifically in the context of executive functions. The assets of some VR-based tools used in rehabilitation centers will be highlighted. For example, they provide a quantitative and qualitative assessment in activities involving different cognitive skills and strategies used by the patients to adapt to the tasks. They also offer customized exercises allowing functions rehabilitation. VR assets and limits for cognitive assessment and rehabilitation will be discussed.

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Interfacing with Virtual Rehabilitation

Albert "Skip" Rizzo, Ph.D.

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Virtual reality (VR) has undergone a transition in the past 20 years that has taken it from the realm of expensive toy and into that of functional technology. When discussion of the potential for VR applications in the human clinical and research domains first emerged in the early-1990s, the technology needed to deliver on the anticipated "visions" was not in place. Consequently, during these early years, VR suffered from a somewhat imbalanced "expectation-to-delivery" ratio, as most users trying systems during that time will attest. Yet the idea of producing simulated virtual environments that allowed for the systematic delivery of ecologically relevant stimulus events and challenges was compelling and made intuitive sense for the future of rehabilitation. That view, as well as a long and rich history of encouraging findings from the aviation simulation literature lent support to the concept that testing, training and treatment in highly proceduralized VR simulation environments would be a useful direction for psychology and rehabilitation to explore. Fortunately, since those early days we have seen revolutionary advances in the underlying VR enabling technologies (i.e., computation speed and power, graphics and image rendering technology, display systems, interface devices, immersive audio, haptics tools, tracking, intelligent agents, and authoring software) that have supported development resulting in more powerful, low-cost PC-driven Clinical VR systems. Broadband internet access and mobile technologies have also driven opportunities for patients to engage in sophisticated rehabilitation activities that are longer limited to the physical confines of the clinic. Such advances in technological "prowess" and expanded accessibility have provided new options for the conduct of rehabilitation research and intervention within more usable, useful and lower cost systems. However, the key to clinical success always requires a thoughtful assessment of what is needed to foster proper interaction in VR that addresses a focused clinical objective. Many new high fidelity rehabilitation hardware options that leverage robotics and motion platforms are getting traction in the marketplace and have been successful in supporting interaction with clinic-based treatment systems. However, to produce the sheer amount of engaged repetition required for successful clinical outcomes, low cost VR systems that can escape the clinic and deliver rehabilitation activities in the home are needed. The creation of such systems requires the use of commodity off-the-shelf interface, tracking and display technologies to promote low-cost access. This presentation will provide an overview of the many ways that VR has evolved with advances in new software, interface, display and Virtual Human systems that will shape the future of rehabilitation.

Plasticity and response to action observation: A longitudinal fMRI study of potential mirror neurons in recovering stroke patients

Iris Charlotte Brunner PhD[1], Jan Sture Skouen PhD[1], Lars Ersland PhD[2], Renate Grüner PhD[3,4]

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Introduction

Reorganization of motor areas after stroke has been examined in numerous imaging studies, but little is known about reorganization processes in putative mirror neurons after stroke. Recently, treatment approaches targeting mirror neurons, such as action observation (AO) have been suggested as an approach to retrain arm motor function post-stroke [1]. However, it is unclear if potential mirror neurons are activated in a similar manner in healthy persons and patients with stroke, and if they change during the course of recovery.

The objective of this study was to examine AO induced neuronal activity in patients with impaired arm movement ability during a recovery phase of 3 months.

Methods

Eighteen patients (61 ± 12 years) with subcortical and cortical stroke lesions affecting arm motor function ability were scanned twice; 1-2 and 3 months post stroke (3T MRI, GE, US). Age and sex-matched control subjects (60.6 ± 11.9 years), with no history of neurological disease were scanned once. Task-dependent fMRI acquisitions included coordinated bimanual movements where participants had to twist a cylindrical device, and action observation where they watched a video showing alternating either movements or still images of a person performing the same task. Image data were analyzed using SPM8 (London, UK). An uncorrected significance threshold of $p<0.001$, with minimum spatial extend of 30 voxels, was applied in all analysis.

Patients underwent arm motor assessment on both test occasions with the Action Research Arm Test (ARAT) and the Nine Hole Peg Test.

Results

Most patients (n = 16) close to completely improved arm motor function from first to second exam, obtaining a score in the ARAT test of more than 50 points. Within 2 weeks post stroke, neuronal activity in response to the action observation condition revealed activation in distinct parietal and frontal areas, Fig.1. Notably, the inferior and superior parietal lobes (BA 40, BA 7) and the premotor cortex (BA 6) were involved, as well as the primary motor cortex (BA 4).

Three months after stroke the general extent of activated clusters had increased considerably. Most activated clusters were observed in the inferior temporal gyrus and the ventral anterior nucleus of the thalamus, which provides major input to the premotor cortex, and the medial dorsal nucleus associated with memory. Other movement-related areas, such as the premotor, supplementary and motor cortex (BA 4, BA 6) showed a spatially more extended response to action observation at the second exam.

The control subjects showed activation including the occipital cortex and distinct areas in frontal and parietal lobes corresponding to areas associated with the mirror neuron system (BA 40) and premotor cortex (BA 6).

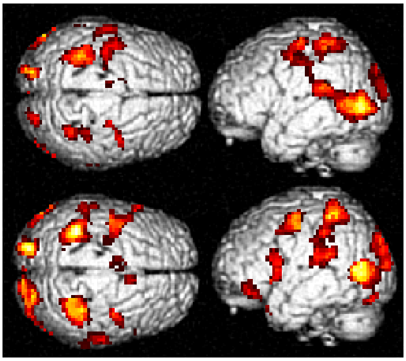

Figure 1. Observation of bimanual movement. Viewed from above (left) and left hemisphere (right): patient group two weeks post stroke (top row), and patient group three months post stroke (bottom row).

Conclusions

The most important finding was the general increase of activated clusters from 2 weeks to 3 months, concomitant with improved motor arm function. Interestingly, similar activation patterns in premotor cortex, the inferior frontal gyrus and the inferior parietal cortex are commonly reported in studies of mirror neuron systems [2]. Motor related areas were involved early and later after stroke. The results of this study corroborate that mirror neurons may constitute a possible access to the motor system.

Acknowledgements: This research was supported by the Grieg Foundation and the Rieber Foundation.

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The effects of electromyography-controlled functional electrical stimulation on upper extremity function and cortical perfusion in stroke patients

Yukihiro Hara[1], Shigeru Obayashi [1], Kazuhito Tsujiuchi [1], Yoshihiro Muraoka [2]

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Introduction

Electromyography (EMG)-triggered functional electrical stimulation is more effective than non-triggered electrical stimulation in facilitating upper extremity motor recovery, even in the chronic stage of stroke. We have applied EMG-controlled FES (EMG-FES) which induces greater muscle contraction by electrical stimulation in proportion to the integrated EMG signal picked up and motor point block for antagonist muscles as a novel hybrid EMG-controlled FES therapy in an outpatient rehabilitation clinic for patients with stroke[1]. Near-infrared spectroscopy (NIRS) is a recently developed neuroimaging methodology that is not influenced by electrical stimulation, and thus can be used to assess brain activity during FES in the rehabilitation room. This study was designed to investigate hemiparetic arm function and cerebral hemoglobin concentration during voluntary muscle contraction, EMG-FES and simple electrical muscle stimulation before and after 5 months of EMG-FES therapy in chronic stroke patients.

Methods

Sixteen chronic stroke patients with moderate to severe residual hemiparesis underwent 5 months of task-orientated EMG-FES therapy of the paretic arm once or twice a week. The objects used were chosen on the basis that they could be grasped by the patient with EMG-FES assistance at the beginning of the training period. Training of activities of daily living, such as washing, drying dishes and folding clothes, was also performed using EMG-FES device according to individual ability. Before and after treatment, arm function was clinically evaluated with the Fugl-Meyer (FM) assessment, maximal grip strength (GS) and cortical activation patterns with oxygenated hemoglobin (Oxy-Hb) concentration changes during voluntary muscle contraction (VOL), simple electrical muscle stimulation (ES) and combined voluntary muscle contraction and functional electrical muscle stimulation (EMG-FES) were assessed using multi-channel NIRS (Figure 1).

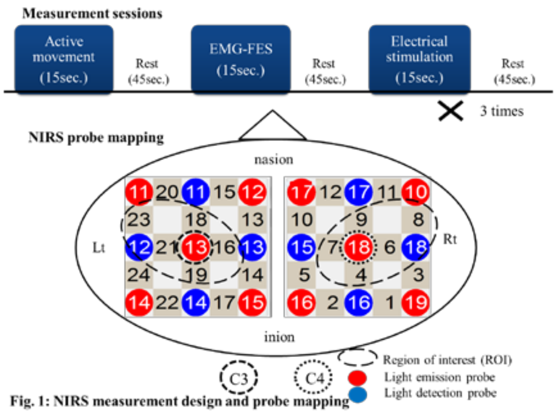

Fig. 1: NIRS measurement design and probe mapping

Results

Prior to EMG-FES treatment, most subjects showed dominant perfusion in the contralesional sensory-motor cortex (SMC). After EMG-FES treatment, SMC with dominant perfusion tended to change to the ipsilesional side. Cerebral blood flow in the ipsilesional SMC was greater during EMG-FES than during VOL or ES; therefore, EMG-FES caused a shift in the dominant brain perfusion from the contralesional SMC to the ipsilesional SMC (Figure 2). After EMG-FES therapy, arm function improved in most patients, with some individual variability, and there was significant improvement in FM score and maximal GS. Clinical improvement was accompanied by an increase in ipsilesional SMC activation during VOL and EMG-FES condition. The increase in ipsilesional SMC activation was moderately correlated with the change in FM score and GS.

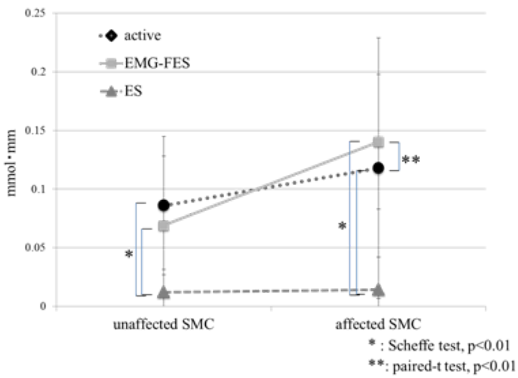

Fig. 2: Oxy-Hb increase at primary sensory motor cortex (n = 16)

Conclusions

These results suggest that the EMG-FES may have more influence on cortical perfusion than voluntary movement or electrical stimulation alone. The fact that the degree of clinical improvement after treatment with EMG-FES was paralleled by changes in cortical activation supports the assumption that treatment-driven clinical improvements in chronic stroke patients are directly related to reorganization at the cortical level[2]. The sensory motor integration that occurs during EMG-FES therapy might facilitate the perfusion of the ipsilesional SMC and result in functional improvement of hemiparetic upper extremity, as revealed by fMRI[3].

Acknowledgements: The authors wish to thank the occupational therapists in the department of rehabilitation medicine, Nippon Medical School, Chiba Hokusoh Hospital, for their cooperation of EMG-FES therapy and measuring NIRS study. This research was funded by Category "B" Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science (Grant no. 20300198). The authors declare that they have no competing interests for this study.

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A telerehabilitation program by virtual reality-video games to treat balance and postural control disorders in multiple sclerosis patients

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Introduction

Multiple sclerosis (MS) is a demyelinating degenerative disease of the central nervous system and it is the most common cause of disability in young people (1,2). Balance and postural control disorders are among the most frequent motor disorder symptoms associated with multiple sclerosis, which require of continuous manner of rehabilitation treatment (3-6); however the access to rehabilitation services is limited.
This study aims to demonstrate the potential improvements in balance and postural control among patients with multiple sclerosis who complete a virtual reality telerehabilitation program that represents a feasible alternative to physical therapy for situations in which conventional treatment is not available.

Methods

Participants: 50 patients with multiple sclerosis mean age 41.28 ± 7.38 year and an EDSS between 3.5-5 were recruited using consecutive non-probability sampling, from Demyelinating Diseases Unit of the Neurology Department at San Carlos University Hospital (Madrid, Spain).

Intervention: The control group (n = 25) received individual physiotherapy treatment twice a week (90 minutes per week) at the Multiple Sclerosis Madrid Association.

The treatment was based on active-assisted mobilization, muscle-tendon stretching, and static and dynamic balance rehabilitation exercises. Participants in the experimental group (n = 25) received individual telerehabilitation treatments (7-11) using the Xbox 360TM console with MicrosoftTM Kinect following a protocol based on three commercial gaming software (Kinect-Joy ride, Kinect-Sport and Kinect-Adventures) (Figure 1).

The protocol proposed tasks included key aspects of postural control such as the alternating load distribution, changes in direction, multidirectional movement, reaction speed, hand-eye coordination, foot-eye coordination

(Figure 2) (12-19). Participants attended 40 sessions at intervals of four sessions per week (100 minutes per week) and these sessions were monitored via videoconference. The treatment schedule lasted 10 weeks for both groups.

Figure 1. Avatar figure provided by Xbox 360TM console with Microsoft^{TM} Kinect

Figure 2. A multiple sclerosis patient practicing the telerehabilitation program at home

Measures: A computerised dynamic posturography (Sensorial Organization Test) (20) and observational clinical scales (Berg scale and Tinetti scale) were used to evaluate all patients at baseline and at the end of the treatment protocol.

Statistical analysis: An analysis of variance (ANOVA) was used to compare the pre- and postintervención differences using the group parameters (Experimental Group and Control Group) as the between-subject factor and the study variables as within-subject factors for each of scales. The significance threshold was set at $P \leq 0.05$, and 95% confidence intervals were obtained for each test.

Results

An ANOVA revealed significant between-group post-treatment differences in the composite equilibrium score percentage from the Sensory Organisation Test ($F= 37.873$; $P<0.001$) showed an improvement in the experimental group. In this sense, an ANOVA revealed significant between-intervention-group differences in the contribution of the vestibular system ($F=12.156$; $P<0.001$) and in the ability to accept incorrect visual information expressed by the visual conflict parameter ($F=15.05$; $P<0.000$) which demonstrates that the experimental group made better use of these informations at post-intervention compared with the control group.
Furthermore, an ANOVA revealed significant between-group post-treatment differences in Berg scale ($F=37.259$; $P<0.001$) and in the Tinetti scale ($F=46.898$; $P=0.002$) showed an improvement on balance and postural control.

Conclusions

Our results demonstrated that a telerehabilitation program based on a virtual reality system allows one to optimise the sensory information processing and integration systems necessary to maintain the balance and postural control of people with multiple sclerosis.
In addition, we suggest that the virtual reality program discussed in this research enables anticipatory postural control and response mechanisms and might serve as a successful therapeutic alternative in situations in which conventional therapy is not readily available.

Key Words: Balance, Multiple Sclerosis**,** Postural Control, Telerehabilitation, Video Games, Virtual Reality.

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The Importance of Visual Feedback: Mirror and Virtual Therapy for Phantom Limb Pain in Upper Extremity Amputees

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Introduction

Shortly after amputation of a limb, 99 percent of all patients experience non-painful phantom limb sensation (1) and up to 80 percent will also experience phantom limb pain (PLP) (2) The duration of each PLP episode can range from seconds, to hours, to constant pain (1).

Despite the high prevalence of PLP among amputees, there currently is no standard effective treatment (pharmacologic or otherwise) for the condition (3) However, several studies have reported on the success of mirror therapy in alleviating or eliminating PLP (4,5) Mirror therapy creates the illusion of two intact limbs through strategic placement of a mirror between the intact and residual limbs, providing the patient with visual feedback that the amputated limb is healthy and able to perform motor movements. Visual feedback appears to be critical to modulating pain relief in mirror therapy (6).

With the importance of visual feedback and cortical reorganization in mind, we designed two clinical studies assessing the efficacy of mirror therapy and virtual reality therapy in reducing PLP in upper extremity amputees. Virtual reality therapy was achieved using a virtual integrated environment (VIE), which produces an on-screen, real-time simulated limb system via myoelectric input from the amputee’s residual limb.

Methods

A total of 18 unilateral, upper extremity amputees (14 mirror, 4 control, and 4 VIE subjects) were recruited from Walter Reed and Brooke Army Medical Centers. Volunteers were randomly assigned to control (covered mirror therapy or mental visualization) or mirror groups and were asked to perform 15 minutes of therapy daily for 4 weeks. VIE participants followed the movements of a three-dimensional simulated limb for 15 minutes at each of

20 study visits. Participants completed pain questionnaires at each session, including the 100-mm Visual Analog Scale (VAS) and Short Form-McGill Pain Questionnaire (SF-MPQ).

Results

***Mirror Therapy*:** Eighty percent of subjects receiving mirror therapy had a decrease in pain (p<0.05) from 43 ± 17.8 (mean ± SD) to 25.4 ± 24.5 mm. Seventy percent of subjects reported a decrease in pain symptom and severity, as measured by the SF-MPQ, although the group as a whole did not experience a significant change (p>0.05). In addition, there was a significant decrease in daily time spent in pain (p<0.05) from 1022 ± 673 to 448 ± 5645 minutes. Controls did not have decreased pain (p>0.05).

***Virtual Therapy*:** Fifty percent of VIE users had decreased VAS pain scores. Seventy-five percent of patients reported a decrease in pain symptom and severity, as measured by the SF-MPQ.

Conclusions

Mirror therapy resulted in significant decreases in PLP amongst upper extremity amputees. Additionally, mirror therapy significantly reduced participants' daily time spent in pain and reduced pain symptoms and severity in 80% of participants. Preliminary data indicates that VIE participants also had decreased PLP. However, a larger sample size is needed to draw definitive conclusions about the effects of VIE treatment on PLP. These findings support the use of mirror therapy as initial treatment for PLP. While mirror therapy requires a patient to have a unilateral amputation, the VIE has the potential to be used for PLP treatment in bilateral upper extremity amputees.

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Virtual rehabilitation applications in motor interventions

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Virtual rehabilitation researchers have traditionally concentrated on either cognitive (memory, focusing, problem solving, dual-tasking), emotive (depression, phobias) or motor (balance, range of motion, strength, dexterity, and extremity function) deficits. However patients' mind, soul and body are interconnected elements of a whole. Burdea (1) proposed the idea of integrative virtual rehabilitation to unify the different fields of research and accreditation, and reduce costs for the client. Economies would be even larger if such integrative virtual rehabilitation happened in the home.

One of the first examples of an integrative virtual rehabilitation system was the BrightArm (2), a low friction tilting robotic table coupled with custom adapting motor/cognitive games. Unlike cognitive training done on the web (ex. Lumosity), BrightArm games involved large movements of the more involved arm coupled with grasping to induce strengthening and mediate dual tasking. The emotive side was addressed by making games always winnable, and providing visual and auditory rewards upon completion.

The next evolution in integrative virtual rehabilitation is to involve not one, but both arms. Bimanual interaction is a natural inducer of split-attention scenarios, increasing cognitive load and indirectly causing more blood flow to the brain. Better irrigation as well as the increased number of cross-lobe neural connections are conducive of brain plasticity thus faster restoration of motor function. While traditional motor training of stroke population is predominantly uni-manual, many daily activities are bimanual. Furthermore, studies have shown that training of the *less involved* upper extremity helped reduce functional deficits in the more involved arm and improve performance in bilateral tasks (3). This may be due to rewiring from the intact hemisphere to the affected one. All these studies point to the need to develop a bimanual integrative virtual rehabilitation environment, one that preferably can be used in the home. The BrightArms system (formerly called RABIT for Repetitive Bimanual Integrative Therapy) has recently been developed (4). It has undergone initial feasibility evaluation on patients chronic post-stroke. Data is currently being analyzed.

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Balance and postural control: The role of the new tecnologies

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As new technologies become commercially available there is often an explosion in their application to rehabilitation. But is any individual who has access to a video game and a computer truly engaged in virtual rehabilitation? If virtual rehabilitation is to develop into a field of research and treatment with effective outcomes we need to identify how acting within the virtual environment modifies performance. Does practice in virtual reality transfer to skill in the physical world? How important is that transference to rehabilitation gains? How much exposure to the virtual environment is necessary or detrimental for learning? How complex should the virtual world be to obtain sustained motor learning? Is motivation and repetition enough, or is there some unique form of central processing that occurs in virtual reality that will support learning and recovery of motor function?

These questions will be explored in the context of balance and postural control. One of the most pervasive disabilities is postural instability because it can arise with changes in both the central and peripheral nervous systems and in the skeleto-muscular system. It is asserted that training postural control using a dynamic platform has not resulted in significant functional carryover because of the limitations imposed on bringing real world variables into that paradigm. This presentation will explore the role that virtual reality technology can play in the assessment and treatment of balance disorders as we progress from a linear model of closed loop, feedback dependent control to current models of sensory weighting and sensory fusion. Data will be presented to demonstrate that practice in a virtual environment exerts neuroplastic changes that result in learning and improved balance control. The impact of particular components of virtual reality on postural control and perception of vertical across the lifespan will be discussed. Evidence will be presented to demonstrate that virtual reality can be used as an intervention and an outcome measure of balance and postural control.

Posters

The assessment of medio-lateral movements After Brain Injury

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Introduction

Motor disabilities in Acquired Brain Injury patients (ABI) are limited to postural control, balance disturbances, mobility and functional disorders in lower and upper limbs ((1)).

To quantify static and dynamic balance there are specific clinical tests and computerized dynamic posturography (CDP) that analyses the patient's center of pressure, anterior-posterior or medio-lateral weight transferences, as well as medio-lateral mean amplitude movements ((2)). At present, clinicians use force plates in traditional motor rehabilitation (TMR), such as Balance Master and Equitest ((4)), but the main drawback deals with the high cost involved (from $50,000 to $100,000).

The effectiveness of Virtual reality in ABI patients produces significant effects in the rehabilitation motor process, with visual and auditory feedback in the therapeutic sessions that offers playful and motivational Virtual Environments (VE) ((4)).

Currently, there are a lot of studies that analyze Virtual Motor Rehabilitation (VMR), in conjunction with low-cost devices, to increase postural control and balance disorders ((5),(6)).

In this study we test medio-lateral weight-transferences in ABI patients, using a specific VE to obtain the mean amplitude (MA). We hypothesized that patient's MA performance increases along their rehabilitation sessions.

Methods

In this study, we created a novel application called Vestibular Two Virtual Rehabilitation (V2R). It is a system that uses a low-cost device, the Nintendo® Wii Balance Board® (WBB), based on the International standard ISO 9999:2011 ((7)) and focused on the following levels: “04-48-24: devices that provide an auditory, visual or tactile response according to a specific physical response”, “05-3: assistive products for training activities of daily living (ADL)”, “12-31-21: force platforms to move a subject in standing position to walk a short distance”.

The experimental study was composed of a group of sixteen ABI patients. The protocol consisted of twenty virtual sessions during three weeks using playful V2R. In each session subjects played with a specific Virtual Environment in standing position, to analyze medio-lateral weight-transferences and to obtain mean amplitude movements along the experiment.

Results

To obtain the statistical analysis, we performed a repeated measure analysis of variance by time with 95% confidence interval, p<0.05, in two points of time (Initial and Final Evaluation). We showed significant improvements over time (p=0.026) in lateral mean amplitude. Results are showed in Figure 1.

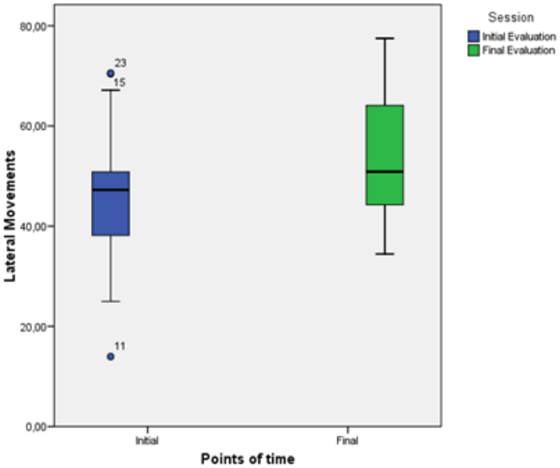

Figure 1. Lateral mean amplitude in sub-periods T1 and T2

Conclusions

The displacement of ABI patients in VMR process produces an assessment measure of postural control. In this study, results demonstrate significant improvement over time in lateral amplitude. Future studies will be focused on the analysis of follow-up periods of time.

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The role of Response Time in acute and chronic ABI Patients

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Introduction

One of the main problems in Acquired Brain Injury patients (ABI) deals with physical and cognitive disabilities, limited movements, muscle weakness and also spasticity ((1)). These problems produce slow movements and mobility reduction due to mental process disturbances ((2)).

The main objectives of motor rehabilitation in ABI patients are focused on recovery motor and cognitive injuries. Virtual Reality applications using low cost devices such as the Nintendo® Wii Balance Board® (WBB) ((6)) have been developed recently to increase the performance of traditional motor therapies ((4)).

The following parameters have been used to evaluate mobility reduction: the step reaction time (SRT) is the time between the target showing and the patient foot movement, the movement time (MT) is the time that the subject needs to place his foot on the platform and the response time (RT) is the total time between the presentation of the target and the completion of the motor action (sum of SRT and MT) ((5)).

The principal aim of the present study was to analyze the limited movements in acute and chronic ABI patients. We hypothesized that patient's RT performance increases along their rehabilitation process.

Methods

In this study, we selected a low cost device, the WBB that accomplishes the International standard ISO 9999:2011 focused on subjects with disabilities, physicians or therapist and researchers ((7)).

On the other hand, we used a specific tool to rehabilitate ABI patients, Vestibular Virtual Two Rehabilitation (V2R). This application was programmed to store different time intervals each millisecond: the point in time in which the virtual object was shown (T1), the time that ABI patient stood on the WBB (T2), and time in which the patient removed the foot from the WBB (T3). Using these times it was possible to obtain the MT (T2-T1) and also the RT (T3-MT).

The experimental study was composed of: a control group with ten acute ABI patients and an experimental group with ten chronic ABI patients. The procedure was performed as follows: to realize 20 virtual rehabilitation sessions playing with a specific virtual game of V2R to step on the WBB around 30 minutes.

Results

The analysis obtained was carried out by the use of repeated measure analyses of variance by group, time and group-by-time using 95% confidence interval, $p < 0.05$, in three points in time. Results are showed Table I.

Table I: Response time in seconds

	Initial Evaluation	Second Evaluation	Final Evaluation	Significance T0-T1	Significance T1-T2
RT					
Acute	1.48±0.41	1.25±0.41	1.20±0.35	T(p=0.000)	T (p=0.000)
Chronic	1.40±0.32	1.08±0.35	1.03±0.36		

Conclusions

The results demonstrated that using VMR therapies in ABI patients increases the RT performance and their limited movements. Future studies will be focused on the analysis of RT in the paretic leg versus non-paretic leg.

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Balloon Analogue Risk Task (B.A.R.T) as a measuring task of decision making in Acquired Brain Injury (ABI)

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Introduction

Although the alteration of the decision making ability is one of the most frequent consequences following an injury in the frontal lobe, there are few known instruments to evaluate decision- making in patients with acquired brain injury (1).
Most of the instruments designed for the evaluation of decision making are difficult to use because of the complexity of its execution. Such instruments require the subjects to have a well preserved ability of complex verbal comprehension, as well as a good functioning of most of the executive functions. Nowadays, the most widely used and validated instrument for the evaluation of such ability is the Iowa Gambling Task (IGT), introduced by Bechara, Damasio, Tranel and Anderson (2), researchers from the University of Iowa. The IGT is a task designed to simulate real life decision making processes, in which the patient must face an activity of punishment and reward. The subject must be capable of understanding the logic of the game and of differentiating between favourable and unfavourable options of the activity, which contribute or hinder the final objective of the task.
More recently, Lejuez et al (3), have designed the B.A.R.T test, a more simple computerised task, used in the field of addictions, psychopathology and risk behaviours, for the decision- making evaluation.
The main objective of the test consists in facing the patient with a risk situation, in which a simple decision must be taken in order to obtain as much money as possible. It is an easier test than IGT, not only as far as its execution is concerned but also for its comprehension, which represents an enormous advantage in its application on patients with brain injuries.

The aim of this study is to test if the Balloon Analogue Risk Task (B.A.R.T) is a suitable instrument to assess decision making in acquired brain injury.

Methods

30 patients with Acquired Brain Injury (ABI) were assessed with the Balloon Analogue Risk Task (B.A.R.T) and with the Iowa Gambling Task (IGT). The same tasks were administered to a control group of 30 healthy subjects and a comparative study was later carried out between both groups in order to evaluate the possible differences in the obtained results. There was also a study carried out in order to evaluate the possible correlation of the two tests (B.A.R.T) and (IGT) in the two groups.

Results

Differences were found in the B.A.R.T task, between the clinical group and the control group: in Pulsations T (p=0,001, CI95%= 126,12-469,34); in explosions T of the clinical group and explosions in the control group (p=0,007, CI95%=0,81-4,99). There were also differences between BARTS of the clinical group and BARTS of the control group, (p=0,000, CI95%=537,21-1575,46).

No correlation was observed in the clinical group between: Net T and Pulsations T (p=0,32, r2=-0,21); Pulsations T and AB (p=0,38, r2=0,19); Total$ BART and Total$ IGT (p=0,53, r2=-0,13). In the control group there was no correlation between: Net T and Pulsations T (p=0,73, r2=-0,07); Pulsations T and AB (p=0,95, r2=0,01); Total$ BART and Total$ IGT (p=0,81, r2=-0,05).

Conclusions

We conclude that the B.A.R.T test is a sensitive instrument for detecting differences in the performance between a control group and a group of patients with ABI. Nevertheless, the scores obtained with this test do not correlate with the scores of the IGT test, suggesting that both tests measure different aspects of decision-making.

Acknowledgements: Everyone who has helped and believed in this paper.

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Upper limb neurorehabilitation in stroke patients: Evidence-based efficacy.

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Aim

To revise and analyze the evidence-based efficacy of therapeutic interventions used for upper limb motor recovery in stroke patients.

Method

A review was carried out of articles and abstracts published over the last ten years in Medline, PubMed, Tripdatabase, The Cochrane Library, and PEDro databases.

Study selection included randomized controlled trials reviews, and randomized controlled trials in acute, subacute, and chronic stroke patients.

Selection included clinical trials with significant sample sizes. Analysed studies used recognised motor and functional assessment scales (i.e. Fugl-Meyer, Barthel, FIM, Jebsen Taylor hand function, Box and block test). Evidence-based levels were set up following classification of evidence-based medicine of Oxford (CEBM).

MesH key words used were: stroke, rehabilitation, motor recovery, upper limb, efficacy, neuroplasticity.

Results

Efficacy of neurodevelopmental therapies such as Bobath, are not superior compared to other therapeutic interventions used in upper limb Rehabilitation of post-stroke patients (level 1a).

Repetitive task training may induce neuroplastic changes in primary motor cortex and secondary motor areas. Because of that augmented efficacy on activities of daily living (ADLs) and motor function shoud be expected. However, there is no evidence of superior efficacy to achieve significant improvements in hand dexterity, and ADLs performance, when this therapy is compared to classic neurodevelopmental techniques.

There are conflicting evidences (level 4) about bilateral arm training improves upper limb function and ADLs performance. Furthermore, bilateral motor training is not superior when compared to unilateral training.

Motor imagery and mirror therapy may contribute to improve upper limb motor function. Both showed slight evidence of efficacy when they were used as adjunct therapies in association with other routine neurrehabilitation procedures.

Constraint induced movement therapy (CIMT) induces brain reorganization by changing cortical motor maps. There is strong level of evidence (level 1a) about its efficacy in subacute and chronic stroke patients with mild upper limb paresis. Patients with visuospatial neglect could also benefit from this therapy. CIMT efficacy in acute stroke patients still remains unclear. It is uncertain whether early onset of treatment could bring increased functional long term improvements.

Patients treated with functional electrostimulation FES achieved significant improvements in arm strength and motor function (level 1a). There are conflicting evidences regarding significant efficacy of FES to increase hand function or diminish disability.

Robot assisted therapies are useful in subacute and chronic stroke patients with mild or serious upper limb paresis. Patients treated with robotic therapies improved proximal motor function (level 1a). However, significant improvements in hand dexterity or ADLs performance still remain unclear.

There is a mild evidence level of efficacy (level 1b) of immersive virtual reality systems, for upper limb motor recovery in subacute and chronic stroke patients. There are not enough number of clinical trials carried out with acute stroke patients to achieve definitive conclusions.

Brain computer interfaces (BCI) is a new promising technology that could be used in stroke neurorehabilitation. Some studies show efficacy of BCI technology using output devices as FES, robots, and orthosis. BCI increased hand motor function, although there were non- significant differences between groups.

Conclusions

Whereas neurodevelopmental techniques are not satisfactory enough to improve upper limb motor function in stroke patients, intensive use oriented-task therapies such as CIMT, mirror therapy, robot-based therapies, or virtual reality systems could improve motor function and ADLs performance on the basis of promoting and enhancing neuroplasticity mechanisms.

Preliminary results suggest good expectations for BCI as a promising tool useful to develop new therapeutic applications that could increase upper limb motor function augmenting interaction between stroke patients and environment.

Using the ICF in stroke clinical practice: efficacy of an individualized rehabilitation program

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Introduction

Stroke is particularly relevant in our society for being the third leading death cause and the main cause of permanent disability in adults in Spain (1). Its effects involve motor functions, cognitive performances, behavioral or psychosocial functioning, and it has critical consequences in social and working daily activities.

