CRRNC
Centro di Ricerca in Riabilitazione Neuromotoria e Cognitiva

30° Anniversario 1987-2017
Fondazione TERESA CAMPLANI
Casa di Cura DOMUS SALUTIS

UNIVERSITÀ · DEGLI · STUDI · DI · VERONA

LA RIABILITAZIONE INTERDISCIPLINARE

della disabilità complessa
fra presente e futuro

24 novembre 2017

Centro congressi "Auditorium Monsignor Capretti"

UOMO–MACCHINA, CORPO-MENTE: ALLA RICERCA DELL'EQUILIBRIO VINCENTE

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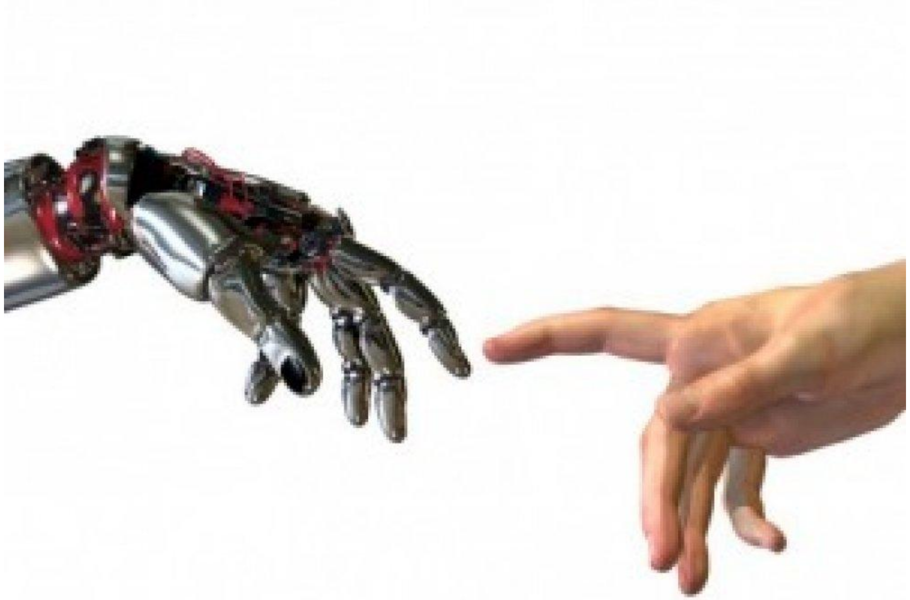
UOC Neuroriabilitazione, Azienda Ospedaliera Universitaria Integrata di Verona



ROBOT PER TRAINING ARTI SUPERIORI E DEMBULAZIONE

Trattamento
- **Intensivo**
- **ripetitivo**

HUMAN-ROBOT INTERACTION
Human's Behavior

- Physical Interaction
  - **Human's Behavior**
    - Postural Adjustments
      - Feedforward
      - Feedback
  - **Robot Behavior**
    - Type of Assistive Device
      - Exoskeleton
      - End-effector
    - Control Strategies
      - Active-Assisted
      - Challeng-based
      - Haptic Stimulation
      - Coaching
- Cognitive Interaction
  - Reasoning
  - Planning
  - Execution

