Presentation slides of the webinar "Neuroplasticity and robotic rehabilitation".

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REBIOTEX

Neuroplasticity and New Technologies for Rehabilitation

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(Madrid – Spain)

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First of all, a reflection ...

REPETITION. **FUNCTIONALITY.** **INTENSITY.**

[Intervention Review]

Repetitive task training for improving functional ability after stroke

Beverley French[1], Lois H Thomas[2], Jacqueline Coupe[2], Naoimh E McMahon[2], Louise Connell[2], Joanna Harrison[3], Christopher J Sutton[2], Svetlana Tishkovskaya[4], Caroline L Watkins[2]

A rehabilitation treatment after stroke has to be **intensive**, **repetitive**, **functional**, **task-oriented**, specific, customizable.

Understanding the pattern of functional recovery after stroke: facts and theories – Kollen et al. 2004
The impact of physical therapy on functional outcomes after stroke: What's the evidence? – Van Peppen et al. 2004

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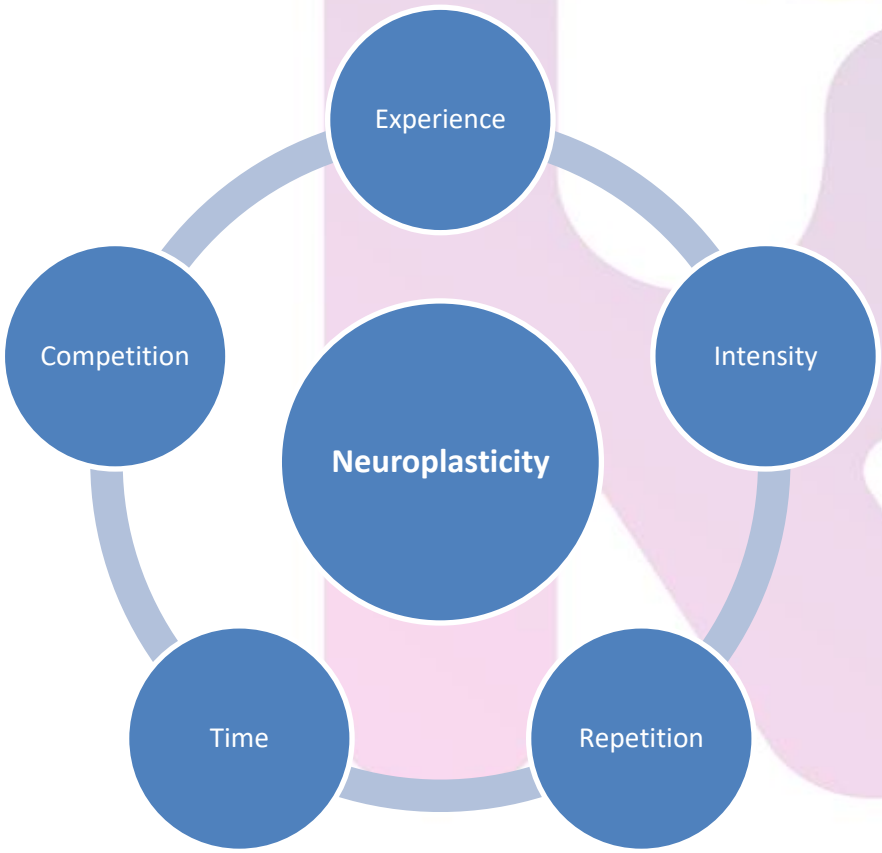
Neuroplastic adaptations?

- **Experience:** Related to the experience, in this case grab and release or gait
- **Intensity**
- **Competition:** Related to learning
- **Repetition Process:** Perform a repetitive gesture
- **Time dependent:** Critical for long-term integration



Calabrò RS, Naro A, Russo M, et al. Shaping neuroplasticity by using powered exoskeletons in patients with stroke: a randomized clinical trial. J Neuroeng Rehabil. 2018;15(1):35. doi:10.1186/s12984-018-0377-8

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My experience

IRF La Salle robotic equipment

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Robotic Glove Gloreha: What is its purpose?