The neuro-rehabilitation is a therapeutic approach based on transdisciplinary work accompanying patients and relatives with the aim of decreasing the level of disability by stimulating recovery (2-4) through patient-centered rehabilitation programs. In order to tailor an individualized rehabilitation program (IRP) is needed to quantify and qualify the therapeutic patients' progress. In this context, the International Classification of Functioning, Disability and Health (ICF)(5) focuses on the classification of the patient's personal factors, environment and activities. This is a modification of the International Classification of Impairments, Disabilities and Handicaps, being an ideal tool in order to classify the initial situation of stroke patients, their evolution and to measure the changes occurred at different stages during the rehabilitation process.

In this study, the objective was to evaluate the effectiveness of an IRP based on the ICF model in stroke patients.

Methods

A transdisciplinary rehabilitation team assessed 36 stroke subjects treated through an IRP based on preserved abilities and personal and contextual factors. The sample was divided into two groups: less than five year evolution (24 subjects) and more than five years of stroke evolution (12 subjects).

The program was conducted during six months with an average of 10 individual sessions per week of neuropsychology, speech therapy, occupational therapy and physiotherapy. The evaluation is performed through the stroke ICF Core-Set (6) before and after the IRP by means of administrating standard batteries and the ICF qualifiers. In order to assess the IRP effectiveness, body functions, activities and environmental factors outcomes were compared before and after treatment using their means. Following this process, those items which had a significant improvement were correlated between them.

Results

The patients with less than five years of evolution showed a major improvement after treatment. This is expressed by significant pre- and post-IRP differences in the CIF items selected and measured. Improvements were found in the Activities of: *Speaking* (p<0.01), *Eating* (p <0.016), *Walking long distances* (p <0.005), *Walking on different surfaces* (p<0.001) and *Walking around obstacles* (p <0.008). Improvements found in Body Functions: *Reception of spoken language* (p<0,003), *Reception of written language* (p<0,01), *Expression of spoken language* (p<0,015), *Expression of written language* (p<0,007), *Expression of sign language* (p<0,028), *Power of muscles of one side of the body* (p <0.03) and *Power of muscles in lower half of the body* (p <0.031).

We obtained significant correlations between the Activities of: *Walking long distances* (p <0.005), *on different surfaces* (p <0.001) and *around obstacles* (p <0.008), *Speaking* (p <0.01) and *Eating* (p<0.016) as well as Body Functions involved in the previous activities: *Reception and Expression language*, *Integrative language functions* (p <0.003) and *Muscle power functions* (p <0.03).

Conclusions

The use of the ICF as a clinical neuro-rehabilitative descriptive tool in a stroke individualized rehabilitation program shows improvement in terms of functionality and autonomy in the activities measured.

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Mirror neuron system activity in the movement of the human gait

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Introduction

Available evidence shows that observation of the actions performed by others is directly connected with the activation of the motor system in the subject who is observing. This finding inexorably sheds light on the contribution of the mirror neuron system (MNS), which plays an active role in so many facets of human behavior (2,3).

The main objective/goal in this study was to examine brain activity and mirror neuron participation when imagination and gait motion observation stimuli were provided. For this purpose, electroencephalograms were employed as instruments of analysis.

Methods

Cross-sectional, observational and descriptive design.

Sample: 41 participants (30 women, 11 men), students at Universidad Católica San Antonio de Murcia, aged 18-40 years old.

Electroencephalography (EEG) data were obtained by means of a 32-channel encephalograph. EEG data were collected from all participants at two time points when participants were required to:

1. Imagine with their eyes open that they were walking.

2. Imagine with their eyes open that they were walking after having watched a video in which someone was walking

Data collection, editing, quantitative analysis, source location (Low-resolution Electromagnetic Tomography-LORETA method), tomographic visualization and statistical analysis (Hotelling's T2 test) were carried out.

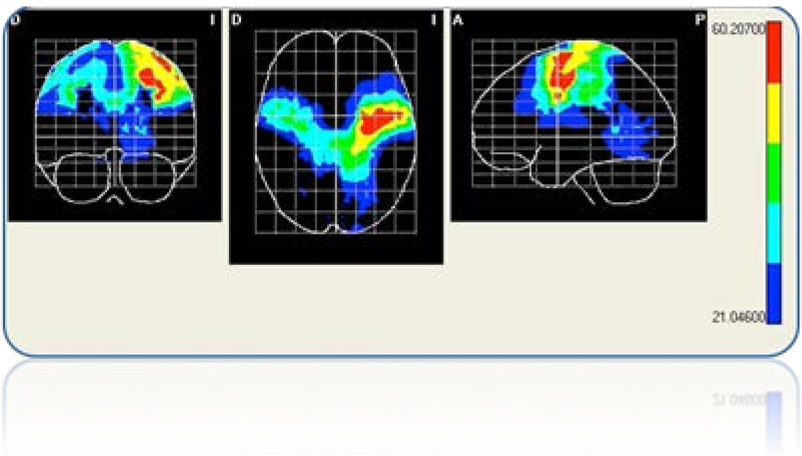
Results

Significant differences between LORETA solutions 1 and 2 are projected on the left precentral gyrus, the left medial frontal gyrus, left superior frontal gyrus, the left paracentral lobe, the left precuneus, right precentral gyrus, the left caudate nucleus, left postcentral gyrus, the right paracentral lobule, the left calcarine fissure, the right posterior cingulate gyrus, the right superior frontal gyrus, the left posterior cingulate, the left lingual gyrus, the right caudate nucleus and the left fusiform gyrus (1).

Conclusions

The use of electroencephalogram, employing low-resolution electromagnetic tomography, proves to be useful in identifying high activity areas in the brain cortex when imagination and gait motion observation procedures are carried out.

The use of video [images] is useful in helping the activation of mirror neuron system, with major activity in the motor areas of the alpha bands.



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Application of neurofeedback techniques in patients with motor function impairment after a stroke.

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Introduction

Neurofeedback training is a proven technique to modify psychophysiological brain activity (1,2,3). Its application is based on a brain-machine interface capable of decoding a signal from the brain to produce a desired response (4). By capturing abnormal activity in a certain region of the brain and giving back to the patient the appropriate information, brain-computer interfaces can operate specifically to increase or decrease brain activity in these regions therapeutically. It is known that motor recovery of patients with hemiparesis after a stroke can be enhanced if a reorganization of brain areas that are involved in motor behaviour in both the damaged and the healthy hemisphere occur (5,6). In this case, we should train patients in learning to reactivate the premotor area (7).

The present study was aimed to study the usefulness and effectiveness of neurofeedback training for improvements in the movement of a paralyzed limb in patients after a stroke in the subacute period.

Methods

The study involved a prospective randomized study with stroke patients included in an intervention group (n = 9) and a control group (n = 8). Added to conventional rehabilitation treatment, the intervention group participated in 20 individual sessions of 1 hour neurofeedback training for a movement of the hand grip, while the control group received only conventional treatment. The activity was measured using surface electroencephalography electrodes in certain predetermined motor areas (12-20 Hz sensorimotor rhythm on electrodes C3 (right hand movement) or C4 (left movement)). It was used BCI 2000 platform (www.bci2000.org), so cortical activity was shown to the patient as a simple computer game, whereby the patient is motivated to change it to achieve a goal. The effectiveness was analyzed clinically, neurophysiologically and functionally before the treatment, at the end of 20 sessions (around 5 weeks for the control group) and after three months follow-up.

Results

Figure 1 shows a summary of the clinical parameters which showed significant improvements, divided by group (neurofeedback vs controls) and time of assessment (pre-, post-treatment and at 3 months follow-up). The rapid improvement stands out in the intervention group in hand press and ankle mobility, while the control group focused its improvements after 10 weeks of intervention in parameters related to the function of grasp and pinch.

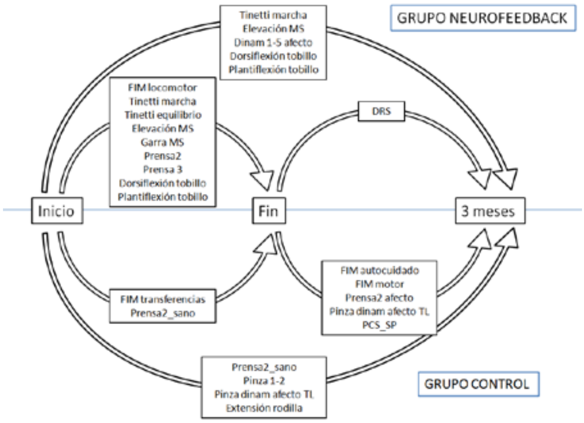

Figure 1. Variables that uniquely / independently show significantly ($p<0.05$) better results in the different time periods studied.

Figure 2 shows the average evolution of cortical activation maps in relation to time of the patients receiving neurofeedback, showing a gradual restoration of cortical activity in the left hemisphere which is consistent with gradual motor function recovery of the hand in these patients.
The results indicate that treatment with neurofeedback produces significant improvements in various operating parameters and greater electrophysiological activity in brain regions affected by stroke.

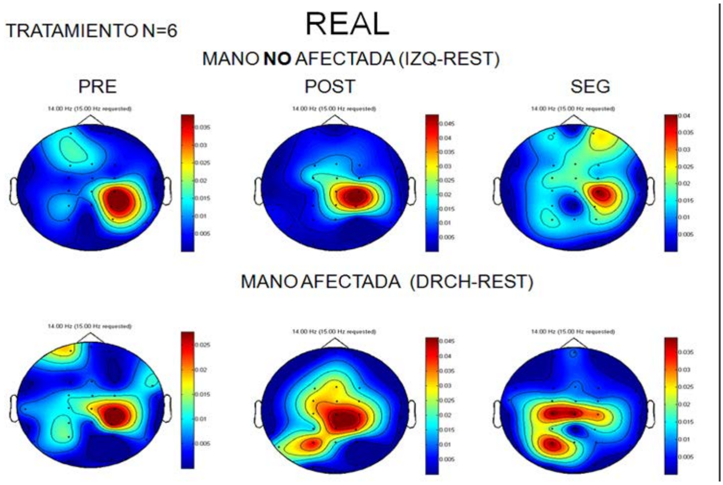

Figure 2. Cortical average activity of the intervention group in the 14Hz band while moving the affected and unaffected hand, during the 3 measurement periods (pre, post-treatment, and follow-up at 3 months).

Conclusions

This study supports the usefulness of combining conventional rehabilitation therapy with brain activity modification techniques for functional improvement in patients after stroke. The study shows a quicker recuperation of functional abilities, whose effect is mitigated over time. Simultaneously, in patients with neurofeedback treatment cortical activation gets reorganized in more similar patterns to the physiological activity.

Acknowledgements: This study has been carried out with the collaboration of a grant from the spanish goverment Imserso, Instituto de Mayores y Servicios Sociales.

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Impact of specific symptoms of spasticity on voluntary lower limb muscle function, gait and daily activities after spinal cord injury

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Introduction

Spasticity is an important sensorimotor disorder that includes several symptoms and which affects between 65-78% of those people with spinal cord injury (SCI). Although Lance (1) originally defined spastic hypertonia based on the presence of velocity-dependent stretch hyperreflexia, the impact of other important symptoms such as cutaneous hyperreflexia, spasms (2) and clonus on voluntary muscle function, gait and daily activities have not been defined. Indeed muscle hypertonia and stretch hyperreflexia after SCI has a limited effect on voluntary movement and moreover have been described by patients as beneficial during transfers (3). As such there is a need to better characterize the impact of different symptoms associated with spasticity, particularly during SCI rehabilitation.

Methods

A descriptive transverse study was performed following authorisation from the local clinical ethical committee. Sixty-five subjects with SCI (American Spinal Injury Association Impairment Scale, AIS A-D) with a neurological level between C4 and L2, with more than four months evolution were recruited. Exclusion criteria included musculoskeletal or peripheral nervous system disorders. Subjects were evaluated with the following clinical scales, ASIA, muscle score for the Tibialis Anterior, Gastrocnemius, Quadriceps and Hamstring muscles and gait function with the WISCI II test. Spasticity was evaluated with the modified Ashworth scale following flexion-extension of the knee and ankle joints, the Penn frequency spasms scale, SCATS scale (4), and the the spinal cord injury spasticity evaluation tool (SCI-SET). Patients were diagnosed with spasticity if they presented a modified Ashworth score ≥ 1+ and/or Penn score ≥ 1 (2). The Pearson correlation test was used to detect association amongst variables.

Results

SCI severity for the present cohort, based on the AIS, included: 24.2% A, 18.2% B, 43.9% C and 13.6% D. The majority of the patients (64%) demonstrated hypertonia according to modified Ashworth scale. Spasm activity was detected in 41% of subjects with the Penn scale (score >1) while 47.6% demonstrated extensor or flexor spasms as revealed using SCATS test.

Subjects with incomplete SCI (AIS C/D, 57.5%) and spasticity demonstrated differential relationships between muscle hypertonia and spasm activity on voluntary muscle function and gait. Specifically hypertonia measured with the modified Ashworth scale impacted negatively on the total lower-limb muscle score (r=-0.32, p<0.05) but not with gait function as measured with the WISCI II (r=-0.26, p=0.11). In contrast extensor spasms measured with the SCATS score were shown to interfere significantly with gait function (r=-0.38, p<0.05). Furthermore a trend for a direct negative impact of extensor, but not flexor, spasms on lower-limb voluntary muscle score was identified for the Tibialis Anterior (r=-0.29,p=0.06), Quadriceps (r=-0.30,p=0.06) and Hamstring muscles (r=-0.34p=0.06). Interestingly the Penn spasm scale failed to demonstrate correlations with either voluntary muscle function or gait.

In general all subjects with SCI spasticity (AIS A-D) revealed moderate symptom interference with daily life activities as measured with the total SCI-SET score, specifically for the modified Ashworth score (r=-0.54, p<0.001, total score for knee and ankle joint flexion-extension), Penn score (r=-0.45, p<0.001) and total flexion and extension spasm SCATS score (r=-0.5, p<0.001).

Conclusions

These data suggest that the development of extensor spasm activity, as measured with the SCATS but not the Penn scale in subjects with SCI spasticity, specifically affects gait function in those individuals with incomplete injury. In contrast, daily life activities are equally affected by the presence of the spasticity symptoms of muscle hypertonia and involuntary muscle contractions (spasms). In conclusion the diagnosis of different symptoms of spasticity is necessary to determine the general impact of this motor disorder syndrome on voluntary muscle function, gait and general life activities, while diagnosis of involuntary extensor muscle spasm activity during subacute neurorehabilitation is important because of its negative effect on residual gait function. Further detailed analysis of the SCI-SET data should reveal both positive and negative effects of specific SCI spasticity symptoms on different daily life activities.

Acknowledgements: This project was funded by the Spanish Ministry of Science and Innovation CONSOLIDER-INGENIO, HYPER project (Hybrid Neuro-Prosthetic and NeuroRobotic Devices for Functional Compensation and Rehabilitation of Motor Disorders, CSD2009-00067), FISCAM (PI 2010/30) and the Fundación Mutua Madrileña 2010.

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Knowledge representation tool for cognitive processes modeling

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Introduction

In the last decades, neuropsychological theories tend to consider cognitive functions as a result of the whole brainwork and not as individual local areas of its cortex. Studies based on neuroimaging techniques have increased in the last years, promoting an exponential growth of the body of knowledge about relations between cognitive functions and brain structures (1). However, so fast evolution make complicated to integrate them in verifiable theories and, even more, translated in to cognitive rehabilitation.

The aim of this research work is to develop a cognitive process-modeling tool. The purpose of this system is, in the first term, to represent multidimensional data, from structural and functional connectivity, neuroimaging, data from lesion studies and derived data from clinical intervention (2)(3). This will allow to identify consolidated knowledge, hypothesis, experimental designs, new data from ongoing studies and emerging results from clinical interventions. In the second term, we pursuit to use Artificial Intelligence to assist in decision making allowing to advance towards evidence based and personalized treatments in cognitive rehabilitation.

This work presents the knowledge base design of the knowledge representation tool. It is compound of two different taxonomies (structure and function) and a set of tags linking both taxonomies at different levels of structural and functional organization.

The remainder of the abstract is organized as follows: Section 2 presents the web application used for gathering necessary information for generating the knowledge base, Section 3 describes knowledge base structure and finally Section 4 expounds reached conclusions.

Methods

Physiological and neuropsychological information contained in the knowledge base has been provided by clinical professionals from Institut Guttmann (4). A specific web application has been designed for gathering this data, which allows therapists to add new elements to the knowledge base and/or to edit the existing ones.

This application consists of four different modules: structures, functions, pathways and circuits. System design is shown in Figure 1.

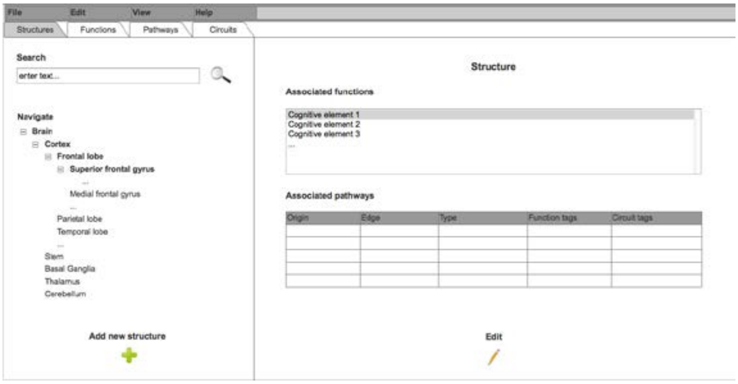

Figure 2. Interface design – Main view

Results

The result obtained from this work is a knowledge base, which will be used for representing cognitive processes. This knowledge base is composed of two taxonomies (anatomical structure and brain function), which are connected at different structural and functional levels by a set of tags.

Taxonomy of anatomical structures

This taxonomy considers five principal divisions based on anatomical information: cortex, brain stem, basal ganglia, thalamus and cerebellum. Each division is subdivided into different levels depending on the specific physiological characteristics of every anatomical structure. Brain structures are classified according to this taxonomy specifying which hemisphere they belong to.

Furthermore, the pathways linking brain structures are also defined. A pathway is described by three parameters: origin anatomical structure, type of connection (depending on the synaptic mechanism involved in the transmission of information) and final anatomical structure. Two structures can be connected by one or more pathways, in one or both directions.

Taxonomy of cognitive functions

This taxonomy classifies cognitive processes. It starts from higher cognitive functions, such as attention, memory, language and executive function, until detailed functions described in neuropsychological literature. Three main sub-levels of this taxonomy have been defined: function, subfunction and cognitive element.

Linking tags

Structure and function taxonomies are linked through tags. Two kinds of tags are defined: network and function tags. The first one identifies brain structures that belong to a higher structural organization (circuits). The second one labels those brain structures, pathways and circuits that are involved in the cognitive process of a specific cognitive element.

Conclusions

This abstract presents a knowledge base as the first step for the development of a knowledge representation tool for cognitive processes modeling. A high complexity lies in the representation of cognitive processes and the management of treatment and assessment data, which results in an important technical challenge in the development of this tool.

The final goal of this tool is to generate scientific evidence on rehabilitation treatments by verifying or refuting therapeutic hypothesis.

Acknowledgements: This research has been partially founded by the Spanish Ministry of Economy and Finance (project TIN2012-38450, COGNITIO).

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Acquisition of motor skills in infants with plagiocephaly: applicability of Le Métayer method

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Introduction

Non-synostotic plagiocephaly is a clinical entity in which the shape of an infant's head becomes altered as the result of external forces applied to the malleable bones of the cranium and can occur pre- or postnatally. It is characterized by asymmetric occipital flattening with ipsilateral frontal bossing. Viewed from above, this results in a parallelogram deformity of the head.

In recent literature, the prevalence of this craniofacial asymmetry varies between 13 and 22%. However, considering preterm neonates and multiple births as risk factors(1), such prevalence is increasing in developed countries.

Plagiocephaly can be corrected with different treatments(2) including repositioning, remodeling with orthotic devices such as headbands and helmets, surgery and alternative therapies like ostheopathic manual therapy.

Numerous authors(3,4,5) have reported that plagiocephaly is associated with motor neurodevelopmental delays. In these studies the infants were not assessed until total correction. Therefore, the fact that in our study such infants with plagiocephaly were monitored monthly during their developmental process until they acquired the adequate motor development for their age is worth highlighting.

The assessment was based on the Le Métayer(6) method, used for the assessment and intervention of the cerebral palsy. It encourages the infants to acquire the normal motor schemes combined with static and balance reactions in order to the different levels of motor development. We propose that it is also a practice method for being used in other pediatrics conditions involving the neurodevelopmental aspects.

The aim of this study was to evaluate motor development evolution in infants with plagiocephaly according to Le Métayer method.

Methods

Prospective clinical trial in which 104 infants with plagiocephaly were referred to Early Care and Monitoring Unit (USAT) of San Cecilio Hospital in Granada, between 2009 and 2012. All the infants, grouped into three categories of severity(7). The study included an assessment of parents and infants. Parents were assessed with a questionnaire about the mother's medical history and birth-related issues. The assessment of infants included anthropometric measures, a positional assessment, the observation of the head, the assessment of severity and motor development. Two experts with more than ten years of experience in Le Métayer method assessed the neurodevelopmental status according to these gross motor skill acquisition: turning around, sitting, crawling and standing. Age in months at which infants achieved this motor skill was recorded. Infants' motor function acquisition was assessed monthly by the same two experts.

Infants were discharged when both experts determined that the plagiocephaly was total corrected and gross motor skills were adequate to the infant's age.

Results

Birth characteristics were similar in the total sample (table 1).

There were significant differences ($P<0.05$) in the acquisition of specific gross motor skills depending on the severity of plagiocephaly (table 2).

Table 1. Clinical characteristics of infants with plagiocephaly according to the severity.

Variable	Total (n=104)	Mild plagiocephaly (n= 44)	Moderate plagiocephaly (n=34)	Severe plagiocephaly (n=26)	P
Female n (%)	37 (35.6)	19 (43.2)	9 (26.5)	9 (34.6)	0.289
Gestation age (weeks)	38.63 (2.123)	38.68 (2.317)	38.75 (2.049)	38.44 (2.064)	0.131
Premature n (%)	21 (20.1)	11 (25)	6 (17.6)	4 (15.3)	0.785
C-section n (%)	41 (39.4)	12 (27.3)	19 (55.9)	10 (38.5)	0.191
Weight at birth (g)	3105.92 (660.180)	3133.61 (688.821)	3044.29 (537.909)	3136.47 (775.185)	0.104
Cephalic perimeter (cm)	34.78 (1.966)	35.07 (2.129)	34.70 (2.168)	34.38 (1.888)	0.147
Thoracic perimeter (cm)	31.71 (4.348)	31.75 (5.560)	30.50 (3.536)	34.00 (1.765)	0.155
Age at referral (days) M (SD)	125.41 (70.390)	102.86 (67.989)	138.47 (64.785)	146.44 (73.330)	4.151*b
Treatment time (months) M (SD)	11.12 (8.933)	7.96 (4.890)	14.74 (12.301)	14.94 (8.862)	4.276*a
Discharge time (months) M (SD)	14.99 (8.754)	11.62 (4.397)	18.94 (12.321)	18.88 (7.754)	5.239*a

Notes:
All categorical variables are expressed as the mean (SD).
The P value is expressed using χ2 in categorical variables and the ANOVA in non-categorical variables.
* P < 0.05
a indicates significant differences between mild and moderate plagiocephaly.
b indicates significant differences between mild and severe plagiocephaly.

Table 2. Gross motor skill acquisition in infants with plagiocephaly according to the severity.

Gross motor skill acquisition Mean (SD)	**Total (n=104)**	**Mild plagiocephaly (n=44)**	**Moderate plagiocephaly (n=34)**	**Severe plagiocephaly (n=26)**	**F**
Turning around	7.92 (2.027)	6.55 (1.499)	8.58 (1.797)	9.36 (1.987)	5.660*ab
Sitting	8.84 (2.304)	7.97 (2.379)	8.73 (1.883)	10.29 (2.114)	3.498*b
Crawling	11.16 (2.606)	11.67 (2.422)	11.00 (3.117)	10.25 (1.061)	0.225
Standing	12.48 (2.216)	11.50 (2.224)	13.43 (1.512)	12.94 (2.495)	1.912

Notes:

All variables are expressed in months.

* $P<0.05$

a indicates significant differences between mild and moderate plagiocephaly.

b indicates significant differences between mild and severe plagiocephaly.

Conclusions

Le Métayer method is safety, well-tolerated and effective in the assessment of non synostotic plagiocephaly, regarding to the acquisition of motor skills. The severity of plagiocephaly is a marker that should be taken into account when designing actions aimed at improving gross motor skill development.

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Neurobehavioral scales in Traumatic Brain Injury

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Introduction

Psychiatric disorders are common consequences of traumatic brain injury (TBI) and can interfere with rehabilitative therapies in these patients, affect functional abilities, cause distress to the family and lead to social isolation. For these reasons, an objective assessment of behavioral and emotional disorders is essential for this population.

Psychiatrists and neuropsychologists deal with symptoms that are not easy to identify. Behavioral disorders sometimes are unpredictable and need a specific environmental trigger to be expressed. It is a fact that we need to improve the description of the neurobehavioral disorders post-TBI in order to establish a common language between professionals.

The use of scales allows us to unify terms both in clinical practice and investigative work; it also constitutes a useful guide in clinical interviews and makes it possible to see outcome changes in patients with or without intervention.

The aim of this study is to review neurobehavioral scales used to measure the non-cognitive disorders of conduct, emotion and mood in TBI patients.

Methods

A systematic literature review was done in Medline, without time limit, which focused on neurobehavioral disorders in moderate and severe TBI patients.

Papers that included mild TBI patients, used psychological instruments that measure the classical personality dimensions or semi structured psychiatric diagnostic interviews based on the DSM-IV o CIE-10 were not considered.

In the same way, studies not focused entirely on neurobehavioural disorders were not included.

Sleep disorders and terms like fatigue, empathy or insight were not considered.

Results

1297 abstracts were reviewed, and 158 articles were selected for the final revision. Ninety articles assessed behavioral disorders, and 68 assessed emotional disorders.

Of these articles the scales more specific to neurological disorders were selected.

Thirty-seven different scales to measure behavioral problems were identified; seven of which represent 65% of them and each one has five or more published papers.

To assessed depression and anxiety disorders forty two different scales were identified. Six of them represented the 55.7% and each one has six or more published papers.

Conclusions

We made a critical analysis of the most representative neurobehavioral scales-- including psychometric properties of instruments, covered domains, item descriptions and administration procedures--applied to moderate and severe TBI patients.

Evaluation of a cognitive treatment for ABI patients using fMRI and DTI

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Introduction

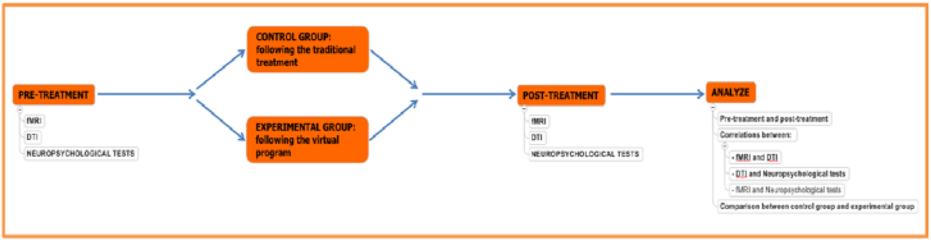
Acquired Brain Injury (ABI) refers to a normally developed brain that suffers from damage at some point of the person's life. Several studies have been conducted to propose and analyze methodologies for the treatment and assessment of the disease. What's more, it constitutes an important branch of the neuroimaging research. However, until now just a few of these studies combine the properties of the functional Magnetic Resonance Imaging (fMRI) and Diffusion tensor imaging (DTI) techniques to evaluate the effectiveness of the rehabilitation, and none of them uses Virtual Reality (VR) to help in the rehabilitation process. However, it has been proven that the use of VR increases the patient's motivation during the rehabilitation process. The combination of fMRI and DTI will allow the comparison of the neuronal activity measured with fMRI with the integrity of the white matter tracts obtained with DTI in different stages of the rehabilitation process.

In this study we propose a protocol to combine these two neuroimaging techniques to evaluate the effectiveness of a VR program for cognitive rehabilitation in patients with ABI. More precisely, our protocol will assess the state of the attentional network of the brain.

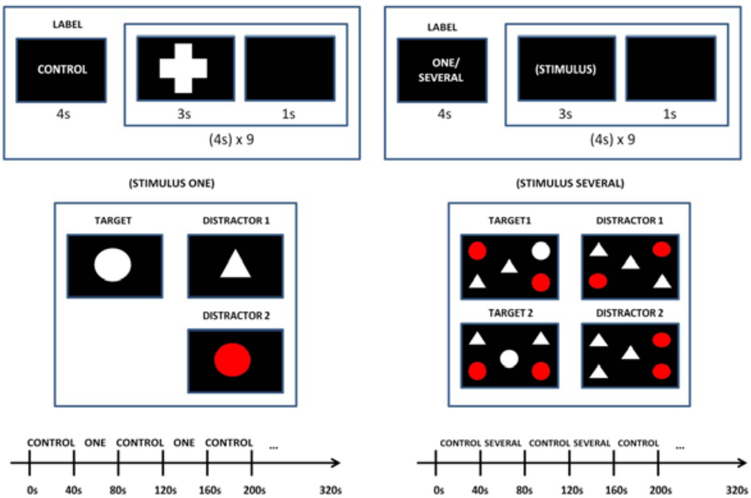
Methods

This study in based on the analysis of the attentional system, one of the most damaged areas after brain injury. For this purpose, we have developed an evaluation protocol based on the recognition of geometric shapes with different levels of difficulty. This task will be implemented inside a magnetic resonance machine. The application of both fMRI and DTI allows the combination of the brain activity measures with information about the white matter tracts' integrity, which allows us to evaluate differences between the parameters before and after the treatment.

The designed protocol will be applied to two groups of patients: one experimental group that will follow the VR treatment, and one control group that will be submitted to the traditional treatment. Those two groups will be scanned before and after the treatment, to analyze the brain activity and tracts' integrity differences due to it. In both pre- and post-treatment scans, they will go on an fMRI scan, a DTI scan and will answer some neuropsychological tests. Afterwards, each group and each scan will be analyzed individually and in comparisons between groups.



During the fMRI, the subjects will pass a protocol to stimulate the brain areas related to attention. There they will answer to two experimental conditions, based on the same task but with different levels of difficulty (ONE and SEVERAL, depending of the number of stimulus showed). In each task, the patients have to press a button each time they see the target image (a white circle), that will appear between distractors (red circles and white triangles). The control task will be to press each time a white cross appears on screen.



Each block (CONTROL and ONE/SEVERAL) is formed by 9 stimuli of 4s of duration each (duration of each block: 40s). There are 4 blocks of each kind that appear alternatively in each condition (4 of CONTROL and 4 of ONE/SEVERAL). The total duration of each condition will be of 320s.

Conclusions

Considering the heterogeneity of symptoms of patients with ABI, this kind of methodology will enhance the objectiveness of the evaluation tools and, ultimately, allow us to adapt the rehabilitation programs to the particular needs of each patient.

Acknowledgements: This study was funded by Ministerio de Educación y Ciencia Spain, Project Game Teen (TIN2010-20187) and partially by projects Consolider-C (SEJ2006-14301/PSIC), “CIBER of Physiopathology of Obesity and Nutrition, an initiative of ISCIII” and Excellence Research Program PROMETEO (Generalitat Valenciana. Conselleria de Educación, 2008-157).

Changes in kinetic patterns in post-stroke patients during robot therapy with different visual feedbacks systems: preliminary findings

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Introduction

A recently theorized TOP-DOWN (TD) approach for robotic assisted gait rehabilitation (1) postulates that a better insight of the cortical function, by means of non-invasive brain/neuronal-computer interfaces (BNCI), will enable the design of more accurately targeted and sophisticated interventions for stroke survivors (2). We have performed a study with the robotic orthosis Lokomat® with the aim of reveal possible differences in patient's performance receiving a conventional feedback (CF) and a TOP-DOWN approach based feedback (TDF) during robotic assisted gait rehabilitation.

Methods

Three stroke survivors were selected to perform a longitudinal crossover training protocol consisting of twelve training sessions, in which every patient received a sequence of two treatments as follows: during first six sessions, they received the CF, which consisted in the Lokomat's integrated feedback (3), and during last six sessions, they received the TDF, which is based on EMG data recorded from a set of leg's muscles, and informs the patient about his/her degree of muscle activation through different gait phases, via an horizontal bar and a colour code. Our analysis was focused on reveal statistical differences on patient's average interaction forces (at both hip and knee joints, during stance and swing gait phases) among both treatments.

Results

In relation to patient A, hip forces during stance and swing phases were increased along treatment with CF, but decreased along treatment with TDF (Figure 1). Along treatment with TDF, average knee forces were incremented during stance phase, but they remained under values reached along treatment with CF; during swing phase average values were reduced along treatment with TDF, and incremented along treatment CF, but the effect of treatments in terms of overall reduction of knee joint forces is higher with TDF than with CF.

For patient B, the analysis of the hip joint kinematics shown the same results that in the case of Patient A. Respecting to the knee joint, there is not significantly differences in interaction forces to evaluate which feedback is more effective to enhance patient's participation.

In the case of patient C, hip forces during stance and swing phases were reduced along treatments with both feedbacks, but the effect in terms of amount of force reduced was higher along treatment with TDF for the stance phase, and along treatment with CF for the swing phase. Knee forces during stance phase were reduced along treatment with TDF but increased along treatment with CF, however, the effect of TDF in terms of amount of forces reduced or incremented was higher along treatment with TDF; during swing phase, the trend is reversed, and forces were reduced along treatment with CF and increased along treatment with TDF, showing opposite effects of similar magnitude.