Pons 2008

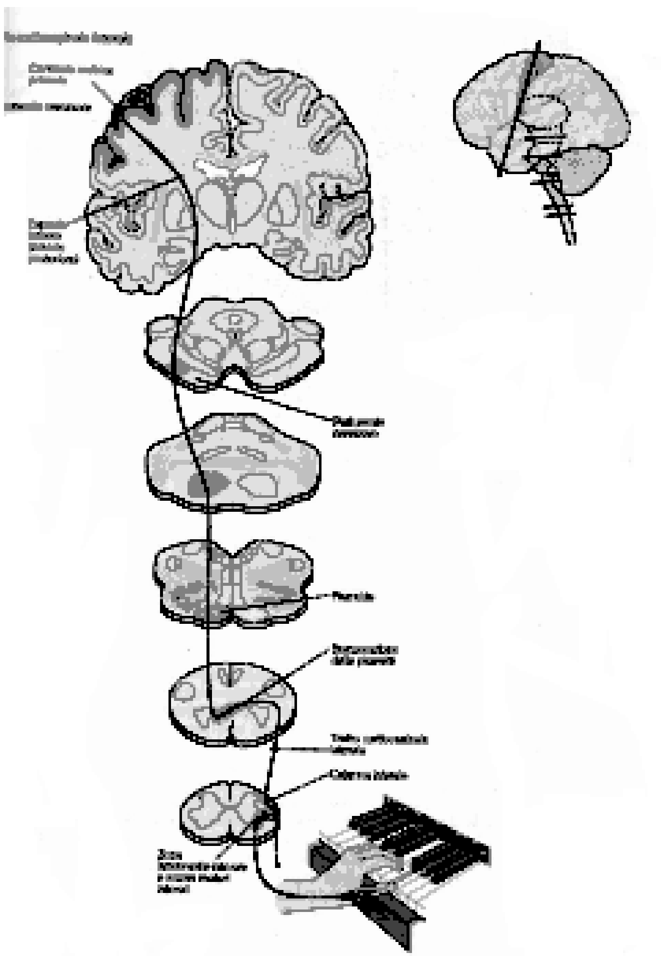
Funzioni dell’arto superiore, equilibrio e deambulazione: diverse modalità di controllo nervoso

- **Rappresentazione nervosa**
  - motoria
  - sensitiva
- **Aspetti cognitivi**
  - Spaziali
    - Coordinate di riferimento
    - Attenzione
  - Pianificazione e programmazione del movimento
  - Apprendimento motorio
  - Modelli interni

Different modalities of sensorimotor control

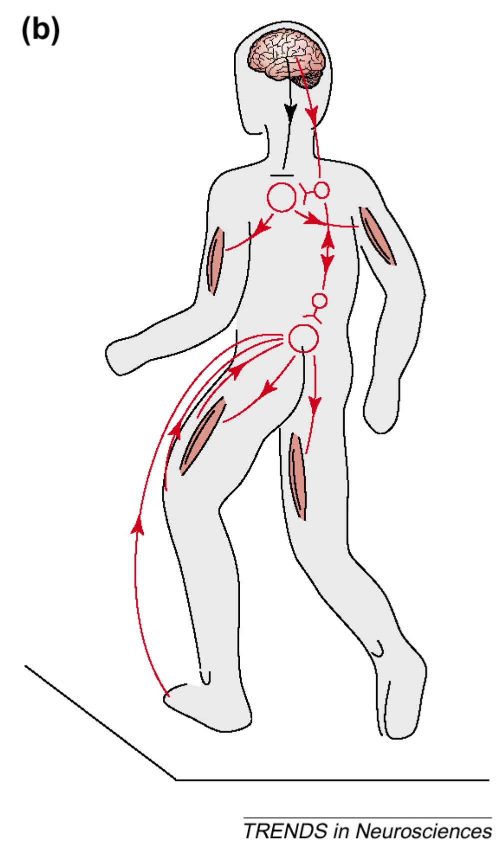
Neural correlates for upper and lower limb function

Fine motor skills



Reaching and grasping
Predominately acquired by experience

Whole body movements



Walking
Largely genetically determined neural circuits
Adapted and perfected by experience