- Upper limb and hand rehabilitation:
  - Passive, active-assisted, active mobilization
  - Degravitate upper limbs

Functionality

Two Important Principles

Combination of physical and cognitive therapies

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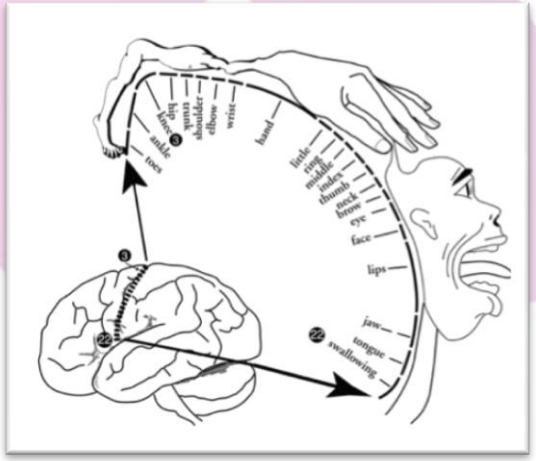
Neuroplastic adaptations?

- **Motor imagery**, movement and **action observation** can activate sensorimotor areas of the brain

Szameitat AJ, Shen S, Conforto A, Sterr A. Cortical activation during executed, imagined, observed, and passive wrist movements in healthy volunteers and stroke patients. Neuroimage. 2012 Aug 1;62(1):266-80. doi: 10.1016/j.neuroimage.2012.05.009. Epub 2012 May 11. PMID: 22584231.
AS Merians, E Tunik, SV Adamovich (2009) "Virtual reality to maximize function for hand and arm rehabilitation: exploration of neural mechanisms - Studies in health technology and informatics, " 2009

- Working with with **feedback**:
  - Sensory
  - Visual
  - Auditory
- Promotes plasticity and motor learning



Sale P., Lombardi V., Franceschini M. (2012) "Hand Robotics Rehabilitation: Feasibility and Preliminary Results of a Robotic Treatment in Patients with Hemiparesis a clinical study" doi:10.1155/2012/820931
Lee D., Seo H., Jung MW (2012) "Neural basis of reinforcement learning and decision making". Annu Rev Neurosci 35:287–308.

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Neuroplastic adaptations?

Research Article

Quantification of Upper Limb Motor Recovery and EEG Power Changes after Robot-Assisted Bilateral Arm Training in Chronic Stroke Patients: A Prospective Pilot Study

Marialuisa Gandolfi,[1,2] Emanuela Formaggio,[3] Christian Geroin,[1,2] Silvia Francesca Storti,[4] Ilaria Boscolo Galazzo,[4] Marta Bortolami,[1,2] Leopold Saltuari,[5,6] Alessandro Picelli,[1,2] Andreas Waldner,[6,7] Paolo Manganotti,[8] and Nicola Smania[1,2]

*"Passive Robot Assisted training **may facilitate cortical neural plasticity** by two mechanisms..."*

"One consists of the simultaneous activation of both hemispheres…"

"…the other mechanism involves facilitation of the contralesional uncrossed corticospinal tract and spared indirect corticospinal pathways."