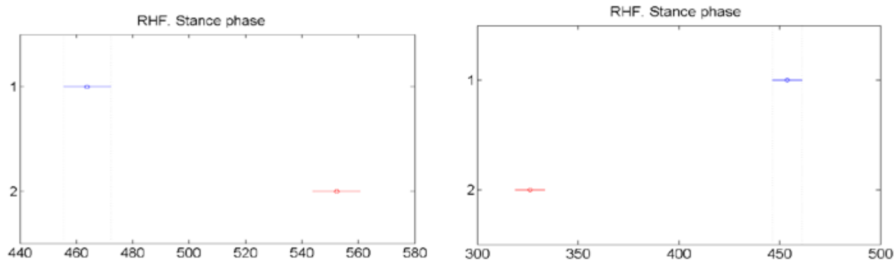

Figure 3. Patient A. Right hip force. Notable differences in kinetic parameters (average values). Anova test results. At left, differences between beginning(1) and end(2) of treatment with CF; al right, differences between beginning(1) and end(2) of treatment with TDF.

Conclusions

All patients achieved a reduction in hip interaction forces during both stance and swing phases when received treatment with TDF, which means an increment in their active participation; meanwhile, when received CF, patient A shown an increment in hip interaction forces, patient C shown a reduction and patient B shown different results in function of the gait phase: increment during swing phase and reduction during stance phase. Respecting to the knee interaction forces, results vary more, and there is not a common pattern, only patient B shown knee interaction forces reduction in both gait phases when received treatment with TDF.

These results show that, respecting hip joint, when patients received treatment with the TOP-DOWN approach based feedback, they achieved a better performance than when they received treatment with the traditional feedback, walking more actively and thus, enhancing their rehabilitation. Regarding the knee joint, there is insufficient evidence to draw firm conclusions. Further analysis comparing these results with muscle activity recordings are needed, in order to correlate interaction forces with patient's muscular effort.

Acknowledgements: this study has been conducted with financial support from the European Commission within the Seventh Framework Programme under contract FP7- ICT-2009-247935: BETTER BNCI-driven Robotic Physical Therapies in Stroke Rehabilitation of Gait Disorders. Also grant from the Spanish Ministry of Economy and Competitiveness CONSOLIDER INGENIO, project HYPER (Hybrid NeuroProsthetic and NeuroRobotic Devices for Functional Compensation and Rehabilitation of Motor Disorders, CSD2009-00067).

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Effectiveness of a Kinect™-based system to relearn step strategies following a stroke

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Introduction

Stroke can cause different dysfunctions that can affect, among other skills, the motor control. Malfunctions that involve the afferent signals from the sensory systems, their processing in the central nervous system, or the efferent pathways will lead to inappropriate muscular responses to the sensory information. One of the most common impairments following a stroke is known as hemiparesis, which is characterized by a reduction in the muscular activation in one side of the body. Hemiparesis affects, among other motor mechanisms, postural control and balance, which can cause a reduction in the patients self-dependency. Current neurorehabilitation approaches try to make patients to relearn motor patterns and strategies that help them to compensate or rehabilitate these impairments. Mechanisms of brain plasticity support the neurophysiological basis of these stroke rehabilitation approaches (1). An increasing number of studies report the positive effects that virtual reality can provide to stroke survivors. The repetition of goal oriented activities within a controlled and adaptable virtual environment (VE) can maximize the clinical benefits of motor rehabilitation (2). The objective of this study was to design and to analyze the clinical effectiveness of a virtual rehabilitation system in the balance recovery of stroke patients.

Methods

The system consisted of a standard PC with a Microsoft® Kinect™. The Kinect™ is a motion tracking system that identifies the 3D position of some joints of the body, from which it is possible to deduce the user's pose. The Kinect™, with a low-cost technology, has proven to be a valid tracking system in comparison with other gold-standard methods (3). The system recreates a simple VE that consists of a checkered floor with a circle in the center and different items that rise from the floor in different positions around the circle. The size, lifetime, distance and area of appearance of the items can be configured by the therapists. The user is represented in the VE by two legs that mimic the movements of the user's feet in the real world. The objective of the exercise is to reach all the items with one leg while maintaining the other leg within the boundaries of the center circle, and to recruit the extended leg within the circle afterwards. The system constantly shows new items that must be reached randomly distributed in the VE, which makes the exercise an intensive training of the step strategy (one of the balance strategies together with the ankle and hip strategies (4)).

Figure 1. Patient interacting with the system

15 hemiparetic patients who satisfied the inclusion/exclusion criteria were included in the study. Inclusion criteria were: 1) age ≥ 18 and ≤ 75 years; 2) chronicity > 6 months; 3) Brunnel Balance Assessment (5): section 3, levels 7-12; 4) Mini-Mental State Examination (6) > 23. Exclusion criteria were: patients with 1) severe dementia or aphasia; 2) cerebellar symptoms.

All the participants underwent 20 sessions of 45 minutes each, which consisted of 6 6-minute repetitions with 1-minute break among them, from 3 to 5 sessions per week. The therapists adapted training to fit each participant's condition. The balance assessment was done with the Berg balance scale (BBS) (7), the balance subscale of the Tinetti performance oriented mobility assessment (POMAb) (8) and the Brunnel balance assessment (BBA). Assessments were conducted at the beginning (initial assessment), at the end (final assessment), and 1 month after treatment (follow-up assessment).

Results

Significant differences in the BBS ($p<0.01$) and a tendency towards significance in the POMAb ($p=0.088$) were found. Post-hoc analysis of the BBS scores showed significant improvement during the treatment ($p<0.01$) but not during the follow-up ($p=0.162$). A significant percentage of participants (26.6%) increased their score during the treatment (chi-square =2.5, $p<0.01$) but no during the follow-up.

Conclusions

Our results suggest that the virtual rehabilitation system can promote the rehabilitation of motor strategies. The statistical analyses support the results of previous studies in the rehabilitation of step (9) and ankle and hip strategies (10). Even though more strict studies are needed, the Kinect™ provided a reliable motion tracking. Interpretation of the results must consider the limitations of the study, but the clinical improvement in the balance, measured by standardized scales, must be highlighted given the chronicity of the sample.

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A video game (Boccia-wii®) as a therapeutic tool in adults with cerebral palsy

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Introduction

Boccia is a paraolympic game, similar to *petanca*, played by people with physical disabilities.

At the CRE (Centro de Referencia Estatal de Discapacidad y Dependencia, León, Spain) it has been designed, with Prometeo enterprise and the University of Leon, a video game called Boccia-wii® where a virtual environment generated by a computer lets to users interacts with different simulated scenarios. This is one of the interventions based in new technologies applied in this center to treat some neurologic disorders, but few studies in this reserach line exist related to adults with cerebral palsy and this is the first pilot study using Boccia-wii ® as a therapeutic tool in this population (Figure 1).

To determine if the training with a video game improves motor function, coordination, performance of Basic activities of daily living (ADL), Elath-related quality of life (HRQoL) parameters and self-steem.

Methods

A evaluation pre-and post-intervention pilot study was performed. Ten patients with spastic tetraparesis from the CRE, diagnosed of moderate CP, were recruited. The information and test used were: active range of motion, muscle activity, fine motor coordination, performance of activities of daily living (ADL), level of health-related quality of life (HRQ-L) and grade of self-esteem, assessed with the Biometrics E-Link® (electrogoniometer and electromyography), Nine Hole Peg Test(1), the Index Barthel (2), the EQ-5D test (3) and the Rosenberg scale (4), respectively. Treatment with the video game Boccia-wii® was conducted over a period of 2.5 months, with one and a half hours of weekly training, spread over 3 days a week, 30 minutes each day.

Results

We obtained significant statistically improvements in coordination and fine motor skills of the hand ($p=0.013$), on the level of HRQ-L ($p=0.00059$), active range of motion in the elbow flexion ($p=0.049$), extension wrist ($p=0.017$), radial deviation ($p=0.017$) and the biceps muscle activity ($p=0.047$) Table 1.

Conclusions

Our results seem to determine that the training with Boccia-wii® is useful in adult patients with cerebral palsy with spastic tetraparesis (5), so it could be established as a therapeutic adjunct in conventional physiotherapy treatments. More studies are need to determinate with a control group if these improvements are present and follow-up results.

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Table 1. Main results

Variable	**Mean pre-intervention**	**Mean post-intervention**	**Level of significance p-value**
Nine Hole Peg Test	140.40	102.00	0.013
Index Barthel	64.50	64.50	1.0001
Rosenberg Scale	27.60	30.30	0.07
HRQL	56.66	54.66	0.085
HRQL EVA	0.710	0.760	0.0059
Trapeze (upper fibers)	1133.90	1137.10	0.959
Pectoralis major	1038.70	1029.00	0.958
Deltoides (previous fibers)	1249.30	1241.00	0.878
Deltoid (middle fibers)	2065.00	2069.70	0.721
Deltoid (posterior fibers)	1747.20	1772.50	0.767
Biceps	1481.50	1537.20	0.047
Triceps	918.30	938.60	0.610
Forearm supination	1285.80	1259.30	0.333
Shoulder flexion	153.10	159.40	0.07
Shoulder extension	22.90	27.60	0.07
Shoulder abduction	143.50	147.40	0.065
External rotation	77.40	77.90	0.799
Internal rotation	75.20	77.40	0.571
Elbow flexion	125.50	124.50	0.049
Elbow extension	4.60	4.40	0.157
Pronation	56.00	55.50	0.610
Supination	60.90	63.50	0.670
Wrist flexion	68.00	78.00	0.051
Extension wrist	50.30	65.00	0.017
Radial deviation	17.20	19.50	0.017
Ulnar deviation	29.90	31.00	0.595

Virtual reality systems for the upper limb in children with cerebral palsy. A literature review

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Introduction

Loss of function in the upper limb in tasks such as reaching, grasping and manipulation are a typical disability in children with cerebral palsy (CP) (1,2).

Virtual reality (VR) framed in the task-oriented motor learning is a new technology that is taking impact over neurorehabilitation treatments in this population (3,4).

The aim of this study was to analyze whether the use of VR improves upper limb function in children with CP reviewing specific scientific literature about this topic.

Methods

A literature review was made using the main data bases like Tripdatabase, Cochrane Library Plus, Pubmed (Medline), CINHAL, ISI web of Knowledge y PEDro, taking into account only original papers. The key words used were cerebral palsy, virtual reality, upperlimb and motor learning. Studies need to be publishing between 2005 and 2011 in Spanish or English. For level of scientist evidence and grade of recommendation were used Marzo and Viana Scale.

Results

The number of articles found was 197. 189 were rejected because they were not specifically related with the topic of this review or not follow our inclusion criteria. Finally, 8 articles were included (Table 1). 3 of them were RCT with a level of evidence 1b and a grade of recommendation A; 4 of them were case reports with low evidence (level 3) and a grade of recommendation D; and finally, only one study was a case report, with low evidence (level 4) and a grade of recommendation D.

Table 1. Main results of included studies

Study	Participants	Outcome measures	Results
Jannink et al (6). RCT	CG:5 (VR) EG:5(VR+FT)	MAUULF Questionnaire Postexperience	(1) Benefits over functionality and motivation values.
Fluet et al (7). RCT	CG: 4 (VR) EG:4 (VR+CMIT)	MAAULF Reaching kinematic	(1) Benefits over motor values in EG (2) Benefits over reaching kinematic in both groups.
Reid et al (8). RCT	CG: 19 (VR) EG:12(VR+FTP y/o TO)	COPM, QUEST, SPPC	(1) Only benefits over social values.
Chen et al (9). Case reports	n=4	Model 370 Vicon Motion PDMS-2	(1) 3/4 children improve reaching kinematic. (2) Fine motility improves in all sample.
Fluet et al (10). Case reports	n=9	MAUULF Dinamometry Pinzometer Goniometry Reaching kinematic	(1) Improvements over upper extremity funcionality. (2) Improvements over range of motion in shoulder flexion, abduction and supination. (3) Improvement over the trajectories but without significant differences in soft movements.
Quiu et al (11). Case reports	n=2	MAAULF Reaching kinematics Active range of movement	(1) In one patient there was a increment from 59.8 to 67.2. (2) In the one there were clinical improvements in active range of motion over shoulder flexion (15º) and supination (50º) and in reaching kinematic.
Li et al (12). Case reports	n=5	QUEST Times are collected by the system Satisfaction questionnaire	(1) Clinical improvements but without significant differences in reaching parameter. (2) Lower time used to complete the tasks. (3) Rise of self-steem.
You et al (13). Case reports	n=1	BOTMP, FMA, PMAL, fMRI	(1), (2) Improvements over motility abilities and movement quality. (3) Improvements over activities of daily life. (4) Activation of contralateral cortex.

EG: Experimental group, **CG:** Control group, **FTP**: Physiotherapy, **MAUULF** : Melbourne Assesment of Unilateral Upper Limb Function Test, **CIMT**: Constraint induce movement therapy, **TO**: Occupational therapy, **COPM**: Canadian Occupational Performance Measure, **QUEST:** Quality of Upper Extremity Skills Test, **SSPC**: Harter Self-Perception Profile for Children **PDMS-2**: Peabody Developmental Motor Scales-Second Function, **BOTMP**: Bruininks-Oseretsky Test of Motor Profiency, **PMAL**: Modified Pediatric Motor Activity Log, **FMA**: Fugl-Meyer Assesment, **fMRI**: Functional Magnetic Resonance Image.

Conclusions

The results are consistent with systematic reviews found. Jannink´s (6) study was the manuscript with greatest scientific evidence, with clinical improvements over upper limb function and motivation. These results are in the line with other authors as Fluet et al (7). Others authors, as Reid et al, did not find statistically results in motor variables, but social parameters. VR devices appear to improve upper limb functionality. This literature review presents limitations as a small number of items reviewed. There is a low scientific evidence and grade of recommendation at the moment to recommend this type of tools in CP patients. There is a need to standardize protocols of VR used and a long-term follow-up. Therefore, is essential to open new lines to research comparing the use of VR with other specific methods of intervention.

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Virtual reality system Toyra®. A new tool to assess and treat upper limb motor function in patients with spinal cord injury

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Introduction

Virtual reality (VR) is a simulation of a real environment generated by computer in which, through a man-machine interface, it allows the user to interact with certain element inside a simulated scenario(1). The VR is presented as a novel and relevant implement in neurorehabilitation, allowing the development of rehabilitation treatments beyond the traditional methods of work.

Systems based on VR could induce a better activity of the motor system and promote a cortical reorganization with the observation and imitation of actions, through the mirror neurons activation(2).

The objective of this work was to examine the efficacy of VR system Toyra® as a tool to assess and treat upper limbs function in people with cervical spinal cord injury (SCI).

Methods

A randomized clinical trial of 10 participants, aged 18 to 60 years. All of these had sustained complete SCI, according to the ASIA's(3) impairment scale at the level of C5 to C8, with less than six months from the injury.

The treatment system employed was the so-called VR Toyra®, which comprises a MTx motion capture sensors (Xsens Ic, Netherlands) and a VR environment that reproduce real-time patient's movement with an avatar displayed on an LCD monitor(4).

Patients in intervention group (IG) (n=5), conducted a treatment program, that included 15 sessions of 30 minutes with Toyra® Activities of Daily Living module, for 5 weeks. Simultaneously those patients received Occupational Therapy and Physiotherapy. Patients assigned to the control group (CG) (n=5) made only the same treatment without receiving Toyra® sessions. Both groups were assessed pre-post treatment, with Toyra® Evaluation session and a set of functional, kinetic and manipulative scales. A student's t test with p-level < 0,05 was performed.

FIGURE 1: Virtual Reality System Toyra®. Patient using VR Toyra® system. Inertial Sensors Xsens (Xsens Inc, Netherlands). Arm movements are captured by Inertial Measurement Units (IMUs). An avatar moving according to the movements of the user performs a task in the virtual scenario

Results

Comparing data obtained after treatment in both groups, no statistically significant differences were found in the kinematic, functional independence, muscle balance and parameters based on dexterity, coordination and grip function. Nevertheless, there were trends of improvement in the parameters of shoulder flexion-extension and elbow pronation-supination and a trend of increase in most items of the scales in the IG.

However, IG obtained better results than CG ($p < 0.05$) when registering and analyzing the 5 sub-test of the Jebsen-Taylor Hand Function Test. This test assesses the manipulative skill, coordination and fine forceps. It means that IG subjects had improved their manual skills.

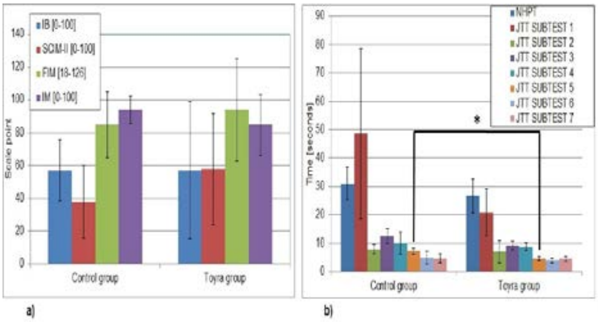

FIGURE 2: Functional parameters in both groups after program treatment (mean and standard deviation). Left figure shows the results of Barthel Index (BI), Functional Independence Measure (FIM), Spinal Cord Independence Measure (SCIM-II) and Motor Index (MI) (a); Right figure shows the results of Nine Hole Peg Test (NHPT) and Jebsen-Taylor Hand Function Test (JTT) (b). *: significant difference ($p<0.05$) found in the sub-test the JTT test 5

Conclusions

The use of this system, in addition with traditional rehabilitation treatment, suggests possible functional improvements in aspects such as skill, coordination and fine grip. The Toyra® system solicits to the patient the execution of arm and hand activities, in which they need to do grip movements. Our hypothesis is that due to this training, patients have increased their manipulative ability. We also think that the little findings found in the others scales are due to the small sample size and the short time of intervention with the Toyra® system. That´s why, it is necessary to conduct studies with a larger sample and more number of sessions to give greater validity to the clinical experience with this device.

Acknowledgements: We thank the consortium including Foundation Rafael del Pino, Foundation of the Spanish National Hospital for Paraplegic Research and Integration (FUHNPAIIN) and INDRA systems for funding this research.

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Efficacy of memory rehabilitation therapy

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Introduction

Why Study Memory Rehabilitation?

- Brain injuries are an especially prevalent and expensive disorder.
- There will soon be an influx of brain injuries with returning veterans.
- Baby boomers commonly complain about poor memory and “senior moments”.
- There are no treatments with widely documented efficacy.
- There are few drug treatments to improve memory.

Memory failures are an inevitable consequence of war, industrial accidents, car/motorcycle crashes, and old age. Research on effective treatment for memory failure has not kept pace with the prevalence of the disorder. There is a great need for efficacy research that documents the effectiveness of memory therapies. To date, there have been only two definitive studies that dealt with this issue.

Cicerone, et al. (1,2): documented a number of therapies with proven efficacy.

Rohling, et al. (4): cognitive rehabilitation treatment effect was significant but not a great deal larger than improvement that occurs with the passage of time.

Methods

Sample: 26 published studies which compared a treatment intervention to a control condition without treatment.

Meta-Analytic procedures were used to evaluate the effect sizes (ESs) computed from the available statistics in each published study. These ESs were subsequently analyzed to determine whether or not the average ES was significantly different from zero, the size of the treatment ES once the control ES was removed, the homogeneity (Q statistic) of the effect sizes, and the degree of dissemination bias (Begg’s statistic). Additional analyses evaluated whether various characteristics of the studies, e.g., patient population, affected the ESs.

Results

Results indicated that the average effect size for the treatment condition was .48 which was significant. However, the effect size for the control condition of .25 was also significant. The ESs were homogeneous with no outliers. There was no significant correlation of the sample sizes in the various studies with the ESs. There was also a significant difference between the ESs in the various types of study. Generally, studies of stroke patients produced larger ESs relative to studies of patients with TBI or other patient populations. Studies that were done before 2005 produced lower effect sizes relative to more recent studies. There was some evidence of dissemination bias which suggests that published studies tend to have large effect sizes.

Conclusions

This study documents the efficacy of therapies that are designed to retrain memory after neurological damage to the brain. Although a certain amount of the improved memory functioning can be attributed to the treatments, there is also a significant amount that occurs simply by the passage of time. Stroke patients seem to benefit the most from these types of therapies. More recent studies produce larger effect sizes, presumably due to improvements in memory therapy techniques and applications, such as computer-based rehabilitation. This type of therapy therefore seems to provide an efficacious mode of treatment for persons with brain injuries, vascular disorders, dementia, or other debilitating neurological conditions.

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Neuropsychological rehabilitation in fibromyalgia patients: Effects of an online cognitive training program

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Introduction

Cognitive impairment has been demonstrated in patients suffering Fibromyalgia (FM), a chronic widespread pain syndrome, in which the neural substrate is still under study. Deficits are commonly found in complex attention, working memory, semantic and episodic memory (1), and patients usually comment on the severe impact that these failures have on their daily living.

The positive effects of neuropsychological rehabilitation programs in people with acquired brain injury have been well established in the scientific literature (2). More recently, efforts have been made to test the impact of computerized cognitive treatments on the neuropsychological functioning of different clinical populations such as people suffering stroke (3) or schizophrenia (4). However, up to the authors' knowledge there are no previous studies which test the effects of an online cognitive rehabilitation program directed to improve cognitive failures in a group of FM patients.

Methods

With the aim of exploring these questions, a total of 37 women with FM participated in our study. The total sample was divided in experimental group (EG; N=19) and control group (CG; N=18). Clinical and neuropsychological assessment was performed before and after a computerized online cognitive training program (COCTP) was conducted on the EG.

Clinical test included the Fibromyalgia Impact Questionnaire (FIQ), Beck Depression Inventory (BDI), Attention Related Cognitive Errors Scale (ARCES), Memory Failures Scale (MFS) and other questions about medication and years of disease.

Neuropsychological evaluation consisted on the Map Search (MS) subtest from the Test of Everyday Attention, the Trail Making Test (TMT), Controlled Oral Word Association Test (COWAT), Semantic Fluency Task (Animals), Stroop Test (ST), and the Digit Symbol (DST) and Vocabulary (V) tests from the Wechsler Adult Intelligence Scale III (WAIS III).

The COCTP, designed by Unobrain Neurotechnologies, had a duration of 11 weeks and included a total of 12 computer games (Table 1), each of which was repeated 8 times along the program spam. The participants in the EG were asked to practice three times per week, with every session including three different games (15 minutes approximately).

Table 1. Description of computer games included in the COCTP.

Game Number	Game Name	Game Description
1	Cazahuevos	A divided attention task where it is required to click on eggs of different colors while eliminating red eagles that appear on the screan at the same time.
2	Inmersión	An auditory working memory exercise in which the location of a submarine is determined by the number of specific tones that must be carefully listened to.
3	Runas	A game of selective attention and visual search where a symbol must be found among other similar ones.
4	Perdido en la charca	A task of visual learning and memory. The player must discover and remember the correct sequence of steps to get to the end of the row.
5	Boom	With the shape of a changing laberinth the player must find the way to disconnect a bomb, testing his executive functions.
6	Palabrejas	An increasing number of bees appear on the screen including words to be read, learned and remembered, a traditional verbal memory task.
7	Ying-Yang	Rotating figures must be matched as fast as possible in this game of visual perception and speed of mental processing.
8	Postales del mundo	An episodic memory task where 7 differences must be found between a picture and its uncomplete copy presented after it.
9	Abre la caja	A short-term memory game where growing sequences of colors and sounds need to be reproduced by the player.
10	Matematicars	Oriented to work arithmetic calculations which will make our race car win the competition.
11	Lluvia de cajas	A space perception task where a number of boxes is to be counted taking into account the perspective.
12	Palabras escondi-das	With a number of different given letters the subject is asked to form as many words as possible in a time given, testing his verbal fluency.

Results

The U-Mann Whitney Tests did not show significant differences between groups in the pre-program assessment in age, years of disease, estimated intelligence, nor in the FIQ, ARCES or MFS and in any of the neuropsychological measures (p<.05) excepting the COWAT (z=-2.543; p<.05) where the CG had higher scores than the EG. No differences were found neither in education level, depression and medication after executing Chi-Square Tests.

Statistical analysis of the post-intervention scores showed significant differences only in the free recall part of the DS test (z=-2,077; p<.05) where the CG performed slightly better than EG.

To explore the differences between pre and post phases in each group we conducted a Wilcoxon Test of related samples. The results for the EG showed significant differences between the two conditions in the MS, TMTA, FAS, Animales, Stroop Color Naming, Stroop Word Color score and DS test (including de Coding, the Incidental learning and the Free recall conditions). The same analysis carried out in the CG only reached significance for the MS test.

A mean contrast between differential scores was also executed using the U-Mann Whitney test. We observed significant higher differences for the EG in the TMTA (z=-2,592; p=.01), FAS (z=-2,350; p<.05) and the Stroop Word Color Condition (z=-2,336; p<.05) and a tendency to the significance was observed also for the TMTB and the DS.

Conclusions

In our experiment we found that FM patients are able to improve their selective attention, verbal fluency and speed of mental processing after a brief online cognitive intervention. Our results are in the line of other that support the positive effects of cognitive training in people with neuropsychological dysfunctions. Different computerized cognitive programs have shown benefits in healthy people (5), malaria survivors (6) or Alzheimer disease (7). Nevertheless, new efforts should be done to shed some light to the neuropsychological rehabilitation of FM patients that would improve their quality of life.

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Feasibility of telerehabilitation system for cognitive treatment in Brain Injury patients

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Introduction

Traumatic brain injury (TBI) is a serious public health problem, because of both its high incidence and the age when it occurs. The impact on a person and his or her family can be devastating and brings important socio-economic problems.

Once the patient has passed the acute phase, TBI contributes to a substantial number of physical, sensitive, cognitive and behavioural disabilities. The cognitive and behavioural disabilities can condition the results of the rehabilitation treatment and have influence on the quality of life of patients and his/her family. Cognitive rehabilitation is fundamental for this kind of patients (1,2).

Nowadays, therapeutic strategies assisted from computer have been used; they have some advantages such as timetable flexibility to perform rehabilitation and personalize the patient´s treatment.

The incorporation of new technology through which allows adaptation and accessing to rehabilitation treatment, especially to those patients with some difficulty to get to the hospital due to a geographic problem or reduced movement (3-5).

OBJECTIVE: To develop a telerehabilitation platform called mHealth for cognitive treatment in patients with moderate/severe TBI and to verify the clinic validity of the cognitive rehabilitation platform.

Methods

Developing the system of the platform: The telerehabilitation platform was designed in Java, as a client-server application, according to defined requirements by multidisciplinary team composed of rehabilitation specialist and engineers of Innovation Technologic Group from Virgen del Rocío University Hospital with collaboration of El Sendero.

The platform allows clinicians to establish, from an evaluated neurocognitive impairment, an individual and structural cognitive treatment.

mHealth was implemented as a web application using Apache Tomcat Server and MySQL database.

The client application was developed for running in tablet PC with android system. Patients use tablet to do cognitive exercises and connect with the clinicians to ask questions about cognitive treatment sending audio messages. Clinicians access to web application on PC or laptop to resolve questions to patients, collect information and monitor the activity and results of the treatment performed. In addition, a videoconference system was implemented using RTMP protocol for exchanging information in real time among clinicians and patients. It also allows clinicians to evaluate the evolution of patients.

Study design: CUASI experimental study, with control group (after approval from ethical committee).

Eleven patients with moderate and severe TBI were included in the pilot. All of them satisfy inclusion and exclusion criteria (cognitive function Ranchos los amigos scale >4, age over 16, language that makes possible cooperation with the treatment, presence of caregivers and 3 G connection).

The patients were divided into: 1) experimental group (cognitive treatment from telemedicine platform and 2) control group (conventional treatment in hospital). All the patients used the Cognitive Stimulation Smartbrain program (5). The duration of the training was 4 months.

All the patients were evaluated at the beginning and the end of the pilot with the following test: Minimental Test, Brief Neuropsychologist scale and Ranchos Los Amigos levels of cognitive functioning scale (LCFS).

Results

Ten patients were included in the study, of those two patients who belong to experimental group were absent along monitoring of the results so we included 4 patients in experimental group and 5 in control group.

We developed a descriptive analysis of the variables included in the study (table 1) according to inclusion in experimental group or control. There were no significant differences between both groups except the age which was higher in control group.

Comparing results in both groups we observed recovery in cognitive deficit as much as in experimental group as control group, obtaining better score in the different measurement instruments used in cognitive evaluation (table 2).

Conclusions

We have developed a telerehabilitation platform for patients who suffer from TBI to perform cognitive treatment from patients 'home, improving accessibility to cognitive treatment in these patients (6).

The results obtained allow us to conclude that the utilization of the cognitive mHealth telerehabilitation platform allows those patients who suffer from moderate/severe TBI to perform cognitive treatment as a fundamental part in their rehabilitation treatment.

Acknowledgements: This work is funded by the Vodafone enterprise and is under the project RETICS (Cooperative Research Thematic Network on Health) Innovation in Medical Technology and Health, Instituto Carlos III. (RD09/0077/00025), 2010.

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Standardizing measurement instruments in an European project: REWIRE (Rehabilitative Way out in Responsive home Environments)

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Introduction

According to the World Health Organization, 15 million people suffer stroke worldwide each year and it will increase over the next years. Of these, 5 million die and another 5 are permanently disabled (1,2).

One of the main factors influencing the functional recovery after stroke is the brain plasticity. Patients who follow a rehabilitation program have a lower risk of functional decline and greater independence than those who do not complete it (3).

The aim of the REWIRE study (develop by a European Consortium funding, call: FP7-ICT-2011-7. ICT FP7) is to develop and evaluate a friendly and accessible virtual reality platform that allows clinicians and patients to work together in a rehabilitation program from patients´ home. Patients perform rehabilitation exercises through the platform; the patient sees himself/avatar on the screen interacting in real time their movements with a virtual game. The system collects the movements made by the patients through a system of cameras and corporal sensors (4). The activity carried out by the patient will be registered in the platform and evaluated by clinicians allowing them to adapt the treatment of the patient.

A pilot study that validates the utility of a virtual reality platform is essential in the project. Numerous measurement instruments are been included in order to obtain that validation.

The purposed of this communication is standardizing those measurement instruments that are used in this project. They will demonstrate if REWIRE system is able to provide accurate rehabilitation treatment.

Methods

After establishing the different variables included in the pilot study and choosing inclusion/exclusion criteria, measurement instruments are selected to analyze the results of the Project.

The selection of measurement instruments has been decided by an expert committee which is constituted by different clinicians from Virgen del Rocio Hospital (Sevilla) and University Hospital Zurich having agreement after four video calls.

The selection process is based on:

1. **Select widely adopted instruments** to facilitate adoption and ensure applicability of the REWIRE platform
2. **Commonly applied in the usual clinical practice of pilot settings** Given that researchers are familiarized with the scales, it is expected to facilitate the pilot study
3. **Avoid Intellectual Property issues:** FIM scale is commonly used by SAS but in order to apply this instrument it is required to pay fee.
4. **Evaluation criteria:** Reliability, Validity and Responsiveness are essential to the evaluation of outcome measurement.

Some of the measurement instruments are not validated in Spanish so we need to develop a translation and cultural adaption process (TCA) for patient reported outcomes as this TCA is necessary for the quality of the study and mainly to compare results among patients in the different countries that they are included.

The process of TCA is the following:

1. **Spanish Translation:** 2 translations from the original version to Spanish by 2 independent bilingual translators.

2. **Backwards Translation:** 2 translations from the Spanish version to the original language by other 2 translators. The objective is detecting possible mistakes or discrepancies.
3. **Assessment of the cultural equivalence for the Spanish version:** A multidisciplinary committee will review the Spanish version, evaluate scale items and verify cultural equivalence (with comparative criteria previously established (5,6,7)) before they approve the final Spanish version.
4. **Determine reliability and validity of the new measurement instrument.**

Results

We selected the following 16 measurement instruments: minimental, Züe Max, NIHSS (8), Berg, Barthel (13), Asworth (9,10), Modified Ranking Scale (14), Six minutes walking, FAC, Fugl_Meyer (11,12), ARAT, Motor Activity Log (15,16), star cancellation test, FAC, Euro-Qol 5D (17) and SIS (18).

Five of them are not validated in Spanish so we had to develop TAC.

After the Spanish translation and backwards translation the committee considered that 60% (FAC, MAL and Fugl-Meyer) were classified in A (semantics and cultural equivalent), 20% (ARAT) in B (similar meaning but some differences) and 20% (Züe-Max) in C (questionable translation, loss of the original meaning)

Those tests classified in B or C, with conceptual difference, were discussed among the different members of the committee until they obtained collective agreement with the translation[4].

Conclusions

After the methodology we have used in the project it is possible to conclude that ARAT, MOL, ZÜE-MAX, Fugl-Meyer and FAC can be used as measurement instruments in Spanish population since they are equivalent to the original version.

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Attentional improvements after a cognitive rehabilitation program in Relapses Remitting Multiple Sclerosis patients

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Introduction

Cognitive impairment is a common feature in multiple sclerosis (MS) patients and occurs in a range of 40 to 60% of all cases (1). Regrettably, our knowledge about the real capacity of cognitive rehabilitation in these patients is scarce.