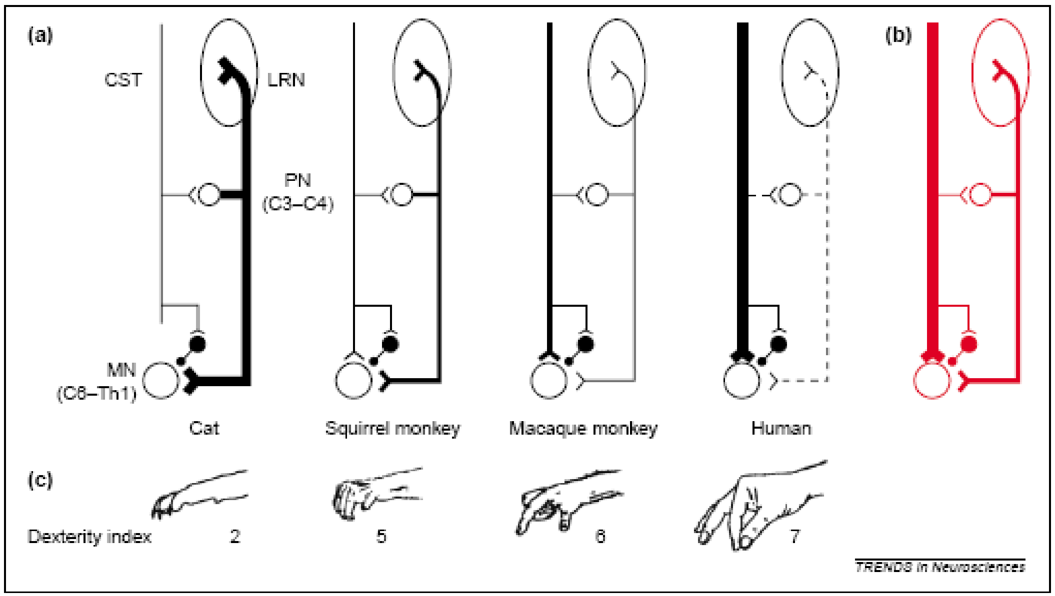
Different Modalities of Sensorimotor Control

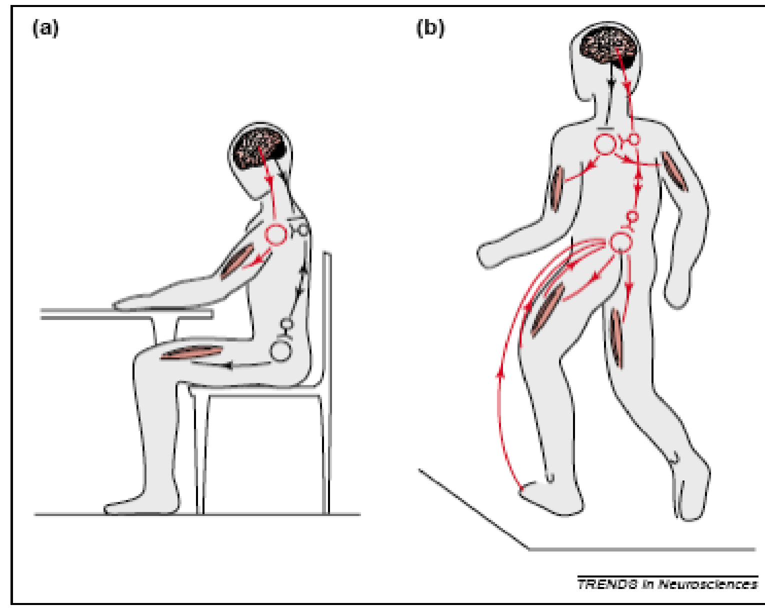
Coordination of Arm and Leg Movements Evidence for Neuronal Coupling

462 Review TRENDS in Neurosciences Vol.25 No.9 September 2002

Do human bipeds use quadrupedal coordination?

Volker Dietz





Contribution of propriospinal and cortical-motoneuronal excitation to control of upper limb motoneurons in cat, squirrel monkey, macaque monkey and human.