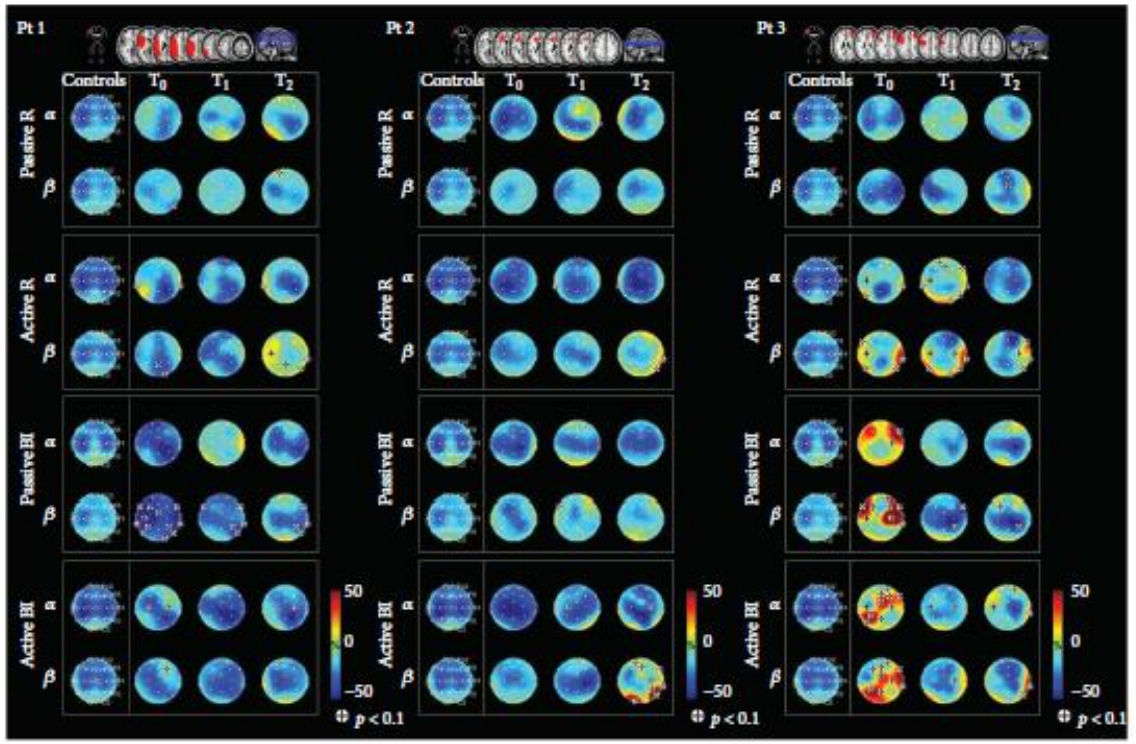

FIGURE 1: Lesions displayed on a magnetic resonance imaging brain template and topographic maps showing ERD/ERS values. ERD/ERS maps in the alpha and beta bands during passive and active movements with the affected hand and during bimanual passive and active movements (patient numbers 1, 2, and 3). Blue indicates maximal ERD. The *t*-test was applied individually for each patient in order to compare the ERD/ERS map of each patient to the mean ERD/ERS map of the controls ($p < 0.1$ ($|t| > 1.895$) indicated by (+)).

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What effects can we expect?

In previous studies, positive changes have been found in the following variables:

- Spasticity [2,3,5]
- Manual dexterity[1, 4]
- ROM[1,]
- Strenght [1]
- Reduce edema[2,3]
- Functional recovery[6]