The present study was carried out with a selection of patients with Relapses Remitting Multiple Sclerosis (RRMS) clinically defined and cognitive deterioration (based in neuropsychological scores). A cognitive rehabilitation program based on Attention Process Training Programme (APT) was applied to them (2,3). The evaluations of behavioral data for the control of the benefit of the rehabilitation program were obtained before the application of the program and after it, to check the possible benefits of the rehabilitation. These results were compared with a group of healthy subjects.

Methods

Fourteen patients with RRMS and seventeen healthy controls took part in this study (exclusion criteria: No motor impairment or the presence of a relapse in the last month in RRMS Group and/or the presence of clear signs of depression or other psychopathological conditions in all the participants). MS Group and Control Group were matched in all sociodemographic parameters. All the participants performed an "Oddball Task" in two separated moments (4,19 months between two evaluations. STD: 1.68). Both groups were evaluated before and after the APT program. The parameters calculated were "Reaction time" (RT) and "Accuracy". Repeated measures analysis of variance (ANOVA) and post-hoc t-test with Bonferroni correction were applied to all the results.

Results

The ANOVA showed a group effect (F (1, 29)= 31, 07 p<0.001) and an interaction effect of reaction time by group (F (1, 29)= 9, 25 p<0.01). A post-hoc analysis showed differences between groups in the two measures ($p<0.05$), with faster RT for controls on both measures. In addition, post-hoc analysis showed that controls had no differences between measures ($p=1.00$), indicating the stability of the paradigm. However, patients had a significant improvement ($p < 0.01$) in the reaction time after the rehab program was applied (Figure 1). No differences were found in Accuracy data between groups and between sessions in any group.

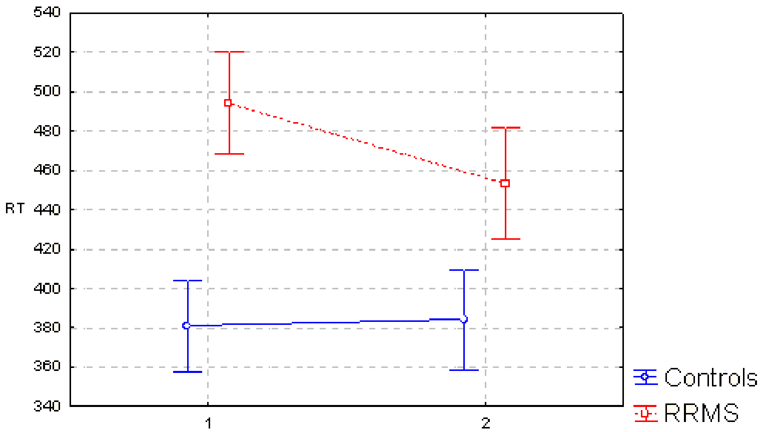

Figure 1. Reaction Times for both groups studied in each moment analyzed.

Conclusions

The evidence of cognitive impairment found in this study and in other works in RRMS patients suggest the need to conduct cognitive rehabilitation programs in these patients (4). In this study, we demonstrated that the behavior (reaction time) improved in a RRMS group after a cognitive stimulation program via computerized assessment. These tools could be useful to assess impairment and possible cognitive improvement related with cognitive stimulation programs. Moreover, it could help in the clinical diary practice of the professionals who works in brain injury or other neuropathological disorders.

Acknowledgements: This study has been supported by Plan Nacional I+D+i PSI2010-16825 (Government of Spain), Asociación Neuroinvest and Asociación Sanitaria Virgen Macarena.

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Evaluation of age parameter in sensorymotor behavior with robotic rehabilitation

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Introduction

The impairment and disability following an acquired brain injury (ABI) are often assessed by many scales that are long, hard and concentrated in only some aspects of the impairment. Therefore, many times it is necessary to use more than one scale in order to achieve a global and complete assessment. Furthermore, although these scales are standardized and validated, they depend on the therapist's perceptual decision when monitoring the behavioral performance of the person, so they are inherently subjective (1). Another limitation of these protocols is their scoring system that is relatively coarse, since the observer typically scores the patient's performance on an ordinal or ordered categorical scale with few options to choose from. This makes it difficult to quantify improvement and detect subtle, but clinically important, functional changes.

The recent development in robotic technology has shown that robotic devices are capable of playing this role in rehabilitation because of their characteristics of objectivity and reliability. They can gather kinematic and kinetic data in order to use them to find useful markers that quantify the motor recovery process (1-3).

The purpose of this study was to use a robotic system and a reaching task to identify useful and noticeable kinematic and kinetic measures in order to determine the influence of age on specific aspects of the sensorimotor function. We hypothesized that people of different ages would show differences in one or more attributes of sensorimotor performance, according to previous studies (4-6).

Methods

PUPArm robotic system

The task was monitored by a pneumatic robotic device of two degrees of freedom called PUPArm (nBio –Miguel Hernández University). The PUPArm was carried out as a rehabilitation robot for the interaction with subjects affected by neurological disorders. The system permits only horizontal motion; involving flexion and extension of the shoulder and elbow and horizontal abduction and adduction. In this study, it was programmed to not assist the participant in completing the task.

Experiment setup & protocol

The design of the protocol was based on Coderre et al (2010) (2) design. Participants were asked to grasp the end-effector of the robotic device in order to reach peripheral targets (1.0 cm radius), "quickly and accurately", from a centrally located target (1.0 cm radius). There were 8 peripheral targets distributed uniformly on the circumference of a circle, and placed at 10 cm from the center target.

Participants

Fifty-one subjects (age 20-80) with no known neuromotor disorders of the upper-limb have participated in the study. They were divided into three groups according to age: Group 1 (age 20 – 40), group 2 (age 41 – 60) and group 3 (age 61- 80). Each group had 17 subjects.

Results

Table 1 shows descriptive statistics including median, kurtosis and asymmetry that were calculated for the three groups.

		Median		Assymetry		Kurtosis	
AgeGroup		MD	MND	MD	MND	MD	MND
Postural Speed (mm/s)	1	0.690	0.660	-0.208	1.003	-0.717	1.585
	2	0.730	0.740	1.777	0.664	4.743	-0.238
	3	0.870	0.690	1.815	0.712	3.338	0.716
Reaction time (s)	1	0.400	0.400	0.493	-0.023	0.962	0.425
	2	0.430	0.430	0.065	-0.253	-1.117	-0.670
	3	0.440	0.440	-1.640	0.929	5.394	0.388
Initial movement direction error (º)	1	9.550	9.760	0.126	-0.558	-1.523	-0.451
	2	10.94	9.280	0.894	0.960	0.137	1.262
	3	18.77	13.29	0.061	1.179	-0.917	2.403
Initial movement ratio	1	0.620	0.630	0.208	-0.275	-0.472	0.667
	2	0.600	0.590	-2.087	-0.283	5.550	-0.729
	3	0.290	0.490	0.487	-0.256	-1.094	-1.059

Maximum speed (mm/s)	1	146.49	155.24	1.599	1.257	2.887	2.928
	2	135.88	137.46	-1.238	0.013	1.248	0.237
	3	92.04	109.39	1.134	1.291	2.535	1.878
Path length (mm)	1	95.91	94.87	0.007	1.862	-0.863	3.143
	2	97.95	94.85	3.125	0.753	11.467	1.294
	3	98.63	97.61	-3.382	-0.161	13.317	-0.967
Movement time (s)	1	0.860	0.810	-0.160	0.208	-0.096	-0.457
	2	0.990	0.890	1.681	1.028	2.740	0.308
	3	1.700	1.340	-0.106	0.558	-0.437	-0.101
Force (N)	1	1.550	1.550	0.134	0.139	-1.807	-1.776
	2	1.380	1.390	-0.236	0.136	-0.277	0.863
	3	1.340	1.380	-2.178	-0.065	6.697	-0.014

Conclusions

The present study used a reaching movement to identify differences in the sensorimotor function due to the age. The nature of the task, without support of the limb against gravity, permitted to explore deficits in motor coordination, and also the influence of loss of muscle strength on motor performance. It was found that, at least in 7 of 8 movement parameters, there is a difference between group 1 and 3. Furthermore, this difference was not the same for both arms (dominant and non dominant). In most cases, it was greater for the dominant arm.

The findings from this study indicate that in the assessment of upper-limb sensorimotor function, the influence of the age should be taken into account. Moreover, robotic systems can provide a new and effective approach in the assessment and rehabilitation of neurological patients. Conventional physiotherapy and robotic technology should not just be alternatives but complementary approaches in the rehabilitation process.

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Differenced Analysis of the Weight Distribution Symmetry during the Sit-To-Stand Movement

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Introduction

Weight Bearing Asymmetry (WBA) is a problem that limits the development of the activities of daily living (ADL) in most patients with loss of postural control. Usually, WBA affects specially patients with neurological impairments ((1)) and patients with musculoskeletal injuries ((2)).

In the rehabilitation of the WBA, the use of a force platform (FP) is very interesting because a FP allows the use of the Center of Pressure (COP) in the process, either to provide a real-time feedback for patient, either to record the evolution of patient. Recently, many authors apply low-cost FP, such as de Wii Balance Board© (WBB) for the assessment of the WBA ((3)), demonstrating their reliability measuring the COP of the patient ((4)).

For the recovery of the symmetry, the sit-to-stand (STS) movement is critical ((5)). In this way, a recently introduced system ((6)) uses the WBB for the recovery of the symmetry in the STS movement.

This contribution presents an evolution of this system that allows recording the symmetry index (SI) in three different phases: when the patient is rising from the chair, when the patient is sitting on the chair and when the patient is standing.

The system has been completed with applications that show this information graphically, allowing clinical specialists to follow evolution.

Methods

The designed system has a very low cost and can be easily integrated in the clinical setting ((6)). It uses a conventional computer with a flat TV and a WBB.

The main stage of the system is a game, providing more entertaining rehabilitation. The system can be customized, covering a wide range of patients.

The system includes an adaptive level that avoids the frustration of patients maintaining their motivation.

The evolution presented in this contribution can distinguish the phase in which the patient is rising, sitting or standing. To do this, the system uses the force registered by the FP, comparing this force with the weight of the patient standing and resting. Figure 1 shows the registered force in 12 seconds; in this period, the user was standing initially, after he carried out the sit-to-stand movement four times.

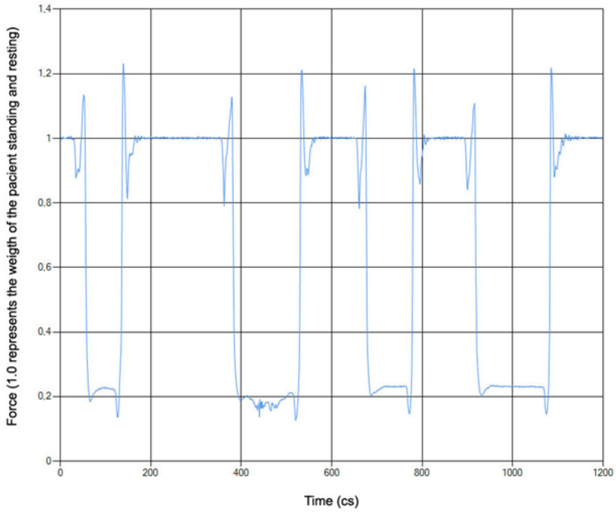

Figure 1. Additional tools have been developed to show detailed the evolution of the symmetry of the patient (Figure 2).

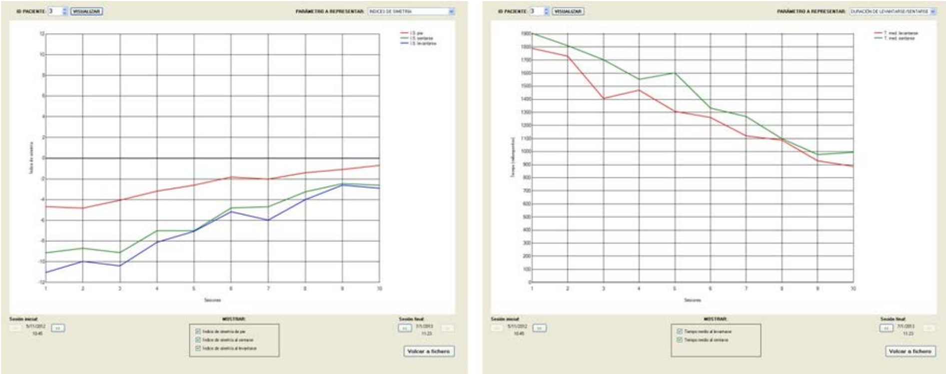

Figure 2. Many information is displayed, including average and standard deviation for the SI of the patient in each session (and in each movement) –Fig ure 2, left- and average time for the STS movement –Figure 2, right-.

Results

The presented system has not yet clinical results, but clinical specialist are encouraged with the system because this information is very interesting to follow patient's evolution.

Clinical specialists are currently elaborating the details of the clinical evaluation. This evaluation may provide also conclusions about the evolution of patients in the different phases (sitting / raising / standing).

Conclusions

In this contribution authors presented a system that registers the WBA for the STS movement. The system details the WBA in the different phases: sitting, raising and standing. Also, the system provides interesting information about other values, such as rising / sitting time.

With this information, clinical specialist can adapt more accurately the rehabilitation program of each patient.

Acknowledgements: This contribution was funded partially by G. Valenciana ("Aj. per la realitzación de proj. d'I+D per a grups d'investigación emergents", GV/2012/069).

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Virtual rehabilitation system for recovery of upper extremity function in stroke patients

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Introduction

The efficiency of integrating technology and virtual reality to improve the motor rehabilitation process has been proven in recent years. Many contributions focused on rehabilitation of functionality of the upper extremities following a stroke, can be found in the current state-of-the-art.

In 2008 an interesting contribution reviewing Virtual Reality Systems for upper extremity rehabilitation was published ((1)). Since then, new systems for the recovery of upper limb functionality have been released with proven efficiency. Many of these systems use robotic aids, especially for the initial recovery stages, such as the system presented in ((2)). Other systems simply track the upper limb of the patient for the interaction with the system ((3)).

In this contribution we present a Virtual Reality system for the rehabilitation of functionality of the upper extremities. This system uses a low-cost tracking system with easy integration in the clinical environment. Also, the presented system can be customized, covering a wide range of patients. In the system, patient can interact with only an extremity (right / left) or with both extremities simultaneously. When the system is used with both extremities simultaneously, patients also work other skills such as divided attention, which is a deficit identified in people with stroke ((4)).

Methods

In the system design, cost and ease of integration in the clinical setting are considered. Relating cost –and also performance-, the selection of the tracking system is critical. For our system we choose Microsoft Kinect©, because it is a low cost device widely available. Kinect allows the 3D location of the patient's limbs during the game with enough accuracy, and does not require the patient to use any added equipment. The choice of Kinect has facilitated the integration in clinical setting: Kinect does not need initial calibration and it is very permissive in the illumination requirements.

Concerning hardware, besides Kinect, the system uses a conventional computer and a display device –a flat TV is recommended-.

As regards to software, the core of the system is a custom-designed game which utilizes the location of the hand(s) to perform the interaction. In the game –basically- the player tries to get different treasures (static and dynamic) avoiding dangerous objects such as dynamite (static object) and bombs (dynamic object) (Figure 1).

Figure 1.

Before the playing stage, the clinical specialist sets the parameters of the game for the patient. Clinical specialists can determine if patient will interact with both hands or only with one hand, the speed and difficulty of the objects, the size of the tracked area and the duration of the session. As in other Virtual Rehabilitation systems, an adaptive level is available; this level adapts the difficulty of the game in real-time depending on how the patient is doing.

After playing, the system shows the main results of the session; these results are accompanied by auditory and visual reinforcement. Also, complete information about the session (results, 3D location of the hands every 15 cs, …) is stored, to help clinical specialists in the supervision of the improvement of the patient.

Results

Currently the system is developed and alpha testing is being carried out to ensure its robustness. Simultaneously, clinical specialists are designing the clinical trial for the system. In this clinical trial they are considering motor scales –for measuring the evolution of the functionality of the upper limbs- and cognitive scales to evaluate other skills such as the divided attention.

Conclusions

In this contribution a work-in-progress is presented. This is a low cost virtual rehabilitation system for upper extremities. The system may be integrated in the clinical routine immediately and permits to work also cognitive skills.

Clinical specialists are stimulated with this first version of the system, and they are designing the clinical trial to evaluate the clinical effectiveness of the system.

Acknowledgements: This contribution was funded partially by G. Valenciana ("Aj. per la realització de proj. d'I+D per a grups d'investigación emergents", GV/2012/069).

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Assistance-as-needed robotic control algorithm for physical neurorehabilitation

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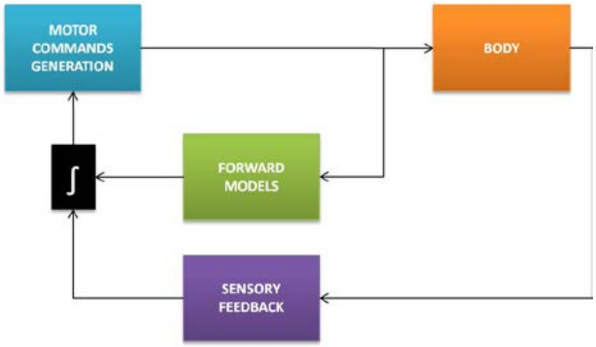
Introduction

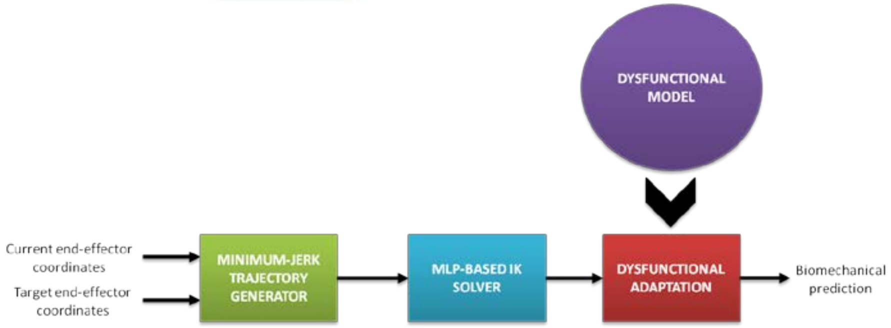
Robotic devices are becoming a popular alternative to the traditional physical therapy as a mean to enhance functional recovery after stroke since they offer more intensive practice opportunities without increasing time spent on supervision by the treating therapist. An ideal behavior of these systems would consist in emulating real therapists by providing anticipated force feedback to the patients in order to encourage and modulate neural plasticity. However, nowadays there is not a system able to work in an anticipatory fashion.

Methods

The authors propose an anticipatory assistance-as-needed control algorithm for a multijoint robotic orthosis to be used in Activities of the Daily Life (ADL)-based physical neurorehabilitation. This control algorithm is based on the computational model of motor control proposed by Shadmehr et al. (1) shown in Figure 1.a. The key component of this motion generation computational model are the cerebellum forward models (2,3): they predict the state of the limb allowing one to act on this estimate of state rather than relying solely on a delayed sensory feedback.



(a)



(b)

Figure 1. (a) Motion generation computational model proposed by Shadmehr et al. (1). (b) Biomechanical motion generation subsystem block diagram

In this case the body is substituted by the patient's upper limb and the forward models are implemented by a biomechanical prediction module that, given the current biomechanical configuration of the patient, estimates the evolution of that configuration to reach a specific target. With this estimation, that depends on both the motion purpose of the patient (ADL specific) and the dysfunctional profile, anticipatory force-feedback can be provided to the subject when a non-adaptive motion is going to take place, increasing the patient participation and the associated muscle activity, and thus modulating the neural plasticity (4,5).
In this fashion, the proposed anticipatory assistance-as-needed control algorithm consists in 3 subsystems:

1. A biomechanical motion prediction subsystem (Figure 1.b) that estimates the subject trajectory depending on a previously created dysfunctional profile; this subsystem is composed of 3 modules, a minimum-jerk (6) trajectory generator, a Multilayer Perceptron (MLP)-based inverse kinematics solver module (7) and a dysfunctional adaptation module

2. A decision subsystem that, considering the motion prediction and based on a fuzzy Bayesian decision system, determines the alternative that maximizes utility (provide force-feedback or not)
3. A command generation subsystem that modulates the orthosis rigidity depending on the assistance decisions. Here, it is important to remark that the control algorithm analyzes every DoF independently

Results

The control algorithm has been validated using a 3 (shoulder flexion/extension -fexS-, abduction/adduction -abdS- and elbow flexion/extension -fexE-) DoF Simulink robotic simulator. Data from five patients, which performed the ADL 'serving water from a jar', were used to perform the simulations.

Table 1 shows the simulations results fragmented into the six different time intervals into which the ADL has been partitioned and averaged for all the patients when the pathological subjects perform them using the orthosis and without using it. Given the measured mean correlation and RMSE it can be observed that when the patients use the orthosis, in all the time intervals the performed motions are very similar in shape to the reference ones being the kinematic evolutions' RMSEs lower than those corresponding to the model boundaries almost in every case (those where the RMSE is higher than the limits, the difference is very low). It is evidenced that the patients perform much better when the robotic orthosis is working, and thus, when the neural plasticity is being encouraged.

Obtained results demonstrate that the assistance-as-needed control algorithm is able to provide anticipatory actuation to the patients avoiding trajectory deviations minimizing the degree of actuation, making the patients not to slack and probably modulating the brain plasticity and motor recovery.

Table 1. Simulation results for the ADL 'serving water from a jar' (R=motion performed using the robotic orthosis; r=motion performed without using the robotic orthosis)

		μ_C			μ_{RMSE}			RMSE $\leq$RMSE$_{limits}$		
		fexS	**abdS**	**fexE**	**fexS**	**abdS**	**fexE**	**fexS**	**abdS**	**fexE**
R	T_1	0,98	1	0,82	3,41	1,40	5,58	all	all	4/5
	T_2	1	1	0,97	2,66	0,92	5,92	all	all	4/5
	T_3	0,97	0,98	0,99	3,78	4,03	4,56	all	all	all
	T_4	0,80	0,84	0,78	4,25	7,78	3,54	all	all	all
	T_5	0,99	0,97	0,97	4,16	2,97	4,40	all	all	all
	T_6	0,98	0,99	1	5,12	2,21	2,54	all	all	all
r	T_1	0,7	1	0,28	13,63	9,31	13,42	0/5	0/5	2/5
	T_2	1	1	0,94	13,48	8,06	15,14	0/5	all	3/5
	T_3	0,51	0,76	0,49	16,29	17,76	16,3	0/5	0/5	0/5
	T_4	0,19	0,36	0,46	17,76	19,36	16,01	0/5	0/5	0/5
	T_5	1	0,97	0,75	14,08	6,69	17,89	0/5	all	0/5
	T_6	0,86	0,98	0,15	14,49	6,46	13,38	0/5	0/5	0/5

Conclusions

The main novelty of this work resides in the anticipatory nature of the proposed assistance-as-needed control strategy. It is demonstrated how with the proposed methodology, robotic-based physical neurorehabilitation can be enhanced.

The main advantages of the proposed control algorithm are that the system is:

- Multijoint: it can work with as many DoF as desired)
- Multihardware: it does not depend on the hardware underneath
- Anticipatory: it is able to provide patients with anticipatory actuation thanks to the implementation of the so called forward models by means of a biomechanical prediction subsystem

Acknowledgements: This research work was partially funded by CDTI (project: REHABILITA; CIN/1559/2009), Spanish Government.

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Clustering techniques for patients suffering Acquired Brain Injury in Neuro Personal Trainer

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Introduction

The study of the effectiveness of the cognitive rehabilitation processes and the identification of cognitive profiles, in order to define comparable populations, is a controversial area, but concurrently it is strongly needed in order to improve therapies.

There is limited evidence about cognitive rehabilitation efficacy. Many of the trials conclude that in spite of an apparent clinical good response, differences do not show statistical significance. The common feature in all these trials is heterogeneity among populations. In this situation, observational studies on very well controlled cohort of studies, together with innovative methods in knowledge extraction, could provide methodological insights for the design of more accurate comparative trials. Some correlation studies between neuropsychological tests and patient's capacities have been carried out (1,2) and also correlation between tests and morphological changes in the brain (3).

The procedure's efficacy depends on three main factors: the affectation profile, the scheduled tasks and the execution results. The relationship between them makes up the cognitive rehabilitation as a discipline, but its structure is not properly defined.

In this work we present a clustering method used in Neuro Personal Trainer (NPT) to group patients into cognitive profiles using data mining techniques. The system uses these clusters to personalize treatments, using the patient's assigned cluster to select which tasks are more suitable for its concrete needs, by comparing the results obtained in the past by patients with the same profile.

Methods

NPT (4,5) is a telemedicine cognitive rehabilitation system, offering to therapists a powerful tool for managing, monitor and evaluate therapies more efficiently, based on computerized tasks assigned to rehabilitation sessions that patients execute.

When a patient suffers an Acquired Brain Injury (ABI), the result of the neuropsychological exploration tests let us know the affectation grade of every cognitive function: attention (sustained, selective and divided), memory (visual, verbal and working) and executive functions (scheduling, inhibition, flexibility, sequencing and categorization).

Every exploration battery item corresponds to a concrete cognitive subfunction. The alteration of one subfunction turns on an alteration of the higher function. This higher alteration also provokes a global affectation profile. Thus, in order to study the efficacy in the procedures an identification of the different profiles is needed and, after that, to define if there is an improvement on a subfunction level, on a function level, or on a global level.

To elaborate the affectation profiles a normalization process is carried out. The different tests results are put on the range 0 to 4, from no affectation, minor, moderate, severe to very severe. This normalization process not only considers the tests results itself, but also the patient's age and study level, because these two demographic data influence the patient's cognitive capacities.

Results

Once the normalized tests results are in the system, clinical criteria for every subfunction, function and global affectation are applied. The identification of these initial affectation profiles allows NPT to group patients into clusters.

This clustering procedure is able to identify groups of patients on a non-supervised manner, implementing the Expectation Maximization (EM) clustering technique using Weka tool. This probabilistic clustering technique is based on a statistical model called mixture, and gives us the probability for each patient to belong each cluster.

Nowadays, the system has 608 patients with a cognitive profile assigned in the database; in total, the system has grouped all these patients into 9 different clusters, what means 9 kind of related patients.

Conclusions

The clustering process used in NPT groups patients with similar characteristics, taking into account the patient's initial neuropsychological exploration, age and study level. Once a patient has a cognitive profile assigned, using data mining techniques, the system makes use of the historical information related to every patient's execution results and their improvement after completing the treatment to determine which tasks are more suitable to each patient. By analyzing which tasks have worked fine in the past for patients with the same cognitive profile, the therapist can easily choose the more suitable tasks for each treatment.

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Effects of emotional valence and three-dimensionality of visual stimuli on brain activation: an fMRI study

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Introduction

Examining changes in brain activation associated with emotion-inducing stimuli is essential to the study of emotions. Due to the ecological potential of virtual reality in neurocognitive rehabilitation, inspection of whether brain activation in response to emotional stimuli can also be modulated by the three-dimensional properties of the images is now important. This study sought to test whether the activation of brain areas involved in the emotional processing of scenarios of different valences can be modulated by three-dimensionality. It focused on the interaction effect among emotion-inducing stimuli of different *emotional valences* (pleasant, unpleasant and neutral valences) and *visualization types* (2D, 3D).

Methods

The sample consisted of 12 healthy male subjects. The group's mean age was 26.58 years old (*SD* = 5.16). The stimuli were three 3D Affective Inducing Scenarios (3DAIS) (1) composed by 3D objects1. Sets of 15 stimuli-objects formed each scenario, with one set per *emotional valence* – pleasant, unpleasant and neutral. The 3D objects database had been previously developed according to the type of contents in the International Affective Picture System (IAPS) (2) and validated with the Self-Assessment Maniquin (SAM)(3). *Visualization type* (2D, 3D types) and *emotional valence* (pleasant, unpleasant and neutral scenarios) were used as factors in a simple within-subjects 3x2 experimental design. The experiment consisted of a single session of fMRI scanning. Data were analyzed through a GLM-based random effects procedure. Resulting whole brain activation maps for all contrasts were thresholded at p-value < 0.001 (uncorrected).

Results

The results show increased brain activation for the 3D affective-inducing stimuli in comparison with the same stimuli in 2D scenarios, mostly in cortical and subcortical regions that are related to emotional processing. In addition, we found the activation of portions of the limbic lobe, traditionally recognized as especially significant for emotion (Table 1). Considering that current neurobiological models of emotion and several studies recognize the mediation of cortical and subcortical areas in emotional processing these results are consistent with the literature (4-6).

Table 1: *Anatomic location, brain hemisphere, brain areas and their Talairach coordinates, in which seven or more voxels were activated, detected through 3x2 ANOVA analysis*: *Interaction effect of* visualization effects *and* valence.

Anatomic Location	**BH**	**BA**	**Coordinates**			***F***	***P***	**Size**
			x	**y**	**Z**			
Uncus	L	36	-19.0	-8.0	-27.0	18.506	0.000019	31
Postcentral Gyrus	R	3	41.0	-20.0	51.0	13.294	0.000164	20
Middle Frontal Gyrus	R	46	53.0	28.0	24.0	16.225	0.000047	15
Declive	R		35.0	-62.0	-15.0	16.723	0.000038	15
Cerebellar Tonsil	L		-37.0	-38.0	-36.0	15.234	0.000070	14
	L		-25.0	-41.0	-42.0	15.584	0.000061	13
	L		-13.0	-56.0	-36.0	14.638	0.000091	8
Cingulate Gyrus	R	24	20.0	-8.0	39.0	15.697	0.000058	10
Lentiform Nucleus	L		-31.0	-14.0	6.0	15.336	0.000067	9

Note: BH = Brain Hemisphere; BA = Brodmann’s area; L = left; R = right; *number of voxels.

Conclusions

This study might enable us to clarify brain mechanisms involved in the processing of emotional stimuli (scenarios' valence) and their interaction with three-dimensionality.

Acknowledgements: This research project was funded by national funds through FCT - Portuguese Foundation for Science and Technology (Ref. SFRH/BD/28510/2006), co-funded by FEDER funds through COMPETE - Operational Programme 'Thematic Factors of Competitiveness, and also co-funded by BIAL Foundation (Ref. 94/08). The authors also wish to thank Eduardo Ribeiro, Ernesto Pinho, Marcos Freitas, and SMIC, for their cooperation in the acquisition of the fMRI data.

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Evidence-based rehabilitation after Acquired Brain Injury: a clinical trial on a Holistic Neuropsychological Rehabilitation Program

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Introduction

Comprehensive-holistic neuropsychological programs have been recommended as a practice standard during post-acute rehabilitation in order to reduce cognitive and functional disability after moderate or severe brain injury. One major challenge of clinical research is to provide systematic data for the development of evidence-based neuropsychological rehabilitation. Rehabilitation after brain injury is concerned with reducing levels of disability, either through restoration, or the use of adaptive and compensatory strategies. The goal of rehabilitation is not only the remediation of cognitive impairment, but mainly the establishment of a meaningfully and satisfactory life in face of persisting limitations. Outcomes may be assessed at the level of impairment, activity or participation. This study aims to evaluate the efficacy of the Holistic Neuropsychological Rehabilitation Program (HNRP), held in Centro de Reabilitação Professional de Gaia in cognitive performance, emotional stability, functional ability and quality of life.

Methods

Twenty-six patients with Acquired Brain Injury (ABI) were selected for a prospective cohort study assigned in two groups: a treatment group (*n* = 15 ABI participants) received HNRP, a control group (*n* = 11 ABI participants) without rehabilitation. Both groups were statistically matched for demographic and clinical factors.

Table 1. Sample description

	N	Age (years) *M/SD*	Gender M/F	Education (Years) *M/SD*	TAI (Months) *M/SD*	Etiology TBI/Stroke	Severity severe/ *moder-ate*
Treatment group	15	29.1/7.5	11/4	9.4/3.4	31.7/20.0	10/5	13/3
Control group	11	35.45*/8.3	8/3	9.8/4.4	41.2/36.9	8/3	8/3

TAI = time after injury; Injury severity: 1=severe 2=moderate

Data was collected in two moments: before and after the program, with a time course of 18 weeks for both groups. Cognitive performance was assessed through neuropsychological standardised tests: *WMS III* for working memory, D2 for sustained attention, and *BADS* for executive functions. Emotional stability was measured by *HADS*. *GOSE* was used to assess functional ability and *Quality of Life* was measured by *QOLIBRI* – a specific scale to assess quality of life after brain injury. *Group*, *Time of Evaluation* and interaction effects were analysed via two-way repeated measures ANOVA.

Results

Concerning attention, a main effect was found for *Time*, with both groups showing better performance in the post-test in concentration [F (1,23)=10.37, *p*=.004). Despite the fact that there was no treatment effect on working memory as a whole, a marginal interaction effect *Group* X *Time* was found for the *Letter-Number Sequencing* subtest [F (1,24)=3.12, *p*=.09], with the Treatment Group reporting a higher score after the program. Regarding executive functions a marginal main effect was found for *Group* X *Time* for the *Rule Shift Cards* subtest with the Treatment Group reporting a higher score after the program [F (1,24)=3.74, *p*=.065]. Concerning emotional stability, an interaction effect *Group* X *Time* was found for depression [F (1,24)=6.11, *p*=.021], with the Treatment Group reporting a lower depression index after the program. As to functional ability and Quality of Life an interaction effect *Group* X *Time* was found, with the Treatment Group reporting an increased Quality of Life [F (1,24)=6.92, *p*=.015] as well as improved functionality after the program [F (1,24)=5.17, *p*=.032].