"[...] task-dependent neuronal linkage of **cervical and thoraco–lumbar propriospinal circuits** controlling leg and arm movements during human locomotor activities"

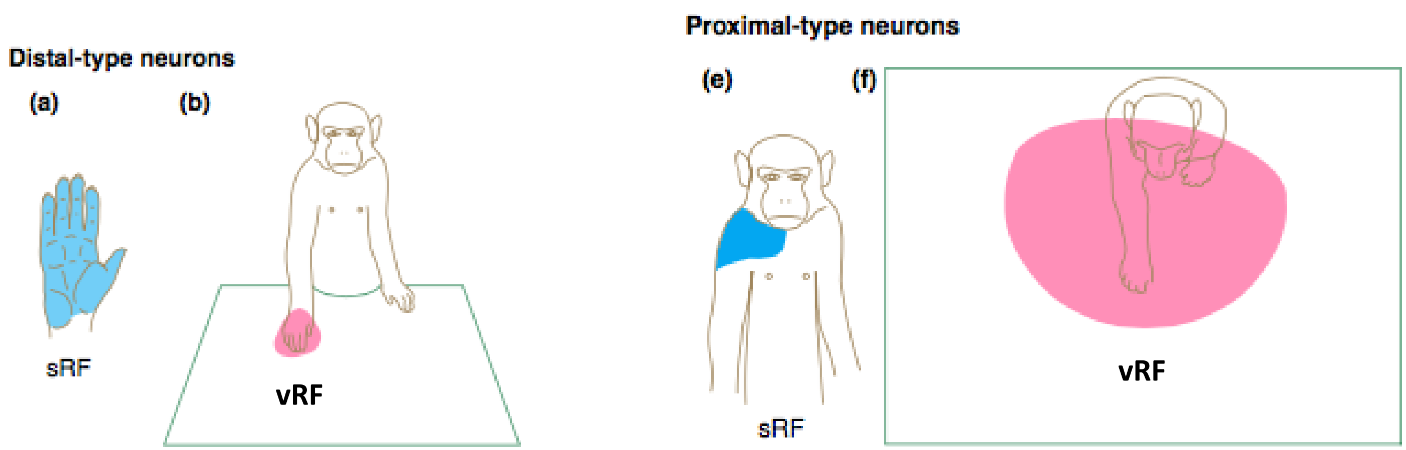
Sistemi sensoriali e controllo dell'arto superiore durante la manipolazione

Review TRENDS in Cognitive Sciences Vol.8 No.2 February 2004
Full text provided by www.sciencedirect.com

Tools for the body (schema)

Angelo Maravita[1] and Atsushi Iriki[2]

[1]Dipartimento di Psicologia, Università di Milano-Bicocca, Piazza dell'Ateneo Nuovo, 1, 20126, Milano, Italy
[2]Section of Cognitive Neurobiology, Tokyo Medical and Dental University, Bunkyo-ku, Tokyo 113-8549, Japan



sRF: campi recettivi somatosensoriali
vRF: campi recettivi visivi

Deficit di sensibilità somatica

Rehabilitation of Somatic Sensation and Related Deficit of Motor Control in Patients With Pure Sensory Stroke

Nicola Smania, MD, Barbara Montagnana, MD, Silvia Faccioli, MD, Antonio Fiaschi, MD, Salvatore M. Aglioti, MD