1. Vanoglio F, Bernocchi P, Mulè C, et al. Feasibility and efficacy of a robotic device for hand rehabilitation in hemiplegic stroke patients: a randomized pilot controlled study. *Clin Rehabil*. 2017;31(3):351-360. doi:10.1177/0269215516642606
2. Bissolotti L, Villafañe JH, Gaffurini P, Orizio C, Valdes K, Negrini S. Changes in skeletal muscle perfusion and spasticity in patients with poststroke hemiparesis treated by robotic assistance (Gloreha) of the hand. *J Phys Ther Sci*. 2016;28(3):769-773. doi:10.1589/jpts.28.769
3. Gobbo M, Gaffurini P, Vacchi L, et al. Hand Passive Mobilization Performed with Robotic Assistance: Acute Effects on Upper Limb Perfusion and Spasticity in Stroke Survivors. *Biomed Res Int*. 2017;2017:1-6. doi:10.1155/2017/2796815
4. Paolo Milia, Maria Cristina Peccini, Federico De Salvo, Alice Sfaldaroli, Chiara Grelli, Lucchesi Giorgia, Nora Sadauskas, Catia Rossi, Marco Caserio, Mario Bigazzi "Rehabilitation with robotic glove (Gloreha) in poststroke patients" Digital Medicine Journal, 2019
5. Miccinilli S, Bravi M, Foti C, Morrone M Maselli M, Santacaterina F, Scotto Di Luzio F, Zollo L, Sterzi S, Bressi F "Robotic hand treatment of patients affected by chronic stroke: a monocentric longitudinal pilot study" J Biol Regul Homeost Agents. 2020 SepOct;34(5 Suppl. 3):79-86. Technology in Medicine
6. Lee HC, Kuo FL, Lin YN, Liou TH, Lin JC, Huang SW "Effects of Robot-Assisted Rehabilitation on Hand Function of People With Stroke: A Randomized, Crossover-Controlled, Assessor-Blinded Study" Am J Occup Ther. 2021 Jan-Feb;75

Intra-session changes

En este vídeo podemos ver los cambios que conseguimos en la destreza manual y fuerza después de una sesión con el exoesqueleto de mano Gloreha Sinfonía

Link to see the video
https://youtu.be/Y36nrHYA7HY

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What effects can we expect?

Varalta *et al. Journal of NeuroEngineering and Rehabilitation* 2014, **11**:160
http://www.jneuroengrehab.com/content/11/1/160

JNER JOURNAL OF NEUROENGINEERING AND REHABILITATION

RESEARCH Open Access

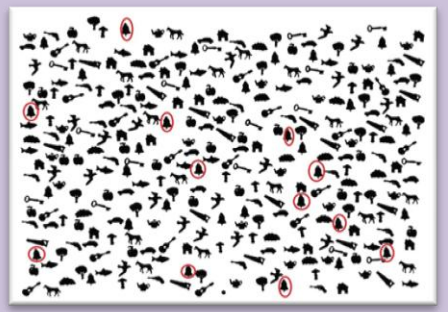
Effects of contralesional robot-assisted hand training in patients with unilateral spatial neglect following stroke: a case series study

Valentina Varalta[1], Alessandro Picelli[1], Cristina Fonte[1], Giulia Montemezzi[1], Elisabetta La Marchina[1] and Nicola Smania[1,2*]

- 2 week treatment program;
- 10 sessions of 30 min 5 days a week;
- Improvement in variables such as the bells test and Purdue pegboard;

Purdue pegboard

The bells test



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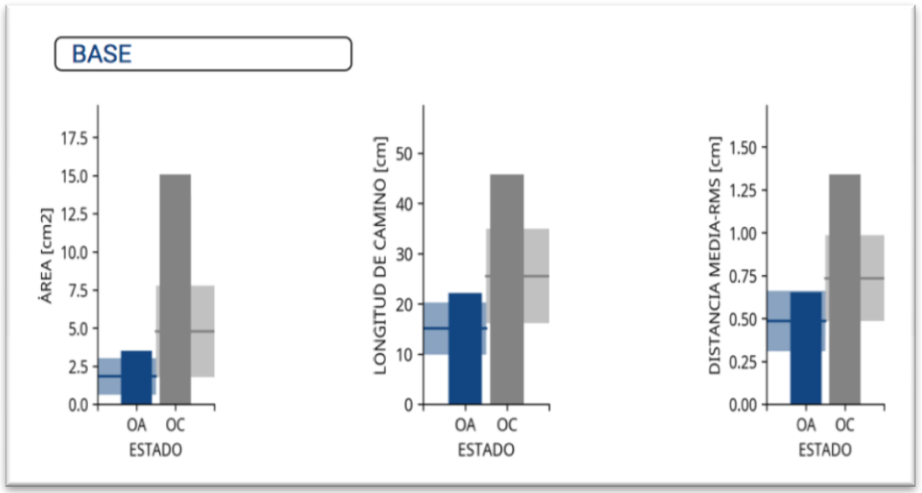
Balance rehabilitation
What is posturography?