Conclusions

The results provide clinical evidence that comprehensive holistic neuropsychological rehabilitation improves emotional stability, functionality and quality of life after brain injury. The weak effect on cognitive functioning is probably related with the fact that standardized tests appear not to be the best option when evaluation improvement in daily function. Other cognitive measures of outcome should be considered to assess intervention, such as goal attainment.

A study of construct validity of ClinicaVR: Classroom-CPT encourages its use in the assessment and rehabilitation of attention and inhibition in children

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Introduction

Having garnered interest both in clinic and in research, the Virtual Classroom (2) was recently revised by the Digital MediaWorks team under the name *ClincaVR: Classroom*. This virtual test is identical to the traditional VIGIL-CPT (1) except for the environment in which it is administered: instead of being presented on a computer screen, the stimuli appear on a whiteboard situated in a virtual classroom. The virtual classroom features objects and people commonly found in real classrooms, such as the blackboard, desks, a teacher and students. Participants were immersed in the virtual environment by wearing an Emagin Z800 HMD with the ability to monitor the wearer's head movements. Participants were able to look 360 degrees around themselves as well as up and down in the virtual environment. Typical classroom sounds were played to the participant through headphones integrated into the HMD. Throughout the duration of the virtual test, the wearer experienced auditory and visual distractions typical of a real classroom, such as a knock at the door, a bell announcing the end of class, children laughing outside and a visit from the principal.

Methods

The study was conducted on 111 children and adolescents aged 6 to 16. All participants were enrolled in a regular school program and had never displayed learning or developmental problems.

Results

Construct validity of *ClinicaVR: Classroom-CPT* was verified by means of a principal axis exploratory factorial analysis with Varimax rotation, which was performed on the scores of the virtual and traditional Continuous Performance Test. Three factors were found, accounting for 76.12% of the total variance. These three factors represented head movements, reaction time and quality of performance (good responses end errors). Results supported the construct validity of *ClinicaVR: Classroom-CPT*.

Conclusions

We recommend *ClinicaVR: Classroom-CPT* as an assessment and rehabilitation tool for attention and inhibition in clinic and research.

Acknowledgements: This research was made possible thanks to the Fond de Développement Académique du Réseau de l'Université du Québec (FODAR) and Fonds Institutionnel de Recherche (FIR) de l'Université du Québec à Trois-Rivières (UQTR).

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Molecular mechanism for cumulative effects of repetitive transcranial magnetic stimulation on neural plasticity in rats

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Background and Aims: We aimed to evaluate the cumulative effect of multi-session repetitive transcranial magnetic stimulation (rTMS) on gene expression and protein synthesis which are correlated with neural plasticity.
Methods: Eight-week-old Sprague-Dawley rats (N=45) were subjected to unilateral rTMS with low- (1Hz, n=15), high- (20Hz, n=15) frequency, or sham (n=15) stimulation groups. Each group were divided into 3 subgroups as the number of stimulation sessions; 1-, 5-, and 10-day (n=5 for each subgroup). Stimulation was applied to the left hemisphere using a 25-mm, figure-of-8 coil for 20 minutes with intensity set at 110% of motor threshold. Brain tissues were obtained 15 minutes after rTMS, and RT-PCR was conducted for *c-fos, vegf, bdnf, mGluR1*, and *GABAa* receptor genes to investigate gene expression concerning immediate early gene, angiogenesis, neurotrophin, long term potentiation and depression. Ratios of fold changes to that of *gapdh*, a house-keeping gene, were compared in each group. Western blot was done for Akt and phospho-Akt (pAkt).
Results: In RT-PCR, *vegf* gene expression showed significant difference between each group with 5-day stimulation. High-frequency rTMS for 5 days increased *vegf* expression (median 0.63, range 0.18-0.87 in sham group; 0.91, range 0.43-1.32 in low-frequency rTMS; 1.59, range 1.56-1.69 in high-frequency rTMS group, p=.006). The *vegf* expressions tended to increase with longer stimulation session, however, were not significantly affected. The *mGluR1* and *GABAa* receptors were increased in low- and high-frequency groups respectively. Levels of *c-fos* and *bdnf* did not differ between subgroups. In Western blot, high-frequency rTMS for 10 days increased pAkt synthesis than 5-day rTMS did (median 2.27, range 1.86-2.34 in 10-day stimulation; median 1.01, range 0.63-1.29 in 5-day stimulation, p<.001).
Conclusions: This study revealed evidence of increased expression following high-frequency rTMS in the gene concerning angiogenesis. It may play a key role in excitation-neurogenesis coupling in rTMS-induced neural changes.

Computer games in the therapy of children suffering from cerebral palsy

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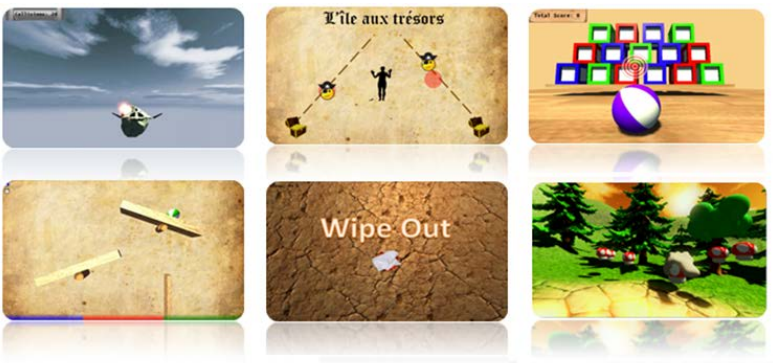
Introduction

The interest in using computer games in the revalidation process of children suffering from cerebral palsy (CP) is growing. Computer games are now part of every day's life of many children, from an early age on. Recent technological developments like the incorporation of advanced camera systems or motion sensors in the game platforms have also resulted in the availability of commercial games for fitness exercises, yoga, balance training and the like. Although such games could also be a motivational factor in the therapy of CP children, commercial games mainly remain unsuited for many CP children, due to the required level of motor control and speed, the visual complexity, the cognitive requirements of the games… The aim of this pilot project was to test the added value in terms of enjoyment of introducing a specifically designed computer game in the treatment of cerebral palsy children during an intensive rehabilitation holiday camp.

Methods



A computer game specifically designed for CP children might eventually be an alternative. However, due to the very broad spectrum of CP children with respect to motor skills, cognitive functioning and visual impairment, such a dedicated game might also only target an extremely limited subgroup of CP children. Recently, we've introduced six different mini games developed specifically for the revalidation of CP children. Each of these games is highly customizable by the therapist; the therapist can not only adapt the difficulty level of the game and the game speed, but also the visual complexity of the scene and even how exactly body movements are affecting the game (1). Games can also be controlled by (a combination of) various input devices including the Kinect camera and balance boards.

In a 10 days intensive rehabilitation holiday camp, children with hemiplegic cerebral palsy (N=12, 9 are female) aged 6-14 performed 9 hours a day a new functional bimanual and locomotor intervention based on games and functional activities (2) .During the first 5 days, the intervention was performed without virtual reality, during the last 5 days, the proposed virtual games were included for 20 minutes per day. Children evaluated the enjoyment of the intervention after 5 days and at the end of the camp using an analog visual scale ranging from 0 to10.

Results

Average score of enjoyment regarding the intervention was 8.0 (2.56) at 5 five and was 9.0 (1.70) at day 10, representing a significant improvement (p=0.04). This suggests that the introduction of virtual reality, in addition to the evolution of the intervention increased the level of enjoyment of the children.

Current preliminary evaluation of our gaming platform is suggesting that both patients and therapists are acknowledging the potential of this approach. Proposed games better match the capabilities of the children and therapeutic objectives of the therapists than conventional commercial virtual games. Larger scale studies in more conventional therapeutic contexts need to be developed in the future to isolate more specifically the effect of virtual reality both in the enjoyment and the therapeutic goal of the patients.

Conclusions

In order to be relevant in the therapy of children suffering from cerebral palsy, computer games must be attractive and motivational to the children, while at the same time in line with the therapeutic objectives. Given the wide diversity of children with respect to motor functioning, cognitive capabilities and visual impairment, we propose highly customizable games according to these three dimensions.

Highly adaptable and configurable games as described above allow a wider population of children and therapists to work with computer games during the revalidation process. Games that better match the possibilities of the children and the therapeutic objectives can potentially result in increased motivation, better compliance and adherence and eventually in improved clinical outcomes.

Acknowledgements: This work was performed in the context of the ict4rehab research project funded by the Brussels Capital Region. The authors are grateful to Dr. Yannick Bleyenheuft (Université Catholique de Louvain) who allowed the use of the specific virtual games in replacement of commercial virtual games during her intensive rehabilitation summer camp 2012.

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Like males, female rats also benefit behaviorally and histologically from environmental enrichment after brain trauma

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Introduction

Environmental enrichment (EE) has been shown to produce marked benefits after TBI and therefore may be considered a rodent model of preclinical rehabilitation. However, the EE focus has been primarily in male rats. In order to validate the model, demonstration of similar efficacy in female rats is necessary.

Methods

Normal cycling females were evaluated for estrous cycle stages on the morning of surgery via vaginal cytologies and then randomly assigned to a controlled cortical impact (2.8 mm tissue deformation at 4 m/sec) or sham injury. Following surgery they were assigned to either TBI + STD (n=8), TBI + EE (n=8), Sham + STD (n=4), or Sham + EE (n=4) groups. Motor recovery was tested on a beam-balance/walk task (days 1-5) or rotarod (every other day for 19 days). Cognitive function was assessed with a Morris water maze task (days 14-19). Hippocampal cell survival was quantified at 3 weeks.

Results

No differences were observed in pro-estrous, estrous, or di-estrous stages and therefore the data were pooled. Additionally, no differences were observed between the sham groups and thus these data were also pooled. The analyses revealed that EE robustly improved motor performance, facilitated spatial learning, and attenuated hippocampal cell loss vs. STD housing ($p < 0.05$).

Conclusion

These data demonstrate that EE confers robust benefits in female rats after CCI injury, which parallels numerous studies in males and lends further credence for EE as a preclinical model of neurorehabilitation.

Acknowledgement: Supported, in part, by NIH grants HD046700 and NS060005 (AEK)

Effects of the Vojta's Reflex locomotion therapy in the locomotion patterns in a Type C SCI patient: Study of a case

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Introduction

Spinal cord injury (SCI) is a chronic or acute multi-factorial and multi-system spinal condition with permanent effect considered as one of the most daunting challenges for rehabilitation. This strongly affects the autonomy and independence of the patients' daily living, particularly in their gait patterns (3-4).

The main objective of this study was to assess the effectiveness of the Vojta's Reflex Locomotion rehabilitation method in the recovery of gait pattern and the increase of cadence and stability in SCI patients (1). This study tracks the evolution of locomotion patterns in a patient diagnosed with Type C SCI (based on the ASSIA scale) related to a surgical intervention for an intramedullary ependymoma (4).

Methods

In our study we treated a 37- year old female patient with Type C SCI with two sessions per week of rehabilitation (spanning four months) that consisted in the application of the first phase of Vojta's reflex rolling and reflex creeping positions. At each treatment session we developed pre and post evaluations for the following indicators: strength and step length with dynamometric platforms, gait duration, cadence and stability in the bipedal position and muscle contraction using electromyography (EMG) (2-3). The patient's condition was also evaluated at the start and end of our study by applying the ASSIA and the FIM scales, in order to confirm the SCI type and the patient's functional independence.

Results

We observed significant improvements in many of the evaluated indicators after the Vojta therapy. The patient showed a significant increase in her walking time and in the number of steps per minute. The patient also reported a reduction of the incidence of involuntary spasms while at rest, mainly in the days of therapy, as well as the disappearance of the burning sensation in her lower limbs. In addition, the patient achieved more normal contractions of the evaluated muscles and better static stability in bipedal position and during gait without any type of biomechanical aid. We also observed a significant increase in the strength and step length. On the other hand, we did not see any significant changes in the ASSIA and FIM assessments after the treatment sessions; therefore we are currently evaluating a longer therapy period.

Conclusions

Our results provide support to the effectiveness of the Vojta Method as a therapeutic tool to improve the locomotion and symptomatology in patients with SCI (1). Its application in the rehabilitation of SCI and other neurological pathologies deserves more consideration in the future.

Acknowledgements: Escuela de Enfermería y Fisioterapia de la Universidad Santa Paula, Ministerio de Ciencia y Tecnología de Costa Rica.

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Upper limb evaluation with robotic exoskeleton. Normative values for indices of accuracy, speed and smoothness

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Introduction

Robotic and non-robotic training devices are increasingly being used in the rehabilitation of the upper limb function in subjects with neurological disorders (1).These devices usually provide numerical indicators that summarize the patient performance, such as the total task time and the percentage of successful movements. Despite of the sophisticated hardware and sensors, the temporal evolution of the movement is often disregarded, while it could provide clinically useful information.

In this study, we present a customized software designed to boost the capability of the ArmeoSpring® (Hocoma AG, Swiss) device in the assessment of reaching movements of adult neurological patients by providing a set of indices assessing precision, velocity and smoothness of the upper limb motion, along with their normative values.

Methods

A custom stand-alone software was developed to retrieve patients data from the database, manage all acquisitions of each patient by means of a graphical interface, compute a set of indices and produce a standardized printable report. The following indices were computed based on the 3D endpoint trajectory: global Hand Path Ratio (HPR), local HPR in the area of the target (locHPR), vertical and horizontal overshoot (vertOS, horOS), maximum and mean velocity (maxVel, meanVel), mean/maximum velocity, number of peaks in the velocity profiles (NVelPeaks) and normalized jerk (NormJerk) (2). These indices were selected with the aim of investigating three different aspects of the motor task: precision, velocity and smoothness (2).
Twenty-five healthy right-handed subjects, aged between 21 and 74 years performed the "Vertical Capture" task of the ArmeoSpring® device, which is one of tasks provided to assess the patient functional level. Available weight reductions were set to their minimum values. The task was repeated for all

the available difficulty levels, from 1 to 4. All kinematic data measured by the potentiometers of the device (e.g. horizontal elbow joint) and the end-point trajectory, were acquired, by setting a specific software registry key according to the device manual.
We investigated the dependency of the indices on the distance and the direction between consecutive targets, and on the difficulty level of the task by means of an ANCOVA test. Next, a correlation analysis followed by a factor analysis was used to identify and group indices assessing similar aspects of the motor task. Finally, normative values for the investigated indices were provided.

Results

We collected a total of 4268 single reaching movements. The distance between consecutive targets was normally distributed (d=20±10cm) and the direction of movements was uniformly distributed over a circumference.

Indices were variable when computed over very short trajectories (e.g. L<5 cm), becoming stable for longer paths, were not affected by the direction of the movement and were minimally affected by the difficulty level, the absolute difference among levels being, for instance, lower than 1% for HPR and lower than 1 cm for vertOS and horOS. Normative values suited to be used for patients comparison are reported in Table 1.

Based on both the regression and the factor analysis, indices were split in three groups: HPR, locHPR, vertOS and horOS dealing with the precision of the task, meanVel and maxVel dealing with the movement velocity, meanVel/maxVel, NVelPeaks and JerkNorm dealing with the smoothness of the trajectory. This results support the hypothesis of using the ArmeoSpring® and the custom-made software to assess the different aspects of the motor control of the upper limb motion. The output window of the software is shown in Figure 1; data are relative to a stroke patient.

Table 1. Normative values for the computed indices during the “vertical capture” task, at the four available difficulty levels. See text for details.

	PRECISION				VELOCITY		SMOOTHNESS		
DIFFI CULTY	HPR(%)	horOS (cm)	vertOS (cm)	LocHPR (%)	meanVel (cm/s)	maxVel (cm/s)	mean/max Vel (%)	NVel Peaks	Norm Jerk
2	137 ± 38	2 ± 2	1 ± 2	156 ± 156	3 ± 2	8 ± 5	39 ± 9	1 ± 1	203 ± 699
3	139 ± 48	2 ± 2	1 ± 2	179 ± 157	3 ± 2	9 ± 6	39 ± 9	1 ± 1	252 ± 911
4	137 ± 38	1 ± 2	1 ± 2	180 ± 145	3 ± 2	8 ± 5	37 ± 9	2 ± 1	201 ± 422

Conclusions

We present normative values for a set of indices of precision, speed and smoothness of the reaching movement during the “vertical capture” task of the ArmeoSpring® device. These values could be used as reference in the assessment of neurological patients. The developed software (Figure 1) could boost the use of this device by adding the quantitative assessment of precision, velocity and smoothness of the upper limb motion. Moreover, the indices could be used to monitor the efficacy of a rehabilitation treatment and provide a feedback on the appropriateness of the selected intervention.

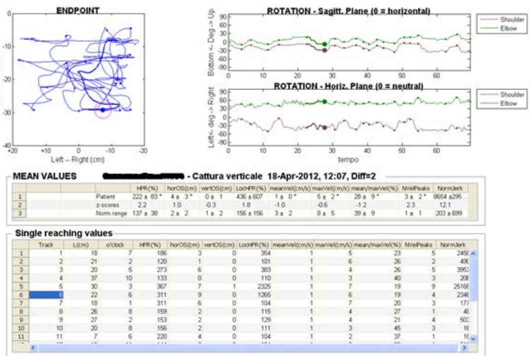

Figure 1. Screenshot of the output window of the developed software, with data of a stroke patient performing the “Vertical Capture” task. An asterisk in the first table indicates values statistically different from the normal range (*P*<0.05). Thick lines refer to track #6, as outlined in the second table. The track length is much greater that the normal reference, due to the presence of several jerky movements, as clearly outlined by the numerical indices.

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Validation of instrumental indices for the upper limb function assessment in neurological patients

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Introduction

Passive robotic exoskeletons are increasingly being used in the rehabilitation of the upper limb function in subjects with neurological disorders (1). We recently developed a customized stand-alone software that boosts the capability of the ArmeoSpring® (Hocoma AG, Swiss) device in the assessment of reaching movements of adult neurological patients by providing a set of indices assessing precision, velocity and smoothness of the upper limb motion, along with their normative values.

In this study, we tested the concurrent validity of these indices by comparing them to a clinically validated scoring system such as the Wolf Motor Function Test (WMFT) (2) in a sample of neurological patients.

Methods

Eleven patients, aged between 36 and 79 years, suffering from neurological diseases (7 Stroke, 2 TCE, 2 inflammatory polyneuropathy) participated in the study. The residual upper limb function was assessed twice, at admission and after 12 rehabilitation sessions (40 minutes, 3 session/week), by the WMFT and by the numerical indices described below.

The WMFT provides a quantitative measure of upper extremity motor ability through timed and functional tasks. It consists of 17 items, two related to subject's force and 15 related to subject's functional ability with a 6-points ordinal score (from 0 to 5) and a maximum total score of 75, lower scores are indicating lower functioning levels.

Numerical indices were computed by a custom-designed software based on the 3D endpoint trajectory of the esoskeleton, during the "Vertical Capture" task of the Armeo Spring ® device. Four instrumental indices assessed the movement precision: global Hand Path Ratio (HPR), local HPR in the area of the target (locHPR), vertical and horizontal overshoot (vertOS, horOS).

Two indices assessed the maximum and mean velocity (maxVel, meanVel). Three indices assessed the trajectory smoothness: mean/maximum velocity ratio, number of peaks in the velocity profiles (NVelPeaks) and normalized jerk (NormJerk).

Indices were compared to the clinical WMFT score, used as gold standard, by the non-parametric Spearman's correlation coefficient.

Results

Twenty-two assessments on 11 subject were considered. All patients completed the instrumental assessment. The WMFT score was distributed between 10 and 75.

Three precision indices were correlated with the WMFT score: HPR (rho = -0.51, p<0.01), locHPR (rho = -0.40, p<0.01) and horOS (rho = -0.35, p<0.01). Among velocity indices, meanVel (rho = 0.36, p<0.01) but not maxVel was correlated with the WMFT score. All smoothness indices were correlated with the WMFT score: mean/max Vel (rho = 0.49, p<0.01), NVelPeaks (rho = -0.43, p<0.01), NormJerk (rho = -0.49, p<0.01).

Conclusions

Instrumental indices were in accordance with the WMFT scores. Lower functioning levels in patients were related to reduced precision or reduced velocity or jerky movements or a combination of them.

We guess that these instrumental indices could be used to integrate and support the clinical evaluation of the upper limb in patients affected by neurological diseases as they separately assess the impairment in the overall control ability, in the velocity generation ability and the presence of jerks. Moreover, these instrumental indices could be used to track the motor recovery over time of patients during their rehabilitation period.

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COGNIFLEX: A virtual system to measure and rehabilitate the cognitive flexibility of autistic children

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Introduction

Cognitive flexibility (CF) is the ability to shift to different thoughts or actions depending on situational demands (1). It is known CF deficits exists in people with autism spectrum disorders (ASDs), that they are related to the typical repetitive behaviors (2), and that they affect their daily life (3). COGNIFLEX will be a virtual cognitive rehabilitation system for the analysis and treatment of CF in children with ASDs. Using the potential of new technologies (virtual reality (VR), augmented reality (AR), and natural interfaces), COGNIFLEX will provide an intuitive way to perform the cognitive rehabilitation exercises. It will offers the therapists a tool to measure CF of the autistic children, offering them the cognitive rehabilitation exercises appropriate to their level of CF. It also will control the rehabilitation process, and will evaluate their progress. The "low cost" of COGNIFLEX will facilitate its integration in the clinical rehabilitation centers.

Methods

COGNIFLEX will have two essential parts: *software* and *hardware*.

* *Software:*

COGNIFLEX will offer several cognitive rehabilitation exercises, each associated with a specific virtual environment (VE). The objective will be to teach autistic children that a same object can be viewed from different perspectives. The VEs will show several realistic images of daily objects from different perspectives. The goal will be to indentify an object, regardless of position, rotation or size variations in which it is viewed. The therapist will be able to offer the same exercises but using virtual objects. In this way, he will modify gradually the position, rotation or size in which the objet will be showed. The goal of these exercises is to measure the level of CF.

COGNIFLEX will offer the possibility to perform the same exercises, but in an AR way. In this manner, autistic children, manipulating the virtual objects, will change themselves the position, rotation or size in which the objects are viewed. The objective is to analyze how the direct manipulation of objects, influences the process of its identification.

* *Hardware:*

COGNIFLEX will use devices which allow the patient to visualize VEs in a sufficiently immersive way, and to interact in an intuitive way. At present there are several "low cost" devices which offer these features. Considering this, COGNIFLEX proposes a 10" tablet to watch the VEs, and also to interact with them by means of its touch-screen. The camera of the tablet will allow to perform the AR environments mentioned previously.

Results

COGNIFLEX is a work-in-progress. We still have no clinical outcomes. Nevertheless, we believe it will have high chances of acceptance. We think the potential of VR, AR, and natural interfaces, can to provide a significant advance in the solution of the problem mentioned previously. Moreover, COGNIFLEX has been designed considering the specifications of the professionals of the cognitive rehabilitation of autistic children, that they also will design the clinical protocol, will evaluate the clinical population, and will integrate the system in special rehabilitation centers.

Conclusions

The importance of CF in the cognitive rehabilitation process of people with ASD is a fact. To measure their level of CF, and to adapt the rehabilitation process to that level, can be very useful. COGNIFLEX is an attempt to analyze how these new technologies can help to this solution.

Acknowledgements: The authors wish to thank the psychologists of the *Centro Privado de Enseñanza Parroquial Don José Lluch (Valencia-Spain)* for their collaboration, and also the professionals of the cognitive rehabilitation process of autistic children that we have known thanks to them.

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Brain structures identification based on feature descriptor algorithm for Traumatic Brain Injury

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Introduction

Traumatic Brain Injury (TBI) (1) is defined as an acute event that causes certain damage to areas of the brain. TBI may result in a significant impairment of an individual's physical, cognitive and psychosocial functioning. The main consequence of TBI is a dramatic change in the individual's daily life involving a profound disruption of the family, a loss of future income capacity and an increase of lifetime cost.

One of the main challenges of TBI Neuroimaging is to develop robust automated image analysis methods to detect signatures of TBI, such as: hyperintensity areas, changes in image contrast and in brain shape. The final goal of this research is to develop a method to identify the altered brain structures by automatically detecting landmarks on the image where signal changes and to provide comprehensive information to the clinician about them. These landmarks identify injured structures by co-registering the patient's image with an atlas where landmarks have been previously detected. The research work has been initiated by identifying brain structures on healthy subjects to validate the proposed method. Later, this method will be used to identify modified structures on TBI imaging studies.

Methods

The goal of this algorithm is to detect and describe local features, considered as blobs, in T1-MRI studies. A blob can be defined as the cross point where at least six direction gradient lines match (2). The selected detector is the Hessian matrix. The proposed algorithm is based on SURF algorithm (3) and is divided into three stages: location of points of interest, orientation assignment and descriptor generation (Figure 1). This method takes as input the cumulative distribution of image intensity values, also known as integral image.

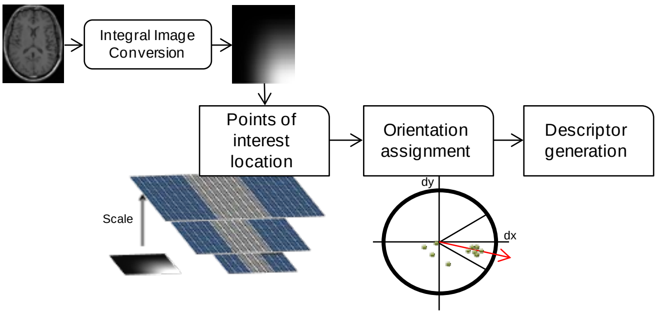

Figure 1. Algorithm Diagram

At the first stage, the aim is to detect blobs. Filters used to find them are based on the Hessian Matrix and they are structured in a pyramidal way, known as scale-space. A multi-scale approximation to a Gaussian second order partial derivative representation in x, y and xy direction is used to generate this scale-space. To make the algorithm independent from local contrast changes, these filters are divided by the standard deviation of pixel values affected by them. Detected landmarks are obtained from the maximum of the determinant of the Hessian matrix by taking into account the size of each filter. Therefore, this algorithm uses solely intensity pixel values affected by each filter and makes the intensity dispersion independent from contrast.

The orientation assignment stage obtains the maximum of the gradient's direction in the neighborhood of each landmark. Finally, information relative to location, orientation and gradient values is stored in a matrix, also known as descriptor.

Results

A set of healthy 42 T1-MRI studies were used and 18 brain structures per study were selected. Table 1 compares the efficiency performance in the detection of brain structures between original SURF and the proposed algorithm. Efficiency is the ratio between the number of landmarks and the area of each selected brain structure.

The proposed algorithm obtains higher efficiency values than the original SURF algorithm owing to landmark distribution. It obtains landmarks homogeneously distributed on cortical and subcortical areas. SURF algorithm acquires landmarks around skull and longitudinal fissure whereas our method includes landmarks located away these two regions.

Table 1. Efficiency per brain structure

	Original SURF	**Proposed Algorithm**
Superior sagital sinus	8.2%	11.8%
Cingulate gyrus	11.9%	14.4%
Tapetum	10.3%	13.4%
Frontal Horn	57.7%	61.7%
Corpus Callosum	9.6%	13.4%
Cave of Septum Pellucidum	11.3%	13.4%
Anterior horn of lateral ventricle	14.4%	16.3%
Foramen of Monro	17.7%	25.6%
Third ventricle	12.3%	14.7%
Lateral sulcus	3.4%	5.5%
Atrium and Chroids plexus of lateral ventricle	11.0%	12.1%
Sylvian fissure	10.3%	11.4%
Parietoccipital sulcus	53.0%	58.0%
Calcarine sulcus	15.1%	17.2%
Superior sagital sinus	19.9%	21.2%
Internal capsule (anterior limb)	31.8%	35.6%
Head of caudate nucleus	20.5%	23.7%
Thalamus	20.3%	34.9%

Conclusions

This abstract proposes a feature-based detection algorithm to identify brain structures on TBI T1-MRI studies. This algorithm has been tested, validated and compared with SURF on healthy MRI. On future works, a volumetric extension of this algorithm will be evaluated with patient studies.

Acknowledgements: This research has been partially founded by the Spanish Ministry of Economy and Finance (project TIN2012-38450, COGNITIO).

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Dysfunctional 3D model based on structural and neuro-psychological information

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Introduction

Acquired brain injury (ABI) (1-2) refers to any brain damage occurring after birth. It usually causes certain damage to portions of the brain. ABI may result in a significant impairment of an individual's physical, cognitive and/or psychosocial functioning. The main causes are traumatic brain injury (TBI), cerebrovascular accident (CVA) and brain tumors. The main consequence of ABI is a dramatic change in the individual's daily life. This change involves a disruption of the family, a loss of future income capacity and an increase of lifetime cost. One of the main challenges in neurorehabilitation is to obtain a dysfunctional profile of each patient in order to personalize the treatment.

This paper proposes a system to generate a patient's dysfunctional profile by integrating theoretical, structural and neuropsychological information on a 3D brain imaging-based model. The main goal of this dysfunctional profile is to help therapists design the most suitable treatment for each patient. At the same time, the results obtained are a source of clinical evidence to improve the accuracy and quality of our rehabilitation system.

Figure 1 shows the diagram of the system. This system is composed of four main modules: image-based extraction of parameters, theoretical modeling, classification and co-registration and visualization module.

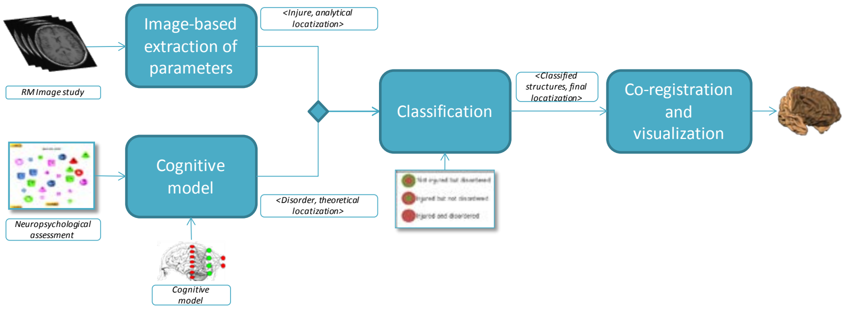

Figure 4. Functional Workflow

The remainder of the paper is organized as follows: Section 2 describes each module, Section 3 presents preliminary results and finally, Section 4 expounds the conclusions.

Methods

Image-based extraction of parameters

The main objective of this module is to extract information relative to brain structures altered after an ABI event. The approach proposed in this system consists of obtaining imaging information based on intensity and location values by applying an imaging descriptor algorithm (3). Each brain structure is identified with landmarks by co-registering the patient's imaging study with a healthy imaging study. Brain structures where landmarks are not detected are considered as **injured**.

Cognitive model

This module consists of a multimodal cognitive model based on graph theory which combines both structural and functional brain data, regarding their relationship as a whole (4). The model gathers the patient's neuropsychological assessment and determines which functional **disorders** the patient presents and which brain structures are related to them a priori, based on theoretical models and previous empirical knowledge.

Disorder classification

Information about injure and disorder is then combined at this stage. According to the results, the system classifies each affected structure as: injured and disordered, injured but not disordered and not injured but disordered.

Co-registration and visualization

The last module computes the deformation of a healthy image-based brain volume to conform it to the classification and final localization obtained from the previous module (5). This 3D dysfunctional volume is displayed using rendering techniques simulating mechanical and tissue properties of the brain, marking out injured from healthy structures.

Results

Figure 2 shows the design of the system interface. This design integrates a tool bar and three different visualization areas: MRI landmarks detection module, graph cognitive module and 3D dysfunctional model.

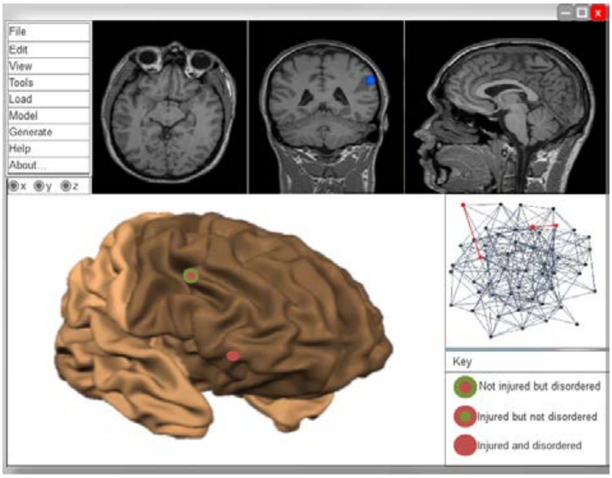

Figure 5. Interface Design

Conclusions

This abstract introduces the first implementation of a system that generates a 3D model representing the dysfunctional profile of a patient with ABI, according to imaging and neuropsychological assessment information. The main goal is to assist the therapist to design the most appropriate therapy for each patient.

Acknowledgements: This research has been partially founded by the Spanish Ministry of Economy and Finance (project TIN2012-38450, COGNITIO).

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The MoCA is better than the MMSE

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Introduction

The screening of cognitive impairment is infrequent and questions asked about cognition during a medical consultation generally follow no standard format (1). Brief cognitive screening tools have been formulated to identify the presence of cognitive impairment and to obtain a standard index of cognitive functioning (2). Medical practitioners would tend to raise the query on which is the recommended tool to use.

This study's objective is to determine the correlation of results of the Mini Mental Status Examination (MMSE) (3) and the Montreal Cognitive Assessment (MoCA) (4) and to determine if the MoCA would detect a higher proportion of patients with cognitive impairment.

Methods

A descriptive study was performed comparing results of MMSE and MoCA amongst all 42 eligible patients admitted at the Rehabilitation Unit with a mean age of 75.4 years. Each subject was tested using the MoCA and MMSE.