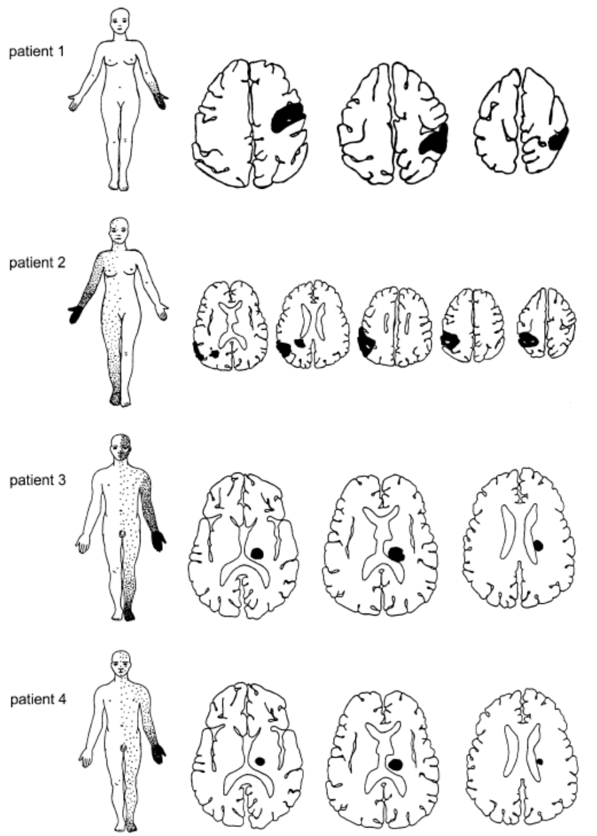
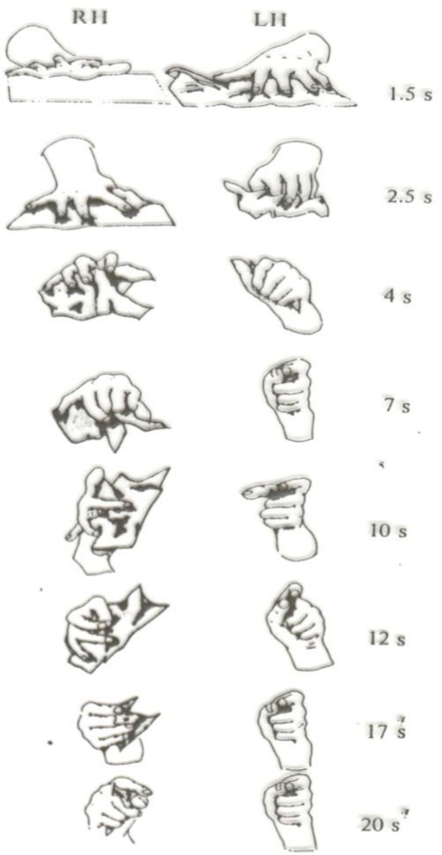


Fig 1. Topographic distribution of somatic deficits and reconstruction of the site and extent of the lesion (according to Damasio and Damasio[46]) in each patient.

Arch Phys Med Rehabil 2003;84:1692-702.



Jeannerod, Micheal and Prablanc, 1984

LOCOMOTION IS THE RESULT OF DYNAMIC INTERACTION BETWEEN A CENTRAL PROGRAM AND FEEDBACK MECHANISMS

LOCOMOTION

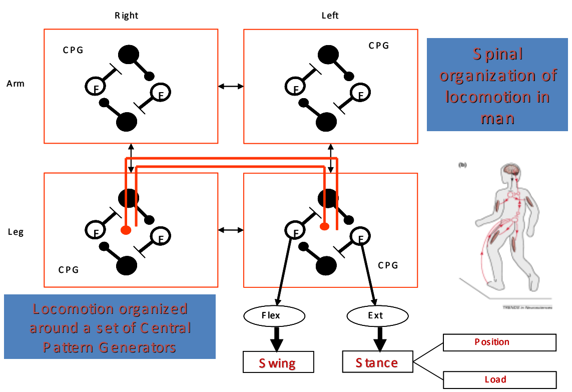
Central Program

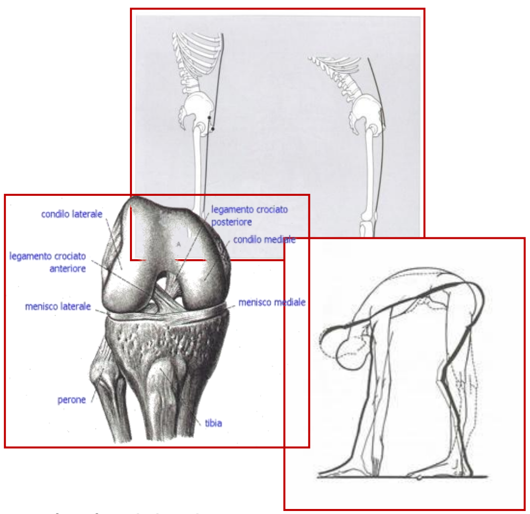
- Central Pattern Generator
- Various descending pathways
- Various brain regions