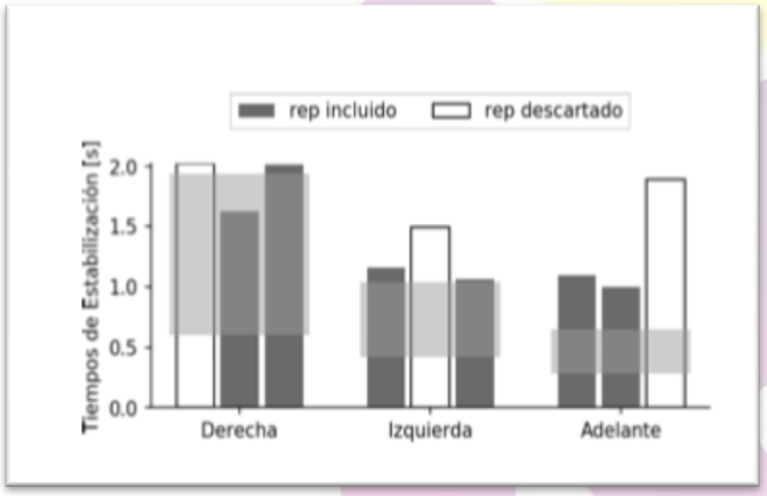
- System that is based on the detection of the displacement of the **pressure center;**
- Evaluate **somatosensory** system;
- **Vestibular**?

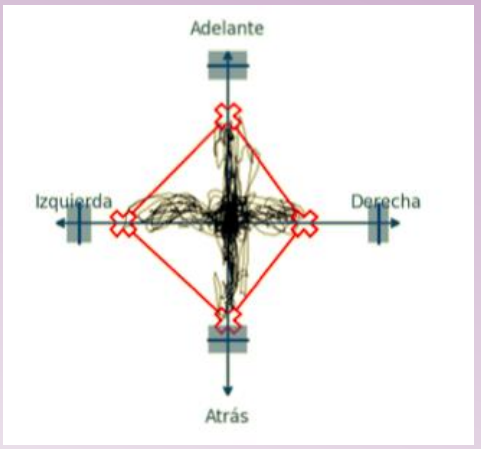
- **Somatosensory system**
- **Vestibular system**
- **Visual system**

Gaerlan MG. *The Role of Visual, Vestibular, and Somatosensory Systems in The Role of Visual, Vestibular, and Somatosensory Systems in Postural Balance Postural Balance* 2010.

How is it quantified?







Sensor	Indicador-Estado Ojos	Valor	Normalidad
BASE	MAX COP ADELANTE [cm]	5.62*	[7.56 , 9.04]
	MAX COP ATRÁS [cm]	5.13*	[5.39 , 6.83]
	MAX COP DERECHA [cm]	4.04*	[7.41 , 8.48]
	MAX COP IZQUIERDA [cm]	5.55*	[7.21 , 8.49]
	ZONA DE ESTABILIDAD [cm2]	51.52*	[99.83 , 129.37]
TRONCO	INCLINACIÓN MÁXIMA ADELANTE [°]	10.68*	[4.50 , 9.85]
	INCLINACIÓN MÁXIMA ATRÁS [°]	0.49*	[0.89 , 8.02]
	INCLINACIÓN MÁXIMA DERECHA [°]	4.31	[2.35 , 10.28]
	INCLINACIÓN MÁXIMA IZQUIERDA [°]	4.74	[3.70 , 10.96]

Cella A, De Luca A, Squeri V, Parodi S, Vallone F, Giorgeschi A, Senesi B, Zigoura E, Quispe Guerrero KL, Siri G, De Michieli L, Saglia J, Sanfilippo C, Pilotto A. Development and validation of a robotic multifactorial fall-risk predictive model: A one-year prospective study in community-dwelling older adults. PLoS One. 2020 Jun 25;15(6):e0234904. doi: 10.1371/journal.pone.0234904. PMID: 32584912; PMCID: PMC7316263.