Results

MMSE scores ranged from 22 to 30 with a mean of 27.54. MoCA scores ranged from 13 to 29 with a mean of 24.02. There were 21 patients (51.2%) reported to have impaired cognition using the MoCA while only 4 patients (9.8%) using the MMSE.

The MoCA and MMSE scores were significantly positively correlated ($r=0.645$, $p<0.01$). Scores by the two tests produced a fairly high Cronbach's alpha of 0.709 which meant the results had reliability or internal consistency.

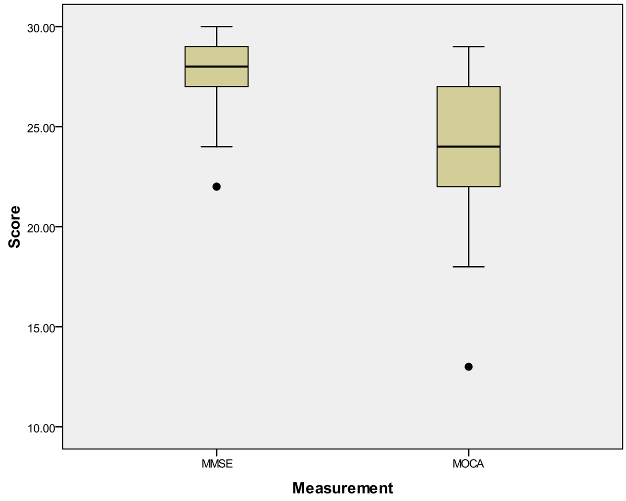

Figure1. Box plot of MMSE and MoCA scores

Conclusions

The study showed that the results of the Mini Mental Status Examination and the Montreal Cognitive Assessment were positively correlated and based on suggestion of previous studies, the MoCA detects a higher proportion of subjects with cognitive impairment (5,6,7).

Recommendation is given for the use of the MoCA based on its ability to examine executive functioning in a more sensitive way (4). It is a standardized, brief, and systematic screening tool of executive functioning that is easily administered within 10 minutes (4) at bedside or clinic environments. The MoCA may be used towards a range of individuals with a varied age group. This would particularly be useful in Rehabilitation Medicine Units where individual therapeutic programs are designed for those identified to have cognitive impairment.

Acknowledgements: Victor Voerman, Deirdre Cooke and the Occupational Therapists of the Mater Rehabilitation Unit.

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Monitoring visual attention on a neurorehabilitation environment based on Interactive Video

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Introduction

The use of new technologies in neurorehabilitation has led to higher intensity rehabilitation processes, extending therapies in an economically sustainable way. Interactive Video (IV) technology allows therapists to work with virtual environments that reproduce real situations. In this way, patients deal with Activities of the Daily Living (ADL) immersed within enhanced environments (1). These rehabilitation exercises, which focus in re-learning lost functions, will try to modulate the neural plasticity processes (2).

This research presents a system where a neurorehabilitation IV-based environment has been integrated with an eye-tracker device in order to monitor and to interact using visual attention. While patients are interacting with the neurorehabilitation environment, their visual behavior is closely related with their cognitive state, which in turn mirrors the brain damage condition suffered by them (3) (4). Patients' gaze data can provide knowledge on their attention focus and their cognitive state, as well as on the validity of the rehabilitation tasks proposed (5).

Methods

Interactive Video (IV)

IV refers to any video whose sequences and displayed information depend on the user's responses. Interactivity is provided by associating an interaction with any element which appears in the video scenes. The regions where those elements are located are called hot spots; the video flow is modified according to the way users interact with them.

The ADL “buying bread” was developed using IV technology (6). Patients navigate through a series of scenes representing the different steps which they have to follow in order to reach a final goal, from sitting on the couch at home (initial state) to buying bread at the bakery (end state). Throughout the task, patients are required to make decisions: choosing the next step, answering questions or interacting with other characters.

Every single action in the task is under therapist control, who has previously adjusted the video to the cognitive capabilities that will be required of the patient. Thus, all stimuli in the scenes may be preprogrammed by therapists in order to help the patient or even distract him/her from completing a task.

Eye-tracker

Tobii 1750 is used as an eye-tracker device (7). The system can provide time-stamped data on the position (x,y) of the user’s gaze focus, the distance between device and user or the user’s pupils diameter. More interestingly, parameters such as patient’s gaze fixation areas and duration, as well as well as the instants when saccade movements occur, can be obtained.

Results

Figure 1 shows the proposed integration schema for using Tobii’s libraries from the IV web application.

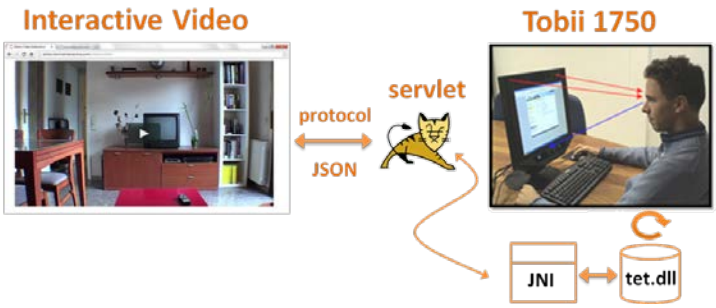

Figure 2. System description

Tomcat servlet allows sending and receiving the necessary requests in an effective way, developing a communication protocol between servlet and web application. This protocol consists of several requests: start/ stop tracking session; start/ stop tracking data acquisition; start/ stop tracking scene data acquisition; and query about user's instantaneous attention.

Thus, the system captures visual attention data while the patient is performing the activity. Tracking data are stored in both a global file and a set of individual files for each played video scene. Heat maps can be obtained for every frame visually representing the areas where a patient pays more visual attention (Figure 2).

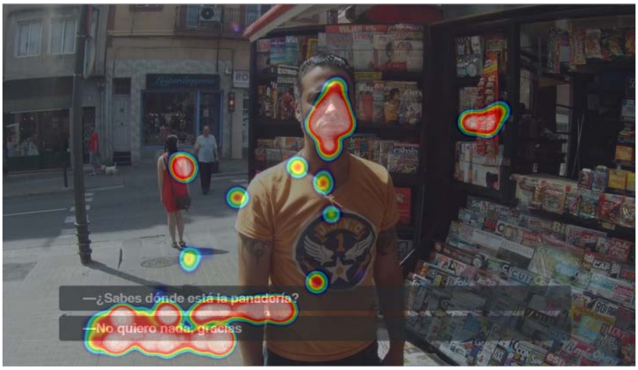

Figure 2. Heat Map

On the other hand, system is capable of detecting attention deficits when patients close their eyes or look away from the screen. The environment will respond to these situations showing new stimuli according to therapists' instructions, trying to retain/recover their attention.

Conclusions

This research describes a system to acquire visual attention data while a patient is carrying out an ADL using a virtual environment based on IV technology. Therapists extract useful information about how patients have performed their rehabilitation tasks, being able to reproduce where patients focused their gaze. Additionally, objective data on stimuli most visualized by them can be obtained, which could provide the basis for a reliable assessment of their performance. Moreover, the ability to detect attention deficits could serve as a trigger to modify the task flow in order to hold patient's attention on the important stimuli.

Acknowledgements: This research has been partially founded by the project CENIT-E "REHABILITA" CEN-20091043.

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Measures of neuropsychological assessment as indicators of success in neuropsychological rehabilitation: an exploratory correlational study

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Introduction

Neuropsychological assessment not only allows diagnosing possible neurocognitive impairments in domains such as attention, working memory, and executive functions, but can also provide useful information for the neuropsychological rehabilitation. By applying a set of valid neuropsychological tests to individuals with Acquired Brain Injury (ABI), and subsequently studying how patients' performance in rehabilitation programs relates with measures that are commonly provided by these tests, we may obtain valuable predictors of individual success that can be considered in neuropsychological rehabilitation.

Bearing this in mind, it is important to identify which measures of neuropsychological assessment can best guide the therapists in the selection of neuropsychological rehabilitation tasks, and in adjusting its difficulty to the potential of each person with ABI.

Methods

Eight ABI participants, with age range from 21 to 57 years old, went through a neuropsychological assessment comprising the following tests: Montreal Cognitive Assessment – MoCa, Wechsler Memory Scale - 3rd edition (WMS III), Trail Making Test - Forms A and B (TMT-A and TMT-B), D2 Test, Wisconsin Card Sorting Test - WCST, and STROOP Colour-Word test. The sequence of the tests was balanced between subjects to control for order effects.
Subsequently, all participants took part in a neuropsychological rehabilitation program comprising several Attention, Working Memory and Executive Function Tasks, organized in increasing levels of difficulty. The level that each participant was able to successfully achieve in each cognitive domain was considered a measure of individual performance in the rehabilitation program. These data were retrospectively correlated with the initial scores

of the neuropsychological assessment in order to identify which ones relate the best with the participants' performance in the rehabilitation program.

Results

The results show a significant correlation between MoCa scores and performance in the working memory tasks. We also found strong associations between D2 and STROOP scores, and the rehabilitation of working memory. Finally, WMS-letters and numbers scores were strongly correlated with the level that participants were able to achieve in Executive Function tasks at the end of the neuropsychological rehabilitation program. No other test scores were significantly correlated with performance in the neuropsychological rehabilitation

Table 1: Correlation coefficients between measures of neuropsychological assessment and performance on tasks of different cognitive domains of the rehabilitation program.

	Attention	*Working memory*	*Executive function*
MOCA	-0.19	0.72**	0.65*
TMT-A	0.39	-0.85	-0.78
TMT-B	-0.03	-0.84	-0.81
WMS III_Total Spacial	0.36	0.41	0.31
WMS III_Letters and Numbers	0.04	0.76**	0.73*
STROOP_ Colour-Word	-0.49	0.79**	0.86*
WSCT_Perseverative Errors	-0.08	-0.37	-0.30
WSCT_Complete Numbers Categories	0.28	0.29	0.12
D2_Gross Results	-0.06	0.77**	0.59

*p<.05
**p<.01

Conclusions

From this exploratory retrospective correlation study, we found that results from MoCa, STROOP and D2 might provide good predictors of patients' performance on working memory rehabilitation, while the WMS-letters and numbers subscale may predict how well ABI patients perform Executive Function tasks. Neurocognitive rehabilitation is a difficult endeavour, particularly when it is not well adjusted to individual weaknesses and strengths. This adjustment must be based on a proper neuropsychological assessment. Therefore a better understanding of the information that can be extracted from neuropsychological measures allows a smoother adjustment of cognitive rehabilitation exercises and helps establishing feasible goals for each individual.

Acknowledgements: neuropsychological rehabilitation, neuropsychological assessment.

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Technical drawing facilitates visual and memory components of spatial ability

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Introduction

Spatial ability develops over time during different stages of life as a result of exposure to several learning environments and life experiences. Therefore, the acquisition of enhanced and complex spatial skills may require training in specific domains as experienced and practiced during instruction and practical execution that encourage visuo-spatial activities.

Visual artists have been shown to possess superior visuo-spatial capacity when compared to non-artists (1, 2) and, as a consequence of brain plasticity, this is reflected in their neural activity (3). Also, it has already been demonstrated that geometry learning fosters improvements in visualization tasks (4).

For this reason, we aim to assess whether technical drawing tuition, which combines visuo-spatial reasoning and geometric learning, can improve visual and memory components of spatial ability.

Methods

Forty-seven undergraduate students (25 female, 22 male, age range = 18–21 years) participated in the study. The study was conducted with 23 students of Graphic Expression in Engineering (Graphic Group) and 24 students who study Literature in Spanish Philology studies (Control Group). The students of the Graphic Group received technical drawing in high school, whereas the Control Group did not study any subject related to drawing. The groups did not differ in their IQ scores. Participants were tested in a session lasting 120 min. *Spatial working memory* was assessed by Figures' Mental Rotation (FMR) test (5), the Spanish adaptation of the Rotation of Solid Figures (6).*Visual perception speed* was assessed by the Identical Forms test (IF) (7). *Spatial recognition memory and delayed matching* *to sample task* procedures were similar to the original test of the Cambridge Neuropsychological Test Automated Battery (8).

Results

The Graphic group shows better visual perceptual speed. The Graphic group presented higher score in the Identical Forms test than the Control group (t_{45}= 2.08, p=0.04). The analysis of visual short-term memory revealed that the groups did not differ in their general score (t_{45}= -0.51, p=0.61) or in their response latencies (t_{45}= -1.14, p=0.26) in the delayed matching to sample test. Regarding spatial short-term memory, the Graphic group shows better execution of the spatial recognition memory task, presenting higher score than the Control group (t_{45}= 2.17, p=0.03) and shorter response latencies (t_{45}= -2.35, p=0.02). Finally, there were not differences between groups in the spatial working memory task that involved the mental rotation of figures (t_{45}=1.76, p=0.08). We have not found differences between men and women in any of the tasks.

Conclusions

There are no significant differences between students of technical drawing and control group in a mental rotation task. However, the more detailed study of the components of this spatial process revealed that students of technical drawing, present a significantly better visual perceptual speed and short-term retention of spatial information than control students. Therefore, technical drawing training can improve visual discrimination and spatial memory. A deep research should be carried out analyzing the effect of technical drawing training on patients with spatial ability disorders.

Acknowledgements: This research was supported by grants from the current Spanish Ministry of Science and Innovation and FEDER (PSI2010-19348) and FMMA (AP/6977-2009).

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Different types of enriched environments and their utility on basic research for neurorehabilitation

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Introduction

Environmental enrichment (EE) is a paradigm that consists of a combination of social, cognitive, physical and sensorial stimulation. Recent evidence obtained in rodents indicates that, enriched environments induce different neuroanatomical, neurochemical, physiological and behavioural changes (1). This experimental paradigm has been applied in different research areas, including addiction, aging, stress, rehabilitation after brain injury, neurodegenerative and mental diseases, development of enviromimetic drugs, childhood abuse and neglect. In the current communication we will discuss the potential utility of different EE paradigms in basic research concerning neurorehabilitation. Previous studies suggest that exposure to enriched environments aids recovery after experimental traumatic brain injury (TBI). Recently, the EE paradigm has been proposed as a rodent model of rehabilitation in humans (2).

Methods

Different paradigms of EE are reported in the recent literature, including: 1) the classic EE paradigm in which animals are housed in large groups (usually 8-10 mice) with toys, houses and running-wheel; 2) Marlau© cages, which are standardized cages containing labyrinths; 3) physical activity through running wheels in the cage; 4) cognitive stimulation with different paradigms and cognitive challenges. These experimental procedures are usually compared with standard housing conditions in which animals are maintained in small groups in a cage containing only sawdust.

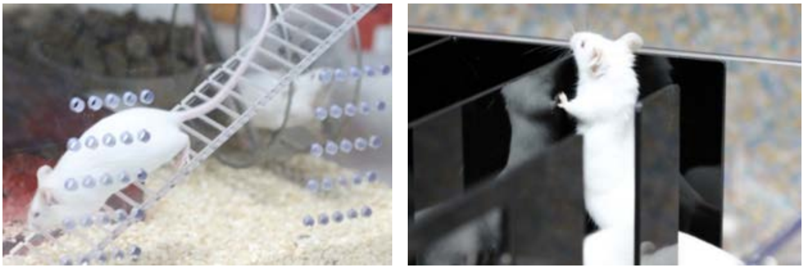

Figure 1. Different types of physical and cognitive stimulation in an enriched environment for rodents.

Results

In our laboratory we have developed a classic EE model in which mice are housed in groups of eight in large cages with a running wheel, a plastic tunnel, an igloo and an assortment of toys. Our results confirm that exposure to this enriched environment induces physiological and behavioural effects in mice, including increased fluid intake, diminished body weight, faster habituation to new environments, decreased anxiety and better performance in learning tasks.

Conclusions

Different studies suggest that, in order to obtain behavioural and physiological changes, there must be interaction between all the main components of EE: physical, cognitive and social. For instance, Sozda et al. (3) demonstrated that exposure of rats with TBI to any one of these three components induced more benefits in cognitive performance and histopathology than no enrichment at all, though the benefits were greater when the enriched environment contained all three elements. However, data comparing different types of complex environments are scarce. Therefore, in the present communication we will analyse the main advantages and limitations of each of four aforementioned types of enriched environments. Further research is needed in order to standardize the variables that may influence results, such as duration of EE procedure, age at which exposure begins, and type of enrichment. Future studies should also evaluate the impact of each one of the separate components. There is great potential interest in translating the use of enriched environments in basic research to clinical and neurorehabilitation settings (4). Although extrapolation from animals to humans is difficult, this objective would be better addressed if experimental procedures were standardized and the main components (physical, cognitive, and social) of enriched environments were designed with the objective of treating brain injury.

Acknowledgements: Supported by grants from “Ministerio de Economía y Competitividad” (PSI2009-10410) and Generalitat Valenciana (GVACOMP2010-273 and PROMETEO/2011/048). Marta Ramos-Campos and Patricia Sariñana-González are granted by Generalitat Valencia (Gerónimo Forteza, FPA/2012/101).

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The effect of Boswellia Serrata on neurorecovery following diffuse axonal injury

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Introduction

This pilot trial was conducted to establish whether Boswellia Serrata (BS), a traditional herbal medicine, could improve outcome of patients with diffuse axonal injury (DAI).

Methods

38 patients with pure DAI were enrolled in this 12-week double blind, randomized, cross over study. The patients were allocated to receive either placebo (group A, n=20) or BS capsules (group B, n=18) for six weeks and then shifted to the other intervention for another six weeks. The disability rating scale (DRS) was used to assess the outcome at two, six, and twelve weeks post trauma.

Results

A non-significant trend in favor of BS was seen for the change on the DRS total scores. On the DRS sub scores, however, a significant improvement occurred on 'cognitive ability to self-care' during the second six weeks in group A on BS, compared to an insignificant spontaneous recovery in group B at the same period on placebo. Moreover, both groups experienced a close-to-significant higher increase in the cognitive function-related items of the DRS during the periods on BS. Reported adverse events were all of mild quality with similar frequency between the groups.

Conclusion

These results suggest that BS resin does not significantly affect general outcome but may enhance the cognitive outcome of patients with DAI.

Depth sensors-based upper limb motion capture system for functional neurorehabilitation

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Introduction

Versatile and accurate motion capture systems, with the required properties to be integrated within both clinical and domiciliary environments, would represent a significant advance in following the progress of the patients as well as in allowing the incorporation of new data exploitation and analysis methods to enhance the functional neurorehabilitation therapeutic processes. Besides, these systems would permit the later development of new applications focused on the automatization of the therapeutic tasks in order to increase the therapist/patient ratio, thus decreasing the costs (1). However, current motion capture systems are not still ready to work within uncontrolled environments.

Methods

The authors propose a depth sensors-based motion capture system able to track the kinematic parameters of the patients' upper limbs while carrying out functional rehabilitation exercises. This system will allow a future analysis of the patients' performance by detecting those clinical response indicators needed to identify the changes related with good and bad prognosis to be either maximized or inhibited.

Figure 1 shows the block diagram corresponding to the proposed platform. The following modules can be identified:

- A communication module to make the depth sensor receive commands
- A monitoring module to process the information captured by the depth sensor and calculate the kinematic variables related to the upper limb motion. In this work, an 8 Degrees of Freedom (DoFs)

kinematic model has been considered (scapular elevation/depression -eleB-, shoulder flexion/extension -fexS-, abduction/adduction -abdS- and rotation -rotS-, elbow flexion/extension -fexE- and pronation/supination -pronoE-, wrist flexion/extension -fexW- and grasping -graspH-).

- A Graphic User Interface (GUI) both to configure the device and to visualize the results

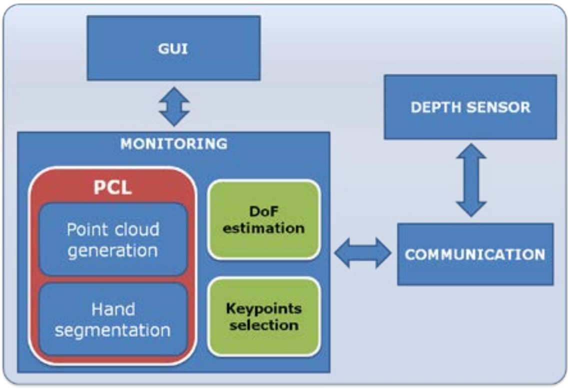

Figure 1. Motion capture system architecture

In this work, *Microsoft Kinect* has been used as depth sensor in such a way that the information provided by this sensor is directly used to calculate all the DoF but the wrist flexion/extension and grasping due to its lack of consistency in detecting hands when the subjects manipulate objects. For this reason, the hand detection has been enhanced by using the Point Cloud Library (PCL) (3) and the MIT's *Hand Detector* (4) algorithms , that use the information provided by *Microsoft Kinect* to generate one point cloud per hand and thus obtain their position by calculating the corresponding centroids. The remaining DoFs are extracted from the Euler angles related to each upper limb segment following (2).

Results

A preliminary validation of a 4 DoF (fexS, abdS, rotS and fexE) motion capture system prototype has been carried out to check the viability of the proposed solution. In this way, a qualitative analysis of a series of analytic movements has been performed. Figure 2 shows the kinematic data calculated by the system when a subject performs the following sequential actions:

1. Rest
2. 90º shoulder flexion
3. 90º elbow flexion
4. Full elbow extension
5. 90º shoulder horizontal abduction
6. Rest

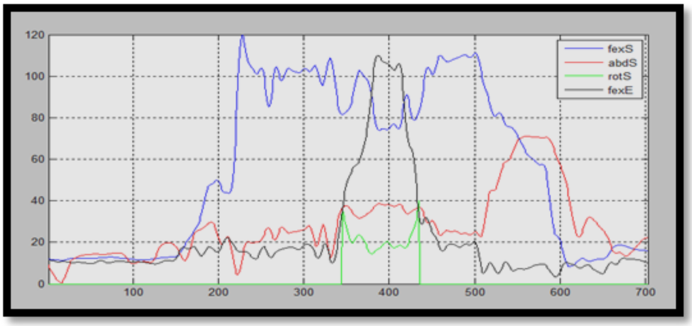

Figure 2. Analytic motion tracked

As it can be observed in Figure 2, all the DoFs have the expected morphology: fexS value is close to the 90º during most of the time; fexE value is close to 0º when the elbow is supposed to be fully extended and is close to 90º when it should be; in the last part of the plot, as expected, abdS takes a value close to 90º; finally both fexS and abdS return to the resting position.

Conclusions

The proposed prototype is considered as a proof concept for a future development of an upper limb motion tracking system. Given the aforementioned qualitative results, next steps to take will be to expand the system to calculate the remaining DoFs (eleB, rotS, pronoE and graspH) and perform a systematic validation by co-registration using the BTS SMART-D tracking system (5) as a gold standard.

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Enhancing the efficacy of virtual reality based pain treatment tools through the use of virtual mirrors and automatic limb posture reconstruction

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Introduction

Majority of the people with an amputated limb undergoes painful sensations as if the missing limb still exists. Several studies have been devoted to the treatment of this phenomenon called phantom limb pain, but most of them did not succeed (1). Ramachandran's mirror box therapy (2) was a breakthrough for understanding and treating it. This technique makes use of a mirror to superimpose the felt position of the phantom limb with the reflection of the intact one in patient's visual field. However, this setup brings about limitations on the viewpoint and head direction of the patient apart from the space constrained in a box for the tasks (3). Although some Virtual Reality (VR) based rehabilitation techniques (4, 5, 6) focused on overcoming these issues, they do not present an intuitive way to drive the phantom limb in the virtual environment. Furthermore, they rely on a first person view from which a user can observe only a small portion of his body. In this paper, we introduce new techniques to overcome these drawbacks. In addition, we present our rehabilitation applications as a proof-of-concept.

Methods

Our contribution comprises three parts. First, we propose the use of a full-body virtual mirror to provide the patient with his avatar's complete visual feedback. The motivation is that people are more prone to accept body ownership in a virtual environment when they see the reflection of their body through a mirror rather than observing themselves from a first person perspective as Slater et al. states (7). Second, we propose motion capturing the full upper body instead of tracking only the intact arm (4, 6) or the remaining portion of the missing limb (5). Therefore, all body parts of the patient are involved in the activities. Finally, we present a solution to automatically estimate the posture and drive the movement of the missing arm to accompany the intact one in a natural way thanks to fast inverse kinematics algorithms rather than mirroring the captured joint angles of the valid arm (4, 6). In this way, the tasks which can be designed are freed from being symmetric ones.

Results

We developed two experimental tasks as proof of concept (Figure 1). In the first one, the user is supposed to reach, hold and move a sphere into another one in the virtual environment via his avatar. The second one includes reaching and up/down-scaling of a sphere. During the tasks, the user is seated in front of a big projection screen from which he can see the virtual scene. In the virtual scene his avatar is also seated, but in front of a virtual mirror, so that he sees his avatar through the mirror. The patient uses both his intact and virtual arms to interact with the scene. Reaching some targets requires the movement of the torso together with the arms to integrate the full-body in the tasks, too. The user is equipped with stereo glasses for providing depth clues.

Figure 1. Our rehabilitation setup: The goal is to connect the amputee more to his avatar thanks to the use of a virtual mirror and full-body posture reconstruction so that doing the exercises helps the patient reconfigure his brain better over multiple sessions. We present our approach on two different tasks: Left: Reach and Move Task. Right: Reach and Scale Task. Note that duplication of the projected image is a natural consequence of stereo-rendering.

Such a setup is more comfortable and provides a better immersion with a greater Field-of-View (FoV) than a Head-Mounted Display (HMD) based solution. For instance, if the user sits 1.2m away from the projection screen whose size is 3.05m x 2.26m, he experiences a diagonal FoV of ~115 degrees whereas most consumer-level HMDs provide a diagonal FoV of 50 degrees (8).

Conclusions

In this paper, we have proposed solutions to the drawbacks of existing Immersive VR based therapy systems for phantom limb pain. The techniques we presented are very generic and they can be adapted to design more complicated tools with entertaining tasks. We plan to do a validation study with patients to confirm the effectiveness of our setup in a clinical environment.

Acknowledgement: We thank Dr. Christophe Perruchoud for his feedbacks on the setup.

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Responsiveness of upper extremity kinematic measures in drinking task and clinical improvement during the first three months after stroke

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Introduction

Kinematic movement analysis is increasingly used as an outcome measure in evaluation of upper extremity function after stroke. Parallel to the increased number of studies using kinematic analysis as outcome measure and reporting statistically significant changes, we need to better understand what these changes mean in context of individual's functioning. In addition, the gained knowledge from kinematic analysis can successfully be used when new technology based measurements are developed. In this study, the responsiveness and expected change in kinematic measures associated with clinically meaningful improvement in upper extremity were evaluated.

Methods

Kinematic movement analysis of a drinking task (1, 2) and a well established clinical assessment test, Action Research Arm Test (ARAT) (3) were performed early (mean 9 days post stroke) and at three months after stroke in 51 subjects. Movement time, smoothness and trunk displacement were the kinematic variables studied. The receiver-operating characteristic curve (ROC) and linear regression analyses were used to evaluate responsiveness of the kinematic measures.

Results

Kinematic measures could discriminate subjects demonstrating clinically meaningful improvements in upper extremity function. The measure of movement smoothness demonstrated the highest AUC (0.84) and sensitivity/specificity. Significant associations were found between the change in ARAT scores and kinematic measures. An approximate 6-8% improvement from baseline in kinematics was associated with clinically meaningful improvement in upper extremity function.

Conclusions

Kinematic measures of movement time, smoothness, and trunk displacement are responsive measures for capturing improvements in upper extremity during the first three months after stroke. The linear regression analysis can successfully be used for assessing responsiveness in kinematic measures and to attain estimates for the expected change in kinematics associated with clinically meaningful improvement. This knowledge facilitates both clinical and movement analysis research and can be valuable in the area of bioengineering when assessment methods for new technology based devices are developed.

Acknowledgements: This work was supported by the the Norrbacka-Eugenia Foundation; Local Research and Development Board for Gothenburg and Södra Bohuslän; the Foundation of the Swedish National Stroke Association; the Swedish Research Council (VR 2011-2718); Promobilia; an unconditional grant from Allergan; Hjalmar Svensson's Research Foundation; Greta and Einar Askers Foundation; Reneé Eanders Foundation; Rune and Ulla Amlövs Foundation; and John and Brit Wennerströms Foundation.

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Effectiveness of Virtual Reality gaming technology in Progressive Muscular Dystrophy rehabilitation

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Introduction

Progressive Muscular Dystrophy (PMD) is a group of genetic muscle diseases characterized by progressive skeletal muscle weakness and skeletal muscle degeneration. Currently there is no available cure for this group of diseases but only symptomatic (corticosteroid treatment) and supportive treatment (rehabilitation). Although rehabilitation is an important factor in the treatment of PMD, as it helps to increase the quality of life as well as the life expectancy of these patients, it is not available or accessible to most of the patients with PMD especially in most of the developing countries. Commercially available Virtual reality (VR) systems can possibly support rehabilitation objectives in training children with muscular dystrophy, and thus help to overcome most of the obstructions of the traditional rehabilitation. We hypothesize that VR gaming systems, are permissible, safe and potentially effective in enhancing total body movement.

Methods

In this randomized and controlled single blinded study with two parallel groups with genetically and histochemically confirmed PMD patients, we compared the effectiveness considering 20 fifteen-minute-sessions of virtual reality rehabilitation using the Microsoft Xbox Kinect (n=5) versus standard rehabilitation (n=5). Effectiveness was evaluated using Vignos lower extremity scale, Brooke upper extremity scale and Motor Function Measurement (MFM) scale. Safety outcome was evaluated by means of biochemical blood tests.

Results

Seven males and three females with a mean age of 7,7 (standard deviation 2,81) years participated in the study. Patients using Xbox Kinect showed a significant improvement in motor function assessment tests compared to patients who underwent traditional rehabilitation therapy. The motor functions in patients using Xbox Kinect, according to the MFM scale, showed an improvement of 9.25±9.7% ($p<0.05$); the D1 dimension (standing and transfers), of the MFM scale, was improved by 11.3±9.9%($p<0.05$), the D2 (axial and proximal motor function) was improved by 13.6±3.7%($p<0.05$) and the D3 (distal motor function) was improved by 21.4±4,6%($p<0.05$). However, according to the MFM scale, the motor functions in patients who underwent traditional rehabilitation therapy remained stable. Vignos lower extremity scale and Brooke upper extremity scale grades remained stable for all the patients. There were no serious adverse events during treatment in either group. No increase was observed in the serum creatine kinase (CK) level during treatment in any of the patients.

Conclusions

The results suggest that Virtual reality gaming systems can be feasible, safe and potentially effective alternatives to facilitate rehabilitation therapy for PMD patients. Further research is needed to determine whether VR gaming systems are effective and safe enough for home physical activity promotion and rehabilitation. Likewise, further study is needed to determine the effectiveness of telerehabilition using these systems in increasing the quality of life as well as the life expectancy of PMD patients.

Prediction of short-term learning of a manual task in asymptomatic subjects by means of Motor Imagery Practice

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Introduction

There is ample evidence that motor imagery is useful for improving some aspects of the performance of a movement. The improvements on execution for non-athletes subjects include advantages in strength, speed and upper limbs accuracy (1,2). The results shows that RP yields better results than just IP or NP, IP being usually better than NP (3,4). Up to now, there is not enough evidence of a low-cost and precise instrument useful for describing and predicting the effects of learning. The aim of this study was to evaluate the short-term effects of learning by means of a simple drawing in asymptomatic subjects who learned it through three different kind of practices -real practice (RP), imagined practice (IP) and non-practice (NP)- executed with their non-dominant hand.

Methods

In an analytic, cross-section, randomized three-blinded study, 121 healthy subjects aged between 18 and 45 years were distributed among three groups. All participants drew a familiar and simple drawing on a graphics tablet as accurately and as fast as possible with their non-dominant hand. Data acquisition was done by means of the mathematical tool Matlab version 7.11.0 (R2010b). We examined the predictions in timing, error, speed and accuracy of the described movement in these groups through a multivariable analysis test using the Pillai trace for the *p* valor and applying the Huynh-Feldt correction.

Results

There have been found statistically significant trends regarding to learning for each of the variables where there can be seen how their evolution is not identical over time. The variables *time (p≥0.004)*, *speed (p≥0,000)* and *precision (p≥0,028)* follow a linear adjustment intra-subjects along the laps (Table 1). The main descriptors of the generalized linear model show strong correlations with a high potency (*p≥ 0,961)* and statistical significance for every intra-subject measure except for the variable *error (p≥0,023)* (Table 2). The variable *error* shows the same linear behavior in the RP group while in the other two groups it follows a quadratic adjustment (of an inverted parabola). This asymmetric behavior of the variable *error* with respect to the other variables in the groups of subjects executing the real movement for the first time is consistent with previously published results.

Table 11. intra-subject statistical fitting of the results of the multivariate analysis model for each of the variables of study.

Variable	Fit	F	Significance	Observed potency
Time	Linear	8,868	,004	,840
	Quadratic	,114	,737	,063
Error	Linear	1,664	,200	,249
	Quadratic	4,539	,035	,561
Speed	Linear	18,423	,000	,989
	Quadratic	7,986	,006	,800
Precision	Linear	4,960	,028	,598
	Quadratic	3,523	,063	,461

Table 22. main descriptors of the results of the proposed prediction model.