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Gait rehabilitation with new technologies

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Exoskeleton-assisted gait in chronic stroke: An EMG and functional near-infrared spectroscopy study of muscle activation patterns and prefrontal cortex activity

Pietro Caliandro [a], Franco Molteni [b], Chiara Simbolotti [a], Eleonora Guanziroli [b], Chiara Iacovelli [c], Giuseppe Reale [d], Silvia Giovannini [e,*], Luca Padua [d,f]

[a] Neurology Unit, Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo A. Gemelli, 8, 00168 Rome, Italy
[b] Villa Beretta Rehabilitation Center, Valduce Hospital, Via N. Sauro 17 23845 Costa Masnaga, Lecco, Italy
[c] IRCCS Fondazione Don Carlo Gnocchi, Milan, Italy
[d] Department of Geriatrics, Neurosciences and Orthopedics, Università Cattolica del Sacro Cuore, Rome, Italy
[e] Rehabilitation Units, Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo A. Gemelli, 8, 00168 Rome, Italy
[f] Neurorehabilitation Unit, Fondazione Policlinico Universitario A. Gemelli IRCCS, Largo A. Gemelli, 8, 00168 Rome, Italy

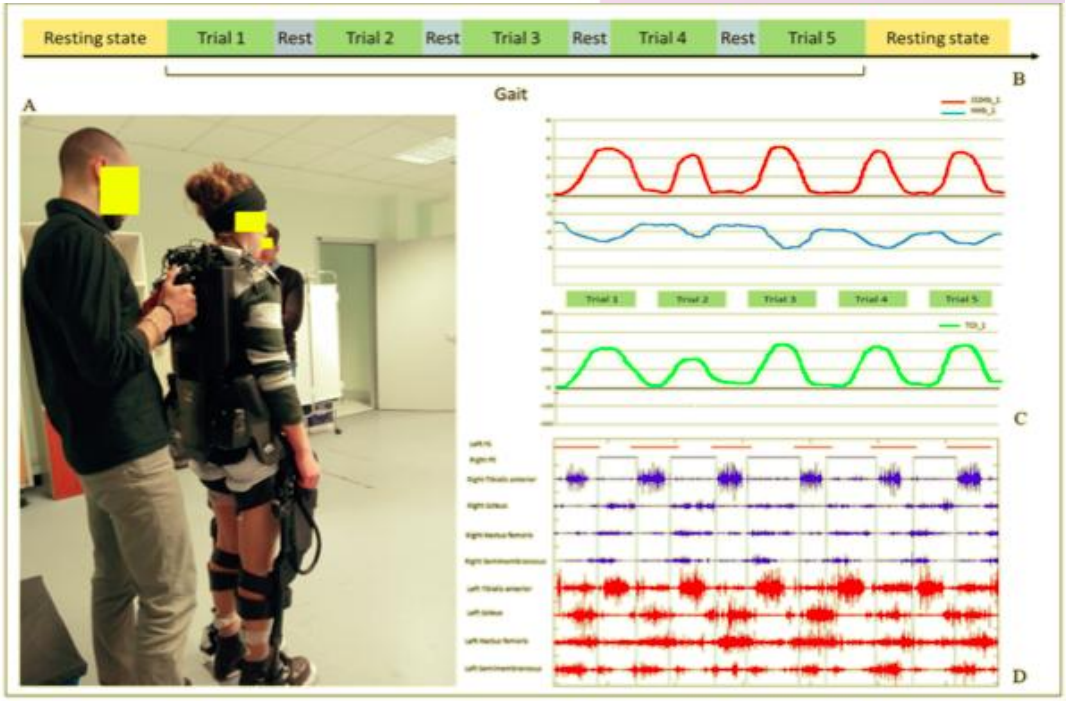

Fig. 1. (A) Experimental set. Subject with Ekso, fNIRS and sEMG electrodes. (B) Experimental task divided into trials. Please notice the initial and final resting states and the 5 gait tasks separated from each other from a rest phase. (C) fNIRS and sEMG trend during the experimental task. Abbreviations: fNIRS = functional near-infrared spectroscopy, sEMG = surface electromyography, O2Hb = oxygenated hemoglobin concentration, HHb = deoxygenated hemoglobin concentration, TOI = Tissue Oxygenation Index, FS = footstep.

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Gait rehabilitation with new technologies

Clinical Case Report

Medicine®

OPEN

Overground exoskeletons may boost neuroplasticity in myotonic dystrophy type 1 rehabilitation

A case report

Simona Portaro, MD, PhD, Antonino Naro, MD, PhD, Antonino Leo, MSc, Vincenzo Cimino, MD, PhD, Tina Balletta, PT, Antonio Buda, PT, Maria Accorinti, MD, Rocco Salvatore Calabrò, MD, PhD*

Outcomes: The patient, after the EKSO training, gained a significant improvement in walking, balance and lower limbs muscle strength, as per 10-meter walking test and Left Lower Limb Motricity Index. Neurophysiological data (electroencephalography and surface electromyography) were also collected to more objectively assess the functional outcomes.

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Gait rehabilitation with new technologies

L300 OFF

L300 ON

What do we get with this?

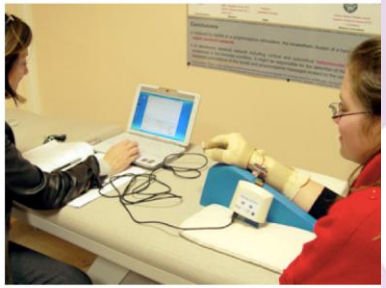
- **Gait symmetry**
- **More steps**
- **Training vs immobilization**

→ FUNCTIONALITY
→ REPETITION
→ INTENSITY

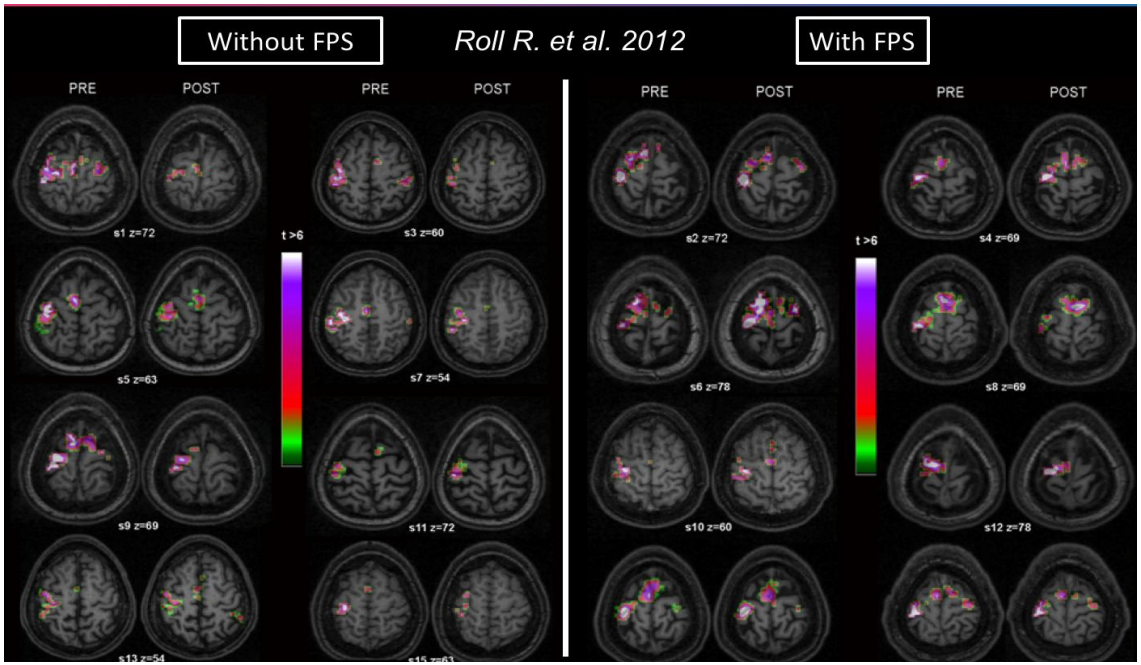
Rehabilitation with new technologies

Example of fMRI with Vibramoov.
In the group on the left the hand was immobilised, and in the group on the right the hand was immobilised and provided with functional proprioceptive stimulation (FPS).
These are the results after 5 days.

Roll R. et al. 2012



- Immobilisation 5 days wrist + hand