Effect		F	Significance	Observed potency
Intersubjects	Intersection	30,346	,000	1,000
	Group	,067	,472	,440
Intrasubjects	Lap	,378	,023	,961
	Lap ⨯ Group	,292	,896	,746

Conclusions

The instrument created ad hoc is simple, low-cost, solid and precise to assess the effects of RP, IP and NP in healthy subjects. It can be used to create solid models to predict the performance of execution and it is useful to assess diverse tasks with differences in their cognitive and physical levels following specific study designs. These tools and methods might be used to evaluate subjects with several health disturbances. The obtained prediction model is potent for describing intraindividual learning (the differences between laps) but not for describing the differences between subjects (due to practice groups).

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Clinical testing of Ekso, a robotic exoskeleton – a study protocol

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Introduction

Ekso (Ekso Bionics, Richmond, CA, USA) (1) is an exoskeleton robot with motorized legs, which allows a person to walk on flat surfaces. It is battery operated and electric motors drive the hip and knee joints, and all movement is controlled by an external controller. Ekso is adjustable and can be individually adapted. Ekso makes it possible to stand and walk with the assistance of either a walker with front wheels or crutches.

Many patients with spinal cord injuries (SCI) have reduced walking function. Robotics is an interesting technology that could have a significant impact on walking. It is therefore of interest to do a systematic, clinical test of the feasibility and safety of training with Ekso.

This testing will be done in close collaboration with the National Association for SCI and is in accordance with the hospital's strategy to assess new technology.

Purpose of the study

To test the Ekso in patients with spinal cord injuries in the clinical context at Sunnaas Rehabilitation Hospital. The following questions will be sought answered:

- Safety of the recommended training protocol?
- Feasabilitiy of the equipment in clinical practice?
- Percieved satisfaction of training protocol by patient?
- How are physiological processes such as heart rate, blood pressure and oxygen uptake affected during walking?
- Assess the impact of spasticity, strength, psychological aspects of fitness and quality of life.

Methods

A multidisciplinary project team including physiotherapists, prosthetist/orthetist, physician and a researcher will participate in the certification course.

Pilot Testing
Design: Case-series design

Indications
Patients with paresis / weakness / paralysis of the lower limbs due to spinal cord injury.

Inclusion criteria
- Body height between 1.60 and 1.90 m, weight under 100 kg and hip width of less than 40 cm
- Normal motion (ROM) of all lower limb joints
- Sufficient muscle strength in the upper extremities to handle a walking aid
- Be involved in a standing training program
- Able to complete at least five training sessions with Ekso
- Be dependent on personal assistance for walking

Contraindications
- Spinal instability or "spinal orthotics" without the clearance from the responsible physician
- Orthostatic hypotension
- A significant degree of osteoporosis
- Uncontrolled spasticity
- Wounds or inadequate skin coverage
- Large side differences in thigh and shin length
- Severe medical conditions like cardiopulmonary disease, cancer, thromboembolism
- Cognitive problems
- Pregnancy

All participants must provide written, informed consent to participate.

The schedule
2012: Introduction to Ekso in the hospital.
January-February 2013: A certification course for the project group. All personnel who will train patients with Ekso must complete the required certification course.
February-April 2013: Test Ekso with approximately 10 patients. They will carry out a systematic training program. Intensity and duration will be resolved in cooperation with Ekso, but a sufficient intensity must be ensured.

Descriptive variables
Age, sex, height, weight, time after injury, level of injury and severity (AIS

level), spasticity (modified Ashworth scale)

Outcome Variables

Pain (SCI pain basic data set) (before and after exercise), Borg scale of perceived exertion (before and during exercise), and level of assistance to don and doff Ekso, and spasticity will be assessed.

These variables will be recorded after each training session:

- Standing and walking time with Ekso
- Total exercise time
- Type of walking aid
- Use of roof rails for extra security
- Level of assistance
- Assessment of skin condition
- Unexpected / adverse events
- The patient's own experience using Ekso

In some patient, these additional variables will be assessed:

- Energy expenditure, pulse and blood pressure during walking
- Mastery expectations, fitness motivation and training mastery

Unexpected / adverse events

All such events will be recorded and reported.

Results

The results will be presented according to guidelines for case series design. The exercise performance; walking distance, speed, duration will be described individually.

Conclusions

The pilot project will be summarized in a project report to the Sunnaas' Consultative Board for Clinic and Research. The results will be presented at relevant meetings and conferences, and may also be presented in Spinal Cord.

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Evidence of Motor Relearning Programme versus the Bobath Concept in the clinical management of acute stroke patients

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Introduction

Stroke is a clinical syndrome characterized by a rapid alteration in brain function. This condition is clearly of vascular origin and may be hemorrhagic or ischemic stroke. It is the second leading cause of death in Chile and one of the leading causes of disability worldwide (1,2,3,5,8). Currently one of the most popular treatment in rehabilitation are: Bobath Concept with Motor Relearning Program (MRP). In this paper, a synthesis of evidence from a systematic review by randomized clinical trials is provided (9,10,11,12).

Methods

The objective the study is to determine whether there is evidence to confirm that the motor neurorehabilitation program is more effective than Bobath therapeutic approach in patients with acute stroke.(13)
For this review we included only trials (RCTs) and controlled clinical trials (CCTs) (13), and the databases used were MEDLINE, CINAHL, CENTRAL, PEDro, and LILACS.

1. Type of study
For the realization of this systematic review a search strategy which included randomized clinical trials (RCTs) and controlled clinical trials (CCTs) that met our eligibility criteria was performed (13).(Figure # 1).

2. Databases
We searched the following electronic databases: MEDLINE (www.ncbi.nlm.nih.gov / pubmed accessed 15/04/12), CINAHL (www.ebscohost.com / CINAHL access 15/04/12), Cochrane Central (www.cochrane.org access 15/04/12), PEDro (www.pedro.org.au access 15/04/12) and LILACS (www.bases.bireme accessed 15/04/12). We selected articles published between June 1, 1980 until June 31, 2011.

3. Search Terms.
Search terms of our review were obtained from the MeSH (thesaurus PubMed) being some of them: stroke, acute stroke, Bobath mode, motor relearning Programme. To carry out a search of the MEDLINE database was used sensitive search strategy proposed in the "Cochrane Handbook" .45
1. "Stroke" [Mesh]
2. Acute stroke
3. (# 1) OR # 2
4. Bobath therapy
5. Bobath mode
6. Motor relearning Programme
7. Movement science based
8. (((# 4) OR # 5) OR # 6) OR # 7
9. "Randomized clinical trials" [Mesh]
10. "Randomized controlled trials" [Mesh]
11. Systematic review
12. ((# 9) OR # 10) OR # 11
13. (# 3) AND # 8
14. (# 13) AND # 12
15. Humans
16. Animals
17. (# 15) NOT # 16

For Central database, Cinahl, Lilacs and PEDro a search strategy combining the MeSH terms mentioned above was performed.

4. Limits search
• Adult patients.
• Patients with acute stroke diagnosed clinically and radiologically.
• neurorehabilitation programs for patients with acute stroke.
• Both genders and all races.
• Articles published in English and Spanish.
• published between June 1, 1980 until June 31, 2011.

5. Selection criteria
For the items selected by the preliminary search, we applied a filter performing a critical reading of abstracts and full texts, which were assessed against the inclusion and exclusion criteria listed below.

5.1. Inclusion criteria:
• Neurorehabilitation intervention study in the treatment of patients with acute stroke.
• Articles that compare neurorehabilitation program MRP therapy versus

Bobath therapy.
• Items that assess the clinical effectiveness of neurorehabilitation programs, across scales of function and quality of life scales.

5.2. Exclusion criteria:
• Articles in preliminary stage and no conclusion or interpretation of results.
• Articles in which the structure of the design does not allow methodologically isolate the effect of the intervention used.

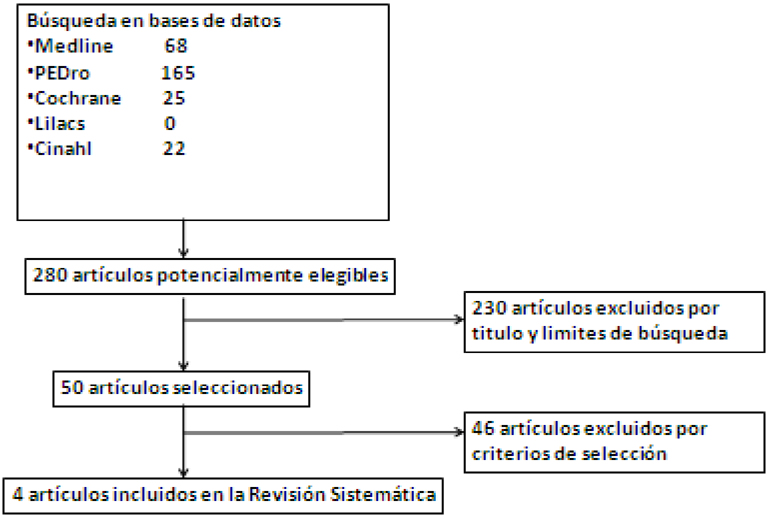

Figure # 1: search algorithm.

Results

We included three studies that comply with our eligibility criteria (1,4,6,7).

Conclusions

There is moderate evidence that the MRP neurorehabilitation program is more effective than Bobath therapeutic model in the clinical management of patients with acute stroke, since the results of RCTs and CCTs do not have statistical power to endorse or recommend the effectiveness of the case studies, we base in the authors' conclusions to deduce or to propose lines of intervention.

Acknowledgements: *Bobath, the stroke, Motor Assesment Scale, Motor Relearning Programme.*

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Effectiveness of a virtual reality video game system as a therapeutic supplement in a school enviroment for children with cerebral palsy

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Introduction

Cerebral palsy (CP) causes physical disability in childhood with restriction on motion, posture and activities (1,2). New technologies of virtual reality (VR) can be found as low cost commercial consoles and be used to develop rehabilitation programs in CP to work key elements for neuroplasticity and motor learning such as repetition of functional tasks, feedback mechanisms and patient's motivation, with the objective to optimize functional recovery, although evidence is limited (3,10).

The aim of this preliminary study is to objectify changes in psychomotor status of children with cerebral palsy after receiving rehabilitation treatment in addition with a videogame system based on non-immersive VR technology (Xbox 360 Kinect™).

Methods

Participants: 11 children with CP were recruited from the Bellas Vistas public school (Madrid, Spain). Children classified in levels I-II in the Gross Motor Function Classification System (GMFCS), and with a mean age of 7.91±2.77 years were included.

Intervention: The participants completed 8 weeks of videogame treatment with Xbox360Kinect™ (Microsoft™), added to their conventional physiotherapy treatment at school. Both therapies were practiced 30min/day, 2d/week each one.

Measures: Assessment of Motor and Process Skills (AMPS) (11,12), Pediatric Reach test (PRT) (13), the 10-meters walk test (10MW) (14,15) the Gross Motor Function Measure (GMFM) (16) and Jebsen Taylor Test of Hand Function (JHFT) (17,18) were used. All these assessments were registered baseline and post-treatment. A two-month follow-up session was programmed.

Statistical analysis: The Friedman test was used to study differences among the three valuations (baseline, post-treatment and follow-up) for each variable. Wilcoxon test was used to study the differences between each evaluation (basal/post-treatment, basal/follow-up and post-treatment/follow-up). P < 0.05 was considered statistically significant.

Results

The Friedman test showed significant differences among the three assessments for each variable: GMFM (p=.001), AMPS motor (p=.001), AMPS process (p=.010), PRT (p=.005) and 10MW (p=.029).

Wilcoxon test showed significant statistically differences pre and post-treatment in all the values (P <0.05), except JHFT´s variables in relation topicking up large heavy objects (P=0.102) and stacking checkers (P= 0.075).

Similarly, results revealed significant differences between baseline and follow-up assessment (P <0.05). There were not statistical differences between post-treatment and follow-up evaluation (P >0.05), indicating a long-term maintenance of the improvements achieved after treatment.

Conclusions

Low cost video games based on VR are potential tools in the school environment rehabilitation context in children with CP. Our Xbox 360 Kinect™ protocol based on working key elements for neuroplasticity and motor learning has showed improvements in balance and activities daily living in CP subjects, but further studies are needed to validate the potential benefits of these video game systems as a supplement for rehabilitation of children with CP.

Key Words: Cerebral palsy. Neurorehabilitation. Video games. Virtual reality

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Preliminary study of the reorganization of cortical pathways in the phantom limb pain

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Introduction

About 85% of people who have undergone amputations suffer the phantom limb syndrome, the sensation that the amputated member is still present and in many cases in pain. This study involves clinical research, based on the study of V.S. Ramachandran and other literature cited, adding evidence about the reorganization of cortical and thalamic maps occurring after amputation. The main contribution of this innovative study is the use of the imaging technique, magnetic resonance tractography. With this technique, we can study in a noninvasive way, the status of damaged sensory and motor pathways following the amputation and, how brain plasticity could help patients to remove or reduce pain by means of future rehabilitation with the mirror box.

Methods

Participant

Amputated patient

Our patient is a 36-year-old woman, with a bilateral amputation below her knees. She underwent a traumatic amputation six years ago and she started with the phantom limb pain three days after the amputation. She had an initial prevention treatment based on antiepileptics and anxiolytics for one year but at present, she has not received any treatment. The patient describes her pain as cramps or itches in their stumps. The pain outbreak is currently suffering sporadic, every two-three months and it depends on the weather, stress, anxiety or sometimes for no apparent reason, for example during her sleep. The outbreak usually takes more than three hours (3-6 hours) and normally, the pain appears when she is not wearing her prosthesis (if the pain wakes her up, it is calmed by placing the prosthesis).

Magnetic resonance tractography

The tractography or DT-MRI is a fast and non-invasive imaging technique used to study the integrity and orientation of white matter nerve tracts "in vivo". It uses a technique known as diffusion tensor (DTI), responsive to the movement of water molecules within tissue. Anisotropic diffusion is restricted in one direction that is dominant in the white matter. If the anisotropy is altered (involving changes of direction change of color) we can evaluate and determine structural alterations present in the pathology.

The methodology is to do a DT-MRI to observe the state of the motor and sensory pathways. The data analysis for DT-MRI is performed by the program Volume-One v.172.

Results

The results shown below are the DT-MRI performed with our patient, mainly shown tractography results on analysis of the pyramidal tract.

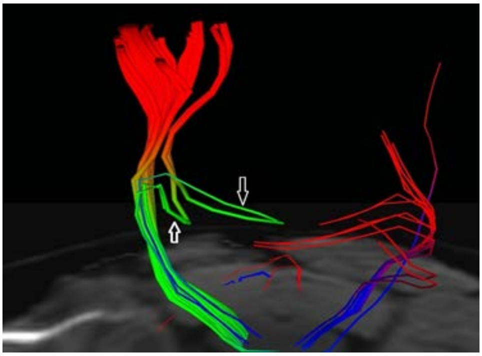

Figure1: Pyramidal tract in sequence away. The arrow indicates where connections are diverted right leg forming a tangle instead of following the path of other fibers.

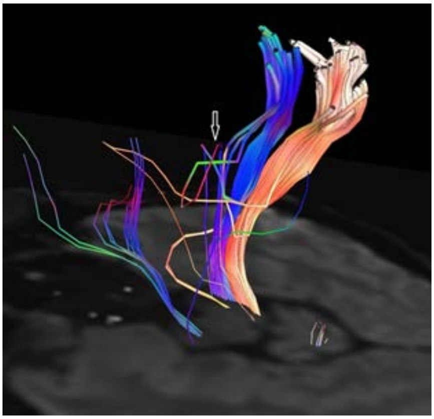

Figure 2: Perspective view of the cortex with sensory (light red) and motor cortex (blue). The arrow indicates the location of the anisotropy in the motor pathway. The tractography shows the weakness of the fibers, which are much thinner than normal fibers. The fibers lose their orientation because of the deafferentation, they are reorganized.

Conclusions

The patient presents clinical deafferentation of degeneration in the pyramidal tract. The tractography shows the deviation of the fibers and their anisotropy, caused by the amputation. However, we don´t know for sure if the pain in this syndrome is caused by deafferentation but we have evidences that this damage exists.

We need to continue the study to improve the results and conclusions. We propose a future study which can show the capacity of the brain plasticity and how the mirror box could help to the phantom limb pain by the reorganization of the pathways.

The study would emply:

- Rehabilitation with the mirror box in amputated patients.

- DT-MRI before and after the rehabilitation with the mirror box to observe the state of the motor and sensory pathways being able to observe the possible reorganization of the pathways and possible reorientation following this rehabilitation.

- Control patients to compare the motor pathways.

Acknowledgements: To my tutors: Antonio Gutierrez, Marien Gadea and Raul Espert for giving me the chance to work with them and helping me to continue with this project.

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Rhythmic activities and rehabilitation of prosody in reading of brazilian students

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Learning disabilities are a constant in scholar environment that teachers, parents, educators and health professionals have come across. Participation in the Brazilian project CIRCO (Integrated Cognitive Rehabilitation Center) allowed the approach to this reality and aroused interest in investigating some of the elements wich may be involved in low academic performance. This work aims to verify the association of the development of rhythmic sense and its importance in reading prosody as a prerequisite for text comprehension. For this purpose an investigation was undertaken in the literature about brain processing of rhythm and its association with the areas and functions of language and a practical examination of this relationship. This work is characterized by a longitudinal case study of case-control that has been carried out with a sample of two subjects. The experimental group was exposed to stimulation of rhythmic activities during participation in the rehabilitation project, during 18 weeks. The results did not suggest a significant difference between groups, neither in comparison of subjects from experimental group, at the beginning and end of the study. However, the qualitative analysis performed from the descriptive results allowed to observe improvement in the responses of experimental group. Thus, it appears that rhythm can be an instrument of stimulation and rehabilitation when used in conjunction with other methods of cognitive rehabilitation in learning difficulties of poor countries students.

Keywords: Rhythm. Reading. Cognitive rehabilitation.

Cognitive reserve: the role of enriched environments in brain rehabilitation

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Introduction

The construct of cognitive reserve holds that maintaining an active cognitive lifestyle delays the onset of cognitive impairment and reduces the risk of suffering dementia. Epidemiological studies suggest that maintaining a complex lifestyle that encompasses cognitive, social and physical engagement, as well as leisure activities, contributes to improve cognitive reserve. Hence those with a higher cognitive reserve will have a more effective and strategic use of brain networks that would explain individual differences in the manifestation of clinical symptoms and allow them to cope better with brain damage (4). We developed the Scale of Cognitive Reserve to assess lifestyle complexity (2).

The objective of this study is to analyze relationships between cognitive reserve and cognitive measurements in a group of healthy individuals, controlling for potential confounding by age. Results could lead rehabilitation programs focused on enriched environments.

Methods

One hundred and seventeen healthy adult participants were divided into two groups according to age: young (aged 36-64) (mean age 48.76 years, ±SD 7.07, 62.1% women) and elderly (aged 65 or older) (mean age 72.9 years, ±SD 6.04, 73.3% women). All of them completed a wide classical test battery that assessed learning, short-term, long-term and working memory, inhibition of automatic response, phonetic and semantic fluency, divided attention and attention span, abstract and visuospatial reasoning, as well as motor skills and premorbid IQ.

We measured cognitive reserve using the Scale of Cognitive Reserve, a psychometric instrument based on daily living and leisure activities, social, academic and additional training engagement. It was registered how often these activities were done along individuals´ lifespans.

Results

Correlational analysis revealed that, after controlling for age, there were statistically significant associations ($p<.05$) between cognitive reserve and the Stroop test (.32), and TAVEC: verbal learning (.32), short-term memory (.31) and long-term memory (.30). The correlation coefficients indicated positive moderate associations. However, statistically significant partial correlations were weakened between cognitive reserve and Digit span subtest (backward) (.19), the FAS word fluency test (.26) and the Animal Naming test (.26), Matrix reasoning subtest (.21), Block design subtest (.19), and ROCF: short-term memory (.23) and long-term memory (0.20). On the other hand, the results showed a lack of statistically significant partial correlations between cognitive reserve and Digit span subtest (forward) (.12), TMT-A (-.11), ROCF: time (-.18) and copy (.16), and premorbid IQ (.10).

Conclusions

Our main conclusions included: (i) cognitive reserve is directly related with cognitive abilities as verbal learning, short-term and long-term verbal memories and inhibition capacity; (ii) the effect of age as a confounder is not constant on the association between cognitive lifestyles and cognitive performance; (iii) and the support given to the critical role of enriched environment, including frequent and diverse intellectual and leisure engagement, in neurorehabilitation programs (1, 3).

Acknowledgements: IL was supported by Plan Propio de Investigación (University of Almeria) and by the Ministry of Economy and Competitiveness (Spain) PSI2011-26985.

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The “Boxes room”: a Virtual task for the assessment and training in very preterm children

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Introduction

Several studies have shown that the preterm children present several neuropsychological deficits of varying severity (e.g. in visuospatial abilities, working memory, executive functioning) (1) and a reduced academic performance. These findings seem growing with decreasing of the gestational age (e.g. before the 32nd week of pregnancy) and/or the birth weight (e.g. ≤ 2400-1500 g.)(1).

In the population of VPT there has been verified that the hippocampus is especially vulnerable, since it seems to be that factors as the hypoxia, metabolic factors, or other factors as the postnatal steroids, might cause neurotoxic effects in the hippocampus having and deteriorated functioning of this area implications in learning and working memory(3,4). The main objective of this study was to characterize the spatial abilities in preterm children and the possibility to training by means virtual reality.

Methods

A sample 7-years-old prematurely born children with a birth weight minor than 2400 g (N=20) were evaluated in a comparison with a matched control group (N=20) of term children, using the Boxes Room (2), a virtual reality version of the holeboard. They were trained in 10 trials to locate the reward boxes in a room with 16 of them available .A neuropsychological profile is obtained to for the preterm children by means of Kaufman Battery.

Results

In general, the premature children present a similar performance that to the control group, except an increase in the number of mistakes when the condition of reinforced boxes increases 16 (3) $F(1,14)=12,24$, $p=0,001$). Significant differences do not appear in variable sex, not in the analyzed interactions.

Conclusions

The preterm children show a normal performance in a task of memory and spatial orientation measured across the virtual Boxes Room task. Nevertheless, the performance is deteriorated when it increases n º of winning boxes, which might indicate that when it increases n º of stimuli or the task increases the complexity, the performance is worse. Tasks like the Boxes Room, in which it is possible to modify the level of difficulty, so much in velocity trials,, number of boxes in the room and number of reinforced boxes can be a very useful tool for the rehabilitation in these children.

This study has supported by the Ministry of Science and Innovation of Spain [Grant: PSI2008-02106].

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Use of NiTi springs for robotic hand rehabilitation

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Introduction

Mobility in the hands may be reduced by various causes, a physical impairment due to a traumatism, or a neurophysiological problem due to a cerebrovascular accident (CVA), such as a stroke. In the case of a neurophysiological problem, when a person loses control over the movements of its hands for some reason, the procedure to recover it is to undergo to a rehabilitation program. In therapies to rehabilitate the movement and control of the hand movements there are usually developed flexion and extension exercises of the fingers and wrist rotation (1).

From this point of view, a robotic device to assist passive rehabilitation therapy would avoid the therapist performing these exercises, which consist on moving the joints of the hand to gradually expand the range of lost joint motion, and gradually smooth muscle tension following a stroke. This would facilitate the work of the physiotherapist since they only have to adapt the rehabilitation device to the patient and then program and execute the therapy.

Methods. Device design process

Mechanism for extension and flexion of the fingers

Now, considering that the system designed should fit relatively easy into the hands for different degrees of spasticity, in some cases the task of mounting the hand on the device may make it difficult for patients who experience pain to move their affected members or those whose muscle tone is very high and offer much resistance to the extension. With this in mind, the design of the mechanism for extending the fingers should provide facility to be mounted on the hand, different degrees of extension for different degrees of injury to patients, possibility of treating fingers together or individually, and a friendly design to make the patient feel confident when using the device. Figure 1 shows the CAD design that is detailed on (2).

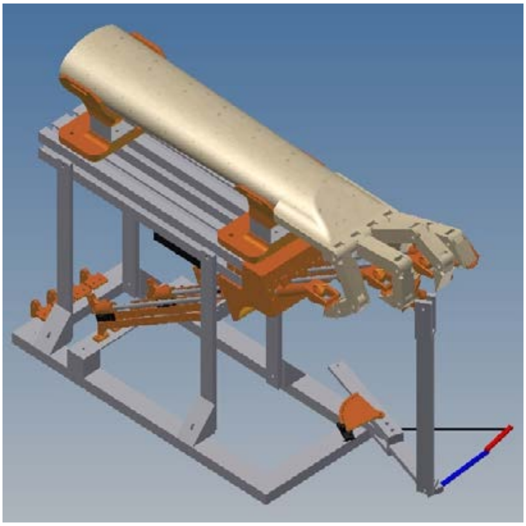

Figure 1. CAD design

NiTi experimentation testbeds

The Nitinol springs used were purchased from the supplier MuscleWires (3). In the experiments there were used springs of 0.75 mm of diameter. However, the spring elasticity constant is not provided by the manufacturer, but it has been determined experimentally in previous works. Specifically, it was taken as reference the results obtained in Brent and McAvoy's work (4), in which it is used a variation of the classical physics experiment to calculate the elastic constant of a spring to obtain the constants associated with the two transformation phases for a Nitinol spring. From this experimental session, it was found that Nitinol springs by themselves take too much time to start recovering their shape, but it is possible to get a better response by cooling them and using the second configuration, in which there is a spring opposite to the other. The cooler used was a 12 Vdc fan.

Control hardware

In this project, it was used Arduino One card (5). The operation modes defined for the system will only seek to extend the fingers to a maximum value (extension) and to return them to their initial position (flexion), therefore this only requires a control strategy that monitors if the fingers have passed those limits, and then switches the corresponding output. So, it has been chosen ON-OFF control. In this type of control only two control outputs are activated, depending on whether the error signal e(t) is positive or negative.

Now to avoid an excessive number of switching that could deteriorate the actuator, a hysteresis band is included, defined as the time difference between the two switching outputs U1 and U2.

The value entered for the output U1 in a range from 1 to 10, defined by the physiotherapist, is translated into a variation of the duty cycle of the PWM signal applied to the Mosfets, who are responsible for energizing the Nitinol springs.

Results

The mechanism designed for this project is able to perform the extent of the patient's fingers. In the case of the thumb, as it only performs adduction-abduction it is not possible to oppose it to the other fingers to practice grips.

In the pilot phase it was verified the correct operation of the actuation system for each finger making cycles that allowed getting the sampling times used to make a maximum extension and flexion of 0.11 m without load. The mean times recorded to extend and flex the mechanism were 12 seconds and 15 seconds respectively. This time difference is primarily due to the way the fans are located, as one allows a better refrigeration of the springs to flexion the fingers.

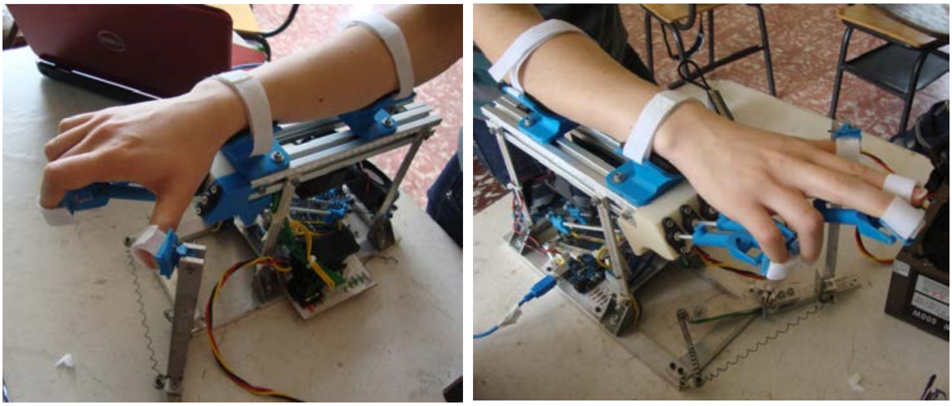

Figure 2. Rehabilitation session with a hemiparetic patient

Conclusions

This article presented the design and construction of a rehabilitation system for hand built with Nitinol springs actuators. There were described the aspects taken into account in designing the mechanism for extending the joints of the fingers and presented a study of shape memory alloys (SMA), and in particular how the Nitinol can be used as an actuator. The design presented incorporated these actuators to perform hand rehabilitation therapy, recommended by physiotherapists. The proper functioning of the device was validated in a patient with right hemiparesis, yielding satisfactory results.

Future work will include other exercises as required by physiotherapists, extend the system for left hand use, and improve power handling of the entire system. This rehabilitation system should also be tested with a diverse group of patients to improve many details; remaining to finally offer it to medical community.

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Co-locating Acute rehabilitation unit with Neurology Unit-- 2years' experience- evidence based policy?

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Introduction

Objective: To objectively capture data on the process and outcome of an acute rehab service co-located with neurology Unit to provide "practice based evidence" in service development policy.

Background: In 2009, the 19 bedded post-acute Neuro-rehab Unit was relocated to the neighboring town to co-locate with the newly formed 18 bedded neurology Unit in a large University hospital in UK.

Methods

As part of a simultaneous national data capture in Australia, Canada & UK, the demography, process, outcome data on disability (FIM-FAM), Rehab Complexity Score (RCS), nursing dependency (NPDS), and length of stay (LOS) were gathered. Descriptive statistics results were graphically presented.

Results

Year 1 (April 2009-April 2010):

Number of patients= 149

Mean age 52 (SD: 14)

Mean LOS 32.42 d (SD: 27.91)

Medical complication: 18%.

RCS median gain: -2.18 (SD 2.61)

NPDS median gain: -7.51

FIM-FAM mean on admission 157, on discharge 209

RCS >8 (complex patients): FIM-FAM changed from 146 to 207 (mean)

Total bed days lost (due to inadequate Social service) 495 days for 13 patients

Year 2: January 2011 to Jan 2012.

No of patients: 123

Mean age 53 (13-89)

LOS: mean 43.3 d (SD 52.96)

RCS: median gain 1 (admission 9, discharge 8)

RCS >8= 67%

FIM-FAM: (median) admission 123 and discharge 184 (Figure 1)

FAM splat (Figure 2) demonstrated success in all domains except in social functioning and crucially where patients require "special" ie one to one nursing due to challenging behaviour.

NPDS: median admission 18, discharge 9

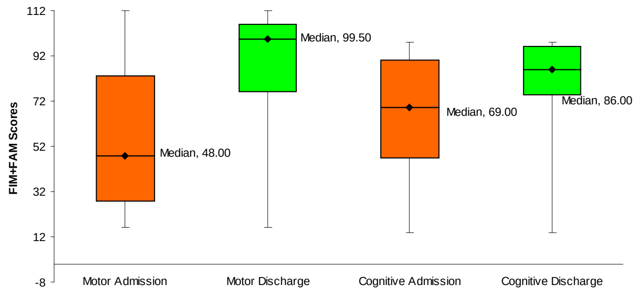

Figure 1: Changes in FIM-FAM out of 210 maximum possible

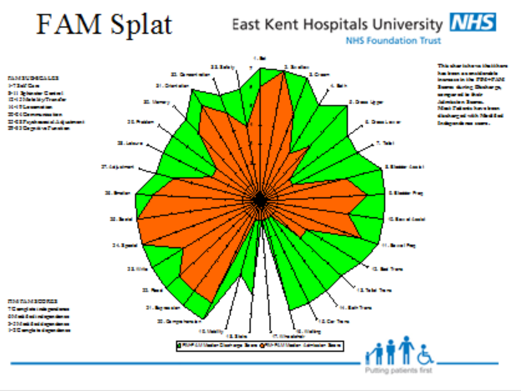

Figure 2: FAM Splat.

Gains were observed in all diagnostic groups (MS, Acquired brain injury (ABI) (trauma stroke) and neuropathy). ABI patients achieved more FIM-FAM gain compared to MS patients. Peripheral Neuropathy patients improved more in RCS compared to ABI.

The neurology Unit's LOS came down dramatically to 4.5 days (mean). However, medical inputs (1) increased substantially. To reduce LOS of Rehab Unit, a dedicated Social Worker post created.

Conclusions

With increasing success of acute neurology and neurosurgery as well as increased demand for rehab, collaborative neuro-medicine and rehab work is needed. However, this success in complex neuro-disabled patients emphasizes the need for developing integrated health and social care pathway. For challenging behaviour, special Unit with appropriate resources need to be considered in service reconfiguration.

Acknowledgements: staff and patients of East Kent Neurorehabilitation Unit

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Does upper limb spasticity treatment improve mobility? A prospective study.

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Introduction

Botulinum toxin (BTX) is recommended treatment for focal spasticity resulting from injury to brain and or spinal cord (1,2).

The recommendation is to target muscles that contribute to a specific functional problem warranting such expensive treatment (£1000 / episode). There is a subpopulation of stroke survivors who could mobilize with difficulties but have severe upper limb spasticity with no prospect of gaining active functional benefit for upper limb function even with BTX.
Stroke survivors consider mobility as their main priority. Lack of appropriate swinging motion of upper limb and Associate Reaction of sudden elbow flexion may impair ambulation. The national guidance from UK & USA does not specifically address this scenario.

Only 1 open label, multi-centre research looks into this, albeit the sample size was only 15 (3). That research group followed strict protocol in gait laboratory in several centres. We wished to generate real life Practice based Evidence using routinely collected data that are meaningful in real life context instead of kinematics data. This also avoided recruitment bias, observer bias, protocol bias in a multi-centre study.

Methods

Data collected prospectively in routine clinical setting, pre and post BTX treatment in a University hospital of UK. IRB approval obtained and outcome data were collected by neuro-physiotherapists.

Outcome measures:

- 10 meter walk to assess speed
- 2 minutes walk to assess endurance
- Rivermead Mobility Index (RMI (0-15) for functional mobility

- Modified Ashworth Score (MAS)
- Disability Assessment Scale (DAS) – upper limb functionality

Statistical methods:

- paired sample t-test
- Wilcoxon signed ranks test
- Spearman's non parametric correlation

Results

- Total sample was 28 of which 10 patients have full set of data. Hence, for the following N=10.
- Mean age 60 yrs (50-71)
- Time since stroke: mean 63.1 (15-288)
- Infarction=90%
- Botox (R) dose : mean 195 Unit (150-200)
- Hemi-spatial neglect: 8 (80%)
- A Wilcoxon signed ranks test indicated that there was a significant difference in all the DAS and MAS conditions pre and post treatment. Notably the MAS scores for the elbow indicate there was a change in spasticity pre and post treatment (Z= 2.53, p< 0.05). The median MAS score changed from 2.5 to 2 post-treatment.
- A paired sample t-test was performed to compare the distance in meters walked during 2 minutes pre and post BTX. The results suggest the average length which individuals walked was increased following treatment. The mean difference between conditions was 15.17m and the 95% confidence interval for the estimated population mean difference is between .249 and 30.60 m. The effect size was close to moderate (d=0.45). Specifically the paired t -test between conditions was significant (t= 2.226, df= 9, p < 0.05, one tailed). The average amount of time an individual spent walking a distance of 10meters decreased following treatment. The mean difference between conditions was 1.5 sec. However paired t -test showed that the difference between the two conditions was non-significant.
- The average amount of time an individual spent walking a distance of 10meters decreased following treatment. The mean difference between conditions was 1.5 sec. However paired t -test showed that the difference between the two conditions was nonsignificant.

- There was a significant negative correlation between post treatment 10meter walk as measured by distance and the pre treatment MAS wrist score (r_s= .668, N=10, p< .05, one-tailed).
- There was a significant positive correlation between post treatment RMI scores and pre treatment MAS wrist scores (r_s= .692, N=10, p< .05, one-tailed).
- There was a significant positive relationship between post treatment DAS limb position scores and the distance walked during 2 minutes pre treatment (r_s= .558, N=10, p< .05, one-tailed).
- There was a significant negative relationship between the time it took to walk 10 meters post treatment and the walking distance during 2 minutes pre treatment (r_s=.665 , N=10, p< .05, one-tailed).
- There was a significant negative relationship between the distance achieved walking 2 minutes post treatment and the time it took in walking a 10 meter Distance pre treatment (r_s= .760, N=10, p< .01, one-tailed).

Conclusions

This small pilot study demonstrated that mobility as measured in clinical setting may be improved significantly. A larger cohort study is needed to validate the findings.

Acknowledgements: staff, patients and R & D department of East Kent Neurorehabilitation Unit

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Predicting functional recovery of the hemiplegic patient: a new and easy tool based on the Barthel Index

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Introduction

Determining the recovery degree of hemiplegic patients and detecting the period when it will occur is important for rehabilitation (1) as recovering the independence level is the main factor that often determines the destination after discharge (2).

The literature places the higher degree of recovery after stroke at early stages. Moreover, longitudinal studies show that almost all stroke patients experience the greatest degree of recovery within the first six months but it does not follow a linear pattern as a function of time (3).

The aim of this study was to establish the expected process of functional recovery of stroke patients during the first six months based on the Barthel Index (BI).

Methods

This study was accepted by the Ethical Committee of Hospital Universitari i Politècnic La Fe of Valencia. 24 patients that suffered a single stroke formed the sample. All patients accepted and signed informed consent. Periodic assessments with the BI were performed along 6 months after stroke. Parametric analysis adjusting the curves to the following equation (Figure 1) using the Levenberg-Marquardt algorithm was performed in order to study the functional recovery curve of patients (based on the BI) and to identify similar recovery patterns.

$$B(t) = G \cdot \left(1 - e^{-\frac{t}{t_0}}\right) - B_0$$

Figure 1: Equation used to adjust the curves (*B(0)* corresponds to the initial value of the BI at the start of the outpatient rehabilitation; *G* corresponds to the gain, i.e. the final value minus the initial value reached; and the variable *t0* indicates the speed at which improvement is achieved).

Results

The study of the functional recovery curve of each patient showed a large variability between subjects. However, two correlations were found: firstly; between the functional recovery and patient's initial BI value; secondly, between the functional recovery and the time after stroke. Therefore, we developed an abacus of the percentile curves on how different individuals with a given initial BI improved over the first six months in order to identify recovery patterns and how this functional recovery would be reach to obtain a more accurate prognosis (Figure 2).

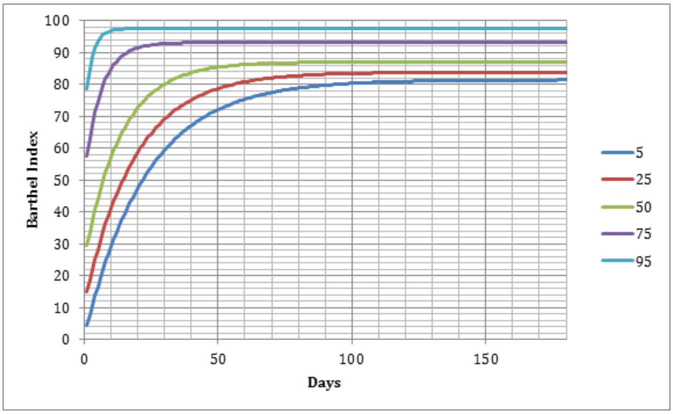

Figure 2: Percentile abacus for functional recovery versus time.

Conclusions

We can mainly conclude that this abacus (Figure 2) is a useful tool to estimate the degree of independence on the performance of activities of daily living that patients will reach based on initial BI as well as to determine the dynamics this process will follow until 6 months after stroke. Additionally, the following conclusions can be drawn:

- The highest degree of functional recovery is achieved within the first 30 days after stroke, gradually increasing until 60 days and then becoming stable at 140 days.
- The BI value at 15 days after stroke for patients who have reached standing position is a good predictor of the independence degree the patient will reach at 6 months.

Acknowledgements: This study was carried out with financial support from the European Commission within the Seventh Framework Programme under contract FP7-ICT-2009-247935: BETTER BNCI-driven Robotic Physical Therapies in Stroke Rehabilitation of Gait Disorders.

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Walking ability after stroke: recovery or adaptation?

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Introduction

The majority of stroke patients achieve an independent gait; however, many do not reach a walking level that enable them to perform all their daily activities (1). Whereas the recovery process of walking has been widely described as it is a major objective of post-stroke rehabilitation, the dynamics of gait recovery and the kinematic factors involved in this process until developing a functional gait pattern are still quite unknown (2). The aim of this study was to analyze kinematics of post-stroke walking recovery patterns by using clinical scales and Inertial Movement Units (IMU's) as an attempt to identify the compensation strategies in which is based the gait recovery process.

Methods

This study was accepted by the Ethical Committee of Hospital Universitari i Politècnic La Fe of Valencia.

The sample was formed by 24 patients that have suffered a single stroke with residual hemiparesis. Those with previous disorders that affected the ability to walk or other health conditions hampering the development of the study were excluded. All patients accepted and signed informed consent.

Periodic assessments of walking ability and functional status were performed along 6 months after stroke by using clinical scales and kinematic analysis of gait. The assessment periods were: hemodynamic stability, beginning of standing, beginning of outpatient physiotherapy and monthly assessment until 6 months after stroke.

Regarding clinical scales, we employed: the Berg Balance Scale (BBS), the Barthel Index (BI), the Functional Ambulation Classification of the Hospital of Massachusetts (FAC) and the Timed Up & Go Test (TUG).

Gait analysis was performed by using 7 Inertial Movement Units (IMU's) fixed on the back over L3-L4 and on the hip, knee and foot of both lower limbs.

Results

R statistics was used for data analysis. From one hand, a Principal Component Analysis was performed to analyze the kinematic parameters. Three principal components were identified that were mainly explained by: hip and knee flexion and extension of non-affected side, ankle flexion and extension of the affected side and pelvis control. Besides, these parameters were correlated with other joint angles and gait cadence.

Regarding cadence, it was strongly correlated with four kinematic variables of the non-affected side (hip abduction-adduction and flexion-extension, knee flexion-extension and ankle flexion-extension) and various clinical scales: BI, FAC, TUG and BBS.

On the other hand, patients with better pelvic control presented higher velocities (TUG) and better balance control (BBS). Regarding this last aspect, patients with better BBS scores reached higher cadences.

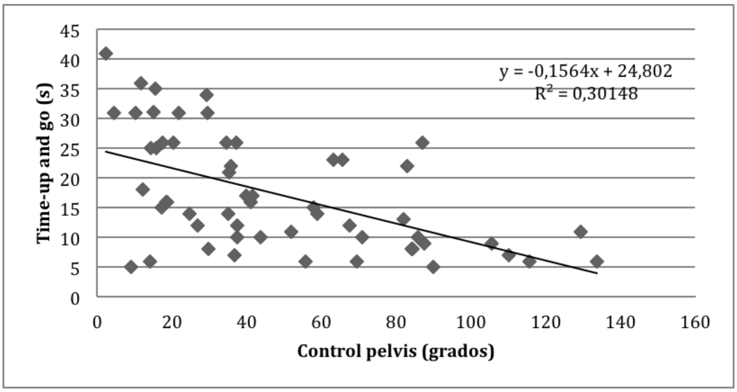

Figure 1: Correlation between pelvic control and the Timed Up and Go Test.

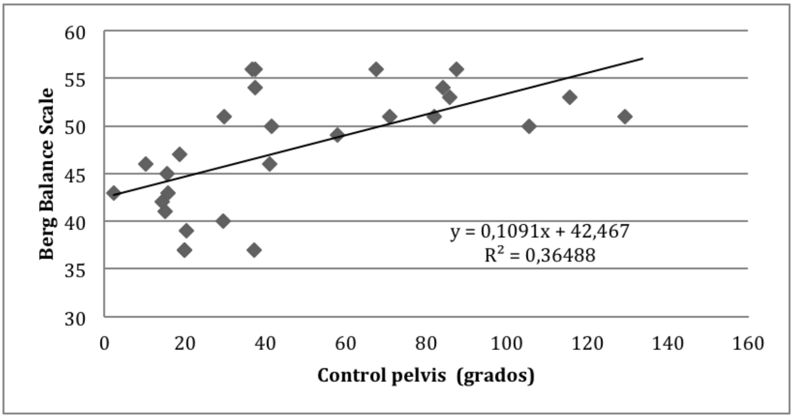

Figure 2: Correlation between gait cadence and the Berg Balance Scale.

Conclusions

We can mainly conclude that patients developed functional gait patterns by compensation mechanisms, especially on the non-affected lower limb. Furthermore, additional conclusions can be drawn:

- Pelvic control is a key factor in gait recovery after stroke.
- The recovery of gait after stroke is based on the development of compensatory strategies of the healthy hip and knee, the flexion-extension of the affected ankle and pelvic control.
- Better pelvic control is associated with better balance, higher velocities (TUG), better levels of gait function (FAC) and higher cadences.

Acknowledgements: This study was carried out with financial support from the European Commission within the Seventh Framework Programme under contract FP7-ICT-2009-247935: BETTER BNCI-driven Robotic Physical Therapies in Stroke Rehabilitation of Gait Disorders.

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Electrical stimulation and upper limb motor recovery after stroke

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Introduction

Neuromuscular electrical stimulation (NMES) is a treatment that has been proposed to enhance motor recovery after a stroke. It has also been suggested that the combination of NMES with other rehabilitation strategies could have an added therapeutic effect (1).

In a previous pilot study (2), significant therapeutic effects of NMES were found on range of motion and grip and pinch strength. The current study extends this investigation, testing the effects of NMES on muscle tone and hand function in patients with post-stroke hemiparesis.

Methods

18 patients completed the study, with a mean age of 74.67 years (SD= 6.8) and a mean time after stroke of 6.39 months (SD= 3.27). Ten were male and eight were female. All of them had hand impairment due to stroke. They were randomly assigned to either the experimental group (conventional rehabilitation and NMES) or the control group (conventional rehabilitation). NMES was applied on wrist and finger extensors for 30 minutes per session, 3 times a week for 8 weeks. Electrostimulation consisted of symmetrical rectangular biphasic pulses, 300 µs pulse width at 50 Hz. The values of ramping up/down period and stimulation on/off time were selected and modified during sessions. Modified Ashworth scale (MAS) and Box and Block test measurements were recorded at baseline, and after 4 and 8 weeks of treatment.

Results

The experimental group showed significant improvements in the MAS score for finger flexors ($F= 7.704$, $p= 0.006$, $\eta^2= 0.325$). However, the treatment only had marginally significant effects ($F= 2.624$, $p= 0.109$, $\eta^2= 0.141$) on the wrist flexors MAS score. Additionally, there were no significant differences between the groups in the elbow flexors MAS score ($F= 1.778$, $p= 0.201$, $\eta^2= 0.100$) and Box and Block test ($F= 0.838$, $p= 0.409$, $\eta^2= 0.050$).

Conclusions

The effects of the NMES on muscle tone and functional motor ability are still unclear once these results and the existing literature in this area are considered (3). Indeed, there are a number of studies that found significant effects, while others failed to do so. A study based on a larger number of participants could shed some light on this controversy, and the consideration of other variables could also provide additional insights.

Acknowledgements: Financial support for this study comes from a grant to the first author by Conselleria file number ACIF/2012/017.

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Interventions aimed to help memory in Mild Alzheimer's: which strategy of memory stimulation is the best?

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Introduction

Till the beginning of this century, neuropsychologists' interventions with Mild Alzheimer's patients included, generally, the continuous training with exercise like remembering shopping lists, news, personal events, repetition training, and so on. Despite the relatively large body of evidence suggesting that these techniques can be effective tools to improve memory, some problems are addressed: needs the patients' motivation to keep in task; requires the use of internal cognitive strategies that the patient's are, sometimes, not able to use because of the disease (1). The focus of neuropsychology research and practice changed to the study of external strategies (like diaries, electronic agendas, and so on), but a problem remained concerning the need of training from the patients for the use of the external memory aids. Consequently, research was conducted with a multidisciplinary team (cognitive scientists, neuropsychologists, and informatics scientists) to create a memory aid that could overcome the previous barrier. SenseCam (a device created by Microsoft research that captured pictures automatically) was then tested as a memory aid to help people to remember information from their daily life. These studies showed that reviewing SenseCam pictures generates powerful cues that help to retrieve episodic information related to the SenseCam images (2,3).

A pilot study conducted for our team also indicated that SenseCam can be used as a cognitive stimulant, helping cognition in general and not only episodic memory (4), as the previous studies indicated (5,6,7). However, it is still unknown whether SenseCam is more effective that a traditional set of cognitive exercises, or more effective than a diary, to improve general cognitive function, in a clinical sample like mild Alzheimer's, because no comprehensive studies involving a detailed neuropsychological assessment, before and after intervention, was conducted so far.

With this in mind, a scientific research is being conducted in order to examine whether SenseCam, a traditional memory training program and a diary can be helpful in order to improve cognitive performance in patients in the first stage of Alzheimer's disease.

Methods

A between subjects procedure was designed in order to test a total of sixty patients diagnosed with Alzheimer's disease in mild stage. The clinical diagnosis is followed with screening neuropsychological measures (Addenbrooke Cognitive Examination – Revised; Geriatric Depression Scale; Clinical Dementia Rating). These patients are randomly assigned in three groups/conditions (two experimental groups and one control group) (see Figure 1).

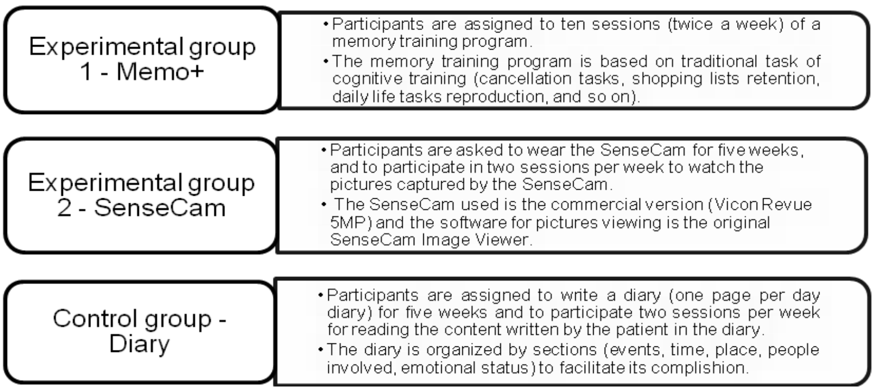

Figure 1 – Experimental and control conditions for the study presented

For the objective assessment of cognitive gains with the use of each method, a comprehensive neuropsychological battery is being applied before the intervention, immediately after and six months follow up. We are interested to test both cognitive function possible changes (Verbal fluency task, Word List I and II – WMS 3; Coding – WAIS-3; Digit Span – WMS 3; Autobiographic Memory Test; Cambridge Test of Prospective Memory; Pyramids and Palm Trees Test; Route Task from RBMT 3) and also the functional status (Adults and Older Adults Inventory of Functional Status -IAFAI; DAFS) and the perceived quality of life (World Health Organization Quality of Life-OLD) changes after each intervention.

Anticipated results

This research is undergoing but according to the pilot studies conducted and to the literature and previous research with this kind of memory stimulation strategies, it is anticipated that, in one side, the SenseCam will allow an improved cognitive function when comparing to the diary method because it seems to provide stronger cues and consequently the SenseCam seems to contribute to a greater sense of well-being because it requires no training[4]. We also consider credible that SenseCam can be more helpful that the traditional memory training program to improve function because the last one requires the use of internal strategies therefore becoming more difficult for the Alzheimer's patients to succeed in these tasks (diminishing their motivation). Despite this anticipated results we will try to understand the apparent superiority of the SenseCam to the other methods in terms of its neurocognitive basis and we aim to build synergies between technologies such as SenseCam and traditional methods in the interventions with mild Alzheimer patients.

Conclusions

Despite these anticipated results we consider according to the previous pilots studies and revious research, we intend to understand in this undergoing research the apparent superiority of the SenseCam to the other methods in terms of its neurocognitive basis and we aim to build synergies between technologies such as SenseCam and traditional methods in the interventions with mild Alzheimer patients.

Acknowledgements: This work is supported by the Fundacão para a Ciência e Tecnologia (Portuguese Foundation for Science and Technology; SFRH / BD / 68816 / 2010) for the first author (PhD Fellowship). Chris J. Moulin is supported by a research donation from Microsoft Research Cambridge to cover the travel expenses associated with presenting research about SenseCam in a series of seminars (2011-12).

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Clinical impact of haemorrhage secondary to spinal cord injury on somatosensory function

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Introduction

Spinal cord injury (SCI) often leads to sensorimotor dysfunction, including paralysis, spasticity and neuropathic pain, which directly impacts quality of life. Several pathophysiological mechanisms contribute to SCI, including neuroinflammation, oxidative stress, edema and neurodegeneration. Acute spinal contusion often involves an acute haemorrhage and expansion which represents a secondary pathological process of necrosis as a consequence of a progressive failure of blood capillary integrity (1). These secondary events also induce ischaemia and tissue hypoxia, while blood accumulation within the spinal cord causes further neuronal cell death due to haemotoxicity (2). Recently it has been postulated that haemorrhage within the spinal cord is associated with changes in sensorimotor function, including neuropathic pain and spasticity after SCI (3). In this preliminary study the clinical impact of spinal haemorrhage secondary to complete cervical SCI on sensorimotor function was measured in subjects during the subacute and chronic phase of injury, with the aim of highlighting the diagnostic utility of measuring spinal hemosiderin volume during the acute, subacute and chronic phases.

Methods

A descriptive pilot study is presented in which seven patients with traumatic SCI were recruited from the Hospital Nacional de Parapléjicos de Toledo following informed consent. Sagittal T1 and T2, with axial T2 medic and SWI magnetic resonance image sequences obtained from the spinal injury level. The volume of haemorrhage was calculated with Cavalieri equation. Basic sensorimotor functional evaluation (ASIA, MRC muscle score, WISCI II), spasticity (SCI-SET, PENN, MAS, SCATS) and neuropathic pain (BPI, NPSI, DN4, and quantitative sensory testing using Thermoroller, Rydell-Seiffer tuning fork, Somedic brush, von Frey 60g) were performed.

Results

Preliminary results indicate that 6/7 subjects with ASIA A/B SCI revealed hemosiderin deposits with a volume of 149-1239 mm^3. In the three subjects with the highest volumes (846 and 1239 mm^3) exhibited preservation of dorsal column function (vibration sensitivity) with a loss of thermal sensitivity to 20ºC at the level of spinal cord injury. Interestingly these subjects reported high NPSI scores related to evoked pain at the level of injury in response to brush and pressure. In contrast in subjects with ASIA A/B SCI with lower hemosiderin volume (<464 mm^3) thermal sensitivity to 20ºC thermal stimulation was present at the level of injury.

Conclusions

Although the sample size of this pilot study is limited, the preliminary data suggest that the presence of haemorrhage at the level of cervical SCI (ASIA A-B) is associated with evoked pain and further extends previous clinical research of the impact of this physical factor on sensory function (4). Evoked mechanical pain with loss of thermal sensitivity and preservation of dorsal column function at the level of SCI in subjects with large hemosiderin deposits highlights the importance of detecting spinal haemorrhage for better clinical management during subacute neurorehabilitation. This ongoing study will assess the contribution of spinal haemorrhage on other measures of sensorimotor function.

Acknowledgements: Fundación Mutua Madrileña 2010.

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Does Robot-assisted gait training ameliorate gait abnormalities in multiple sclerosis?

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Introduction

Gait disorders are common in multiple sclerosis (MS) and lead to a progressive reduction of function and quality of life. Studies describing MS gait patterns in subjects with a wide range of walking disabilities highlighted an overall impairment of spatio-temporal parameters and reduced hip extension during late stance (1,2).

Studies on robot-assisted gait training in MS subjects with walking disabilities are inconclusive (3-5). In particular, changes in the biomechanical parameters of gait due to any form of training have not been measured before. We thought that gait analysis could provide a discriminant in effectiveness across different possible training methods.

The aim of this pilot randomized study is to test the hypothesis that robot-assisted gait training (RAGT) could have higher benefit, compared to conventional therapy (CT) in improving spatio-temporal and gait mechanics in subjects with MS.

Methods

We enrolled MS subjects with Expanded Disability Status Scale (EDSS) scores within 4.5-6.5. The experimental group received 12 RAGT sessions over 6 weeks training (Lokomat, Hocoma AG, Switzerland). The control group received the same amount of CT. Spatio-temporal and kinematic gait parameters were assessed pre-training, post-training and after 3 months with a stereophotogrammetric system with 6 infrared cameras (VICON 460, Vicon Motion System). We analyzed the following sagittal plane parameters: minimum pelvic rotation (P3), hip flexion (H1) at heel strike; maximum hip exstension (H3) and flexion (H5). Hip total sagittal plane excursion (H6). Within-group differences after treatment and at 3-months follow-up were evaluated with a paired t-test. Significance level was set at 0.05.

Results

16 subjects were included in the final analysis (5 males and 11 women, 55.3±11.7 years, 17.7±11.1 years from MS onset, 5.7±0.7 EDSS score). In RAGT group, overall improvements in spatio-temporal parameters (gait speed, cadence, double support, step length and time) were found. Gait speed increased by 0.06 m/s ± 0.10 after treatment ($p<0.01$) without any effect at 3 months. The double support phase decreased by 4.63% ± 10.45 after RAGT ($p<0.05$) with a retention after 3 months of 4.04% ± 10.99 ($p<0.05$). In the CT group no remarkable change in gait speed, cadence or double support phase was found. All spatiotemporal data are reported in Table 1.

After RAGT, a slight reduction of minimum pelvis rotation (-2.8° ± 5.6) was detected ($p<0.01$). Increased hip extension (-2.6° ± 7.0) during late stance was found ($p<0.05$). These kinematic gains were further consolidated at the 3-months follow-up (P3= -3.6° ± 7.4, $p<0.01$; H3 = - 5.2° ± 6.9, $p<0.01$). After CT intervention minimum pelvis rotation was decreased (-2.1° ± 4.2, $p<0.05$) with no retention at 3 months. No significant changes in hip kinematics were found. Pelvis and hip kinematic data are reported in Table 2.

Conclusions

Gait patterns in MS were characterized by a reduced gait speed and step length, a prolonged double support time with kinematics deviations, such as an increased anterior pelvic tilt and a reduced hip extension. Robot-assisted gait training could be helpful in ameliorating these abnormalities that can be interpreted as a combination of central and sensory pathway disruptions.

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Table 1: Changes in spatio-temporal parameters.

	RAGT (n=8)		CT (n=8)	
	mean	mean change from baseline	mean	mean change from baseline
Gait speed (m/s)				
Pre	0.55 ± 0.24	-	0.46 ± 0.22	-
Post	0.62 ± 0.18**	0.07 ± 0.11	0.45 ± 0.20	-0.01 ± 0.13
3 months	0.58 ± 0.21	0.03 ± 0.12	0.44 ± 0.22	-0.02 ± 0.08
Cadence (step/min)				
Pre	74.42 ± 24.09	-	69.98 ± 15.56	-
Post	80.75 ± 20.37**	6.33 ± 10.12	69.68 ± 14.36	-0.30 ± 12.82
3 months	77.46 ± 19.76*	3.04 ± 9.29	68.93 ± 17.93	-1.05 ± 9.64
Double support (%)				
Pre	35.6 ± 7.9	-	36.9 ± 9.9	-
Post	31.0 ± 5.5*	-4.6 ± 10.4	35.4 ± 7.5	-1.4 ± 7.3
3 months	31.4 ± 6.6*	-4.2 ± 11.3	38.4 ± 9.0	1.5 ± 7.1
Step length (m)				
Pre	0.43 ± 0.08	-	0.37 ± 0.13	-
Post	0.46 ± 0.05*	0.03 ± 0.07	0.37 ± 0.13	0.00 ± 0.06
3 months	0.46 ± 0.10*	0.03 ± 0.11	0.36 ± 0.14*	-0.01 ± 0.04
Step time (s)				
Pre	0.95 ± 0.51	-	0.90 ± 0.25	-
Post	0.80 ± 0.26**	-0.15 ± 0.35	0.91 ± 0.23	0.01 ± 0.24
3 months	0.83 ± 0.24	-0.12 ± 0.34	0.97 ± 0.41	0.07 ± 0.32

* $p < 0.05$, ** $p < 0.01$ (these p-values represent the mean comparison of post- and 3 months to baseline)

Table 2: Changes in pelvic and hip kinematic parameters.

	RAGT (n=8)		CT (n=8)	
	Mean (angles)	mean change from baseline	Mean (angles)	mean change from baseline
P3				
Pre	13.2 ± 10.0	-	11.4 ± 5.6	-
Post	10.4± 5.1**	-2.8 ± 5.6	9.2 ± 4.3*	-2.1 ± 4.2
3 months	9.6 ± 6.0**	-3.6 ± 7.4	10.1 ± 6.7	-0.5 ± 7.1
H1				
Pre	36.0 ± 8.1	-	34.1 ± 4.6	-
Post	35.1 ± 5.0	- 0.9 ± 5.9	33.9 ± 5.1	-0.1 ± 4.7
3 months	33.1 ± 7.7*	- 2.9 ± 6.8	32.6 ± 7.1	-1.3 ± 8.9
H3				
Pre	-0.5 ± 10.8	-	-1.1 ± 9.1	-
Post	-3.2 ± 6.3*	-2.6 ± 7.0	-2.1 ± 10.2	-0.9 ± 6.3
3 months	-5.2 ± 6.9**	- 4.7 ± 8.5	-1.6 ± 10.0	0.0 ± 13.3
H5				
Pre	38.8 ± 9.3	-	35.7 ± 4.2	-
Post	38.5 ± 5.5	-0.2 ± 6.1	35.4 ± 6.1	-0.2 ± 4.9
3 months	34.9 ± 5.8*	-4.2 ± 10.1	35.2 ± 6.3	-0.4 ± 7.8
H6				
Pre	39.8 ± 7.3	-	37.1 ± 10.1	-
Post	42.3 ± 6.0**	2.5 ± 5.1	37.9 ± 10.4	0.7 ± 6.6
3 months	41.5 ± 6.1*		37.2 ± 10.2	-0.4 ± 12.4

* $p < 0.05$, ** $p < 0.01$ (these p-values represent the mean comparison of post- and 3 months to baseline)

Virtual reality neurorehabilitation of walking early after stroke

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Introduction

Virtual reality (VR) is increasing in popularity in stroke rehabilitation research. It has the potential to motivate patients during repetitive tasks and provide kinematic data required for objective assessment in the clinical environment (1,2). However, there are few studies exploring the use of VR specifically with gait training after stroke (3), and those studies that have used VR have focused on a particular aspect of walking rehabilitation, such as walking over obstacles, rather than encompassing a broader approach. Additionally, the existing VR gait studies primarily target chronic stroke patients, but it has been demonstrated that patients with mild, moderate and severe impairment level reach peak walking function recovery within four, six and eleven weeks post-stroke (4). Here, we describe a novel VR application to motivate and engage patients during walking rehabilitation physiotherapy sessions. Two case studies are presented that explore the effectiveness and feasibility of the feedback aid for gait training in sub-acute stroke patients.

Methods

We have designed a bespoke feedback aid, through consultation with stroke survivors and rehabilitation professionals, which allows patient movement to be visualised during gait training. Patients, and their therapists, are presented with a stick figure visualisation that mimics the user in real-time or post-hoc, depending on the task and the patient's ability to process information. Three dimensional motion capture allows users to see their movements from different viewpoints enabling a better understanding of movement patterns and compensatory strategies employed. The feedback aid was designed to fit into clinical practice for early and advanced gait rehabilitation. Hip, knee and ankle range of motion targets can be superimposed on the stick figure to motivate patients, and each exercise is recorded such that users are able to track progress.

Case studies were undertaken to assess the effectiveness of this feedback aid in a 6 week gait training programme consisting of twice weekly training sessions. A 62 year old male (S1) and 56 year old female (S2), 20 days and 3 months post-stroke respectively, participated. Outcome measures used were walking speed, Functional Ambulation Classification (FAC), Timed Up and Go (TUG) and Stroke Impact Scale-16 (SIS-16).

Results

Participants commented on the system's role in providing an increased sense of involvement and understanding of their rehabilitation, and in maintaining motivation levels. Moreover, the participants demonstrated clinical improvements in walking speed and TUG. S1 and S2 increased their walking speed by 0.70 and 0.15 metres per second and decreased their TUG by 8.27 and 4.37 seconds respectively. Both participants increased their FAC score from 4 to 5, indicating a return to pre-stroke FAC. Participants indicated that they experienced reduced difficulty in mobility tasks, increasing their SIS-16 score by 10% (S1) and 26% (S2).

Conclusions

Findings suggested this feedback approach to be a useful adjunct to early stroke rehabilitation. Such feedback has the potential to assist users in interpreting their movement performance, to encourage correct movements over compensatory patterns and enhance mobility outcomes after stroke. A feasibility randomised controlled trial is currently being undertaken to compare the effectiveness of this VR intervention against an intensity-matched placebo and a standard care control.

Acknowledgements: This work was supported by the Cross Research Council, Lifelong Health and Wellbeing programme co-ordinated by the MRC. Thanks to the Stroke Managed Clinical Network in NHS Lanarkshire and the greater envisage project team.

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Efficacy of constraint-induced movement therapy: A clinical case

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Abstract

Hemiplegia is one of the clinical forms appearing in infantile cerebral palsy (ICP). Motor and sensory functions of the half of the body are altered due to contralateral side brain damage. We present the results obtained after the application of the modified constraint-induced movement therapy (CI) in a 2 years old child with ICP hemiplegia.

Introduction

The CI is one of the treatment strategies that use the principles of neural plasticity to help to acquire the motor skills of the involved upper extremity. This therapeutic approach involves restriction of the involved extremity and intensive training with specific tasks, oriented at the increase of its use in daily activities.

Aim

This work pretends to demonstrate the efficacy of the CI therapy in a 2 years old child with a ICP hemiplegia and the increased use of the plegic side.

Method

According to Taub et al., (1993), The CI has a protocol that incorporates two fundamental components: The use of a retaining device (slings on the non-involved extremity) and the continued use of the involved upper extremity 3 hours per day for three weeks. In this case, two hours at the Rehabilitation Unit and the remaining hour at home under family supervision. The therapist indicates the specific activities to develop according to the CI phase. The activities are proposed according to the degree of development of the child specific manual skills, increasing the degree of difficulty during the three weeks of treatment.

Results

Initial evaluation of the child's involved upper extremity was assessed with the Quality of Upper Extremity Skills Test (QUEST), which is a reference measure that evaluates the quality of upper extremity function in four domains. There were three assessment periods: at the beginning of intervention, post-intervention and one month follow-up.

Areas	**Percentile rank**		
	Intervention	Post-intervention	1 Month follow-up
Dissociated Movements	56,89%	78,68%	79,36%
Grasp	37,02%	85,18%	96,30%

Conclusions

Intensive monitoring during the 3 weeks of the CI therapy intervention confirms that the functionality and ability sections of the involved extremity have been positive, with an increase of the frequency of use. This indicates that the involved extremity has improved at a sensorimotor level, due to its continued use. However, it was not possible to guide the learning towards bimanual activities, which had to be trained in later sessions.

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