- Before & after immobilisation :
  - > fMRI
  - > Range of motion measurements
- 2 Groups of subjects
  - Group 1: conventional immobilization
  - Group 2 : Functionnal Proprioceptive Stimulation (2x30 minutes/day)



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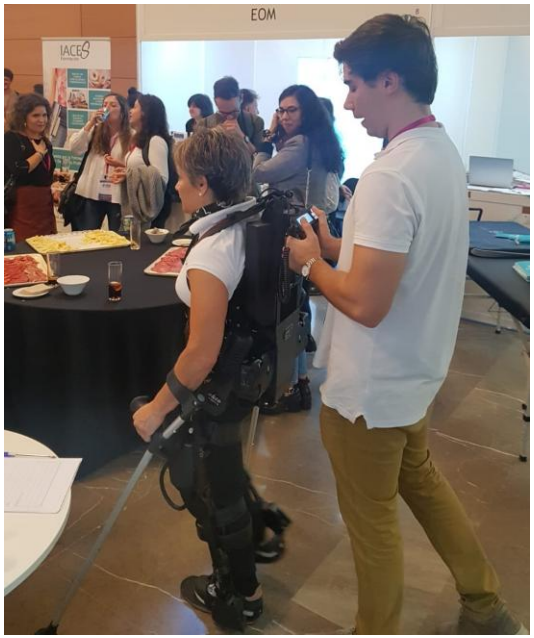
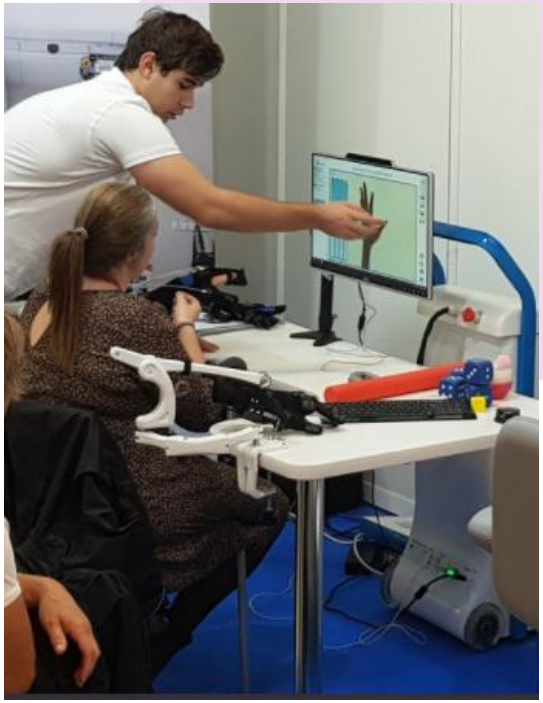
Conclusion





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Thank you for your attention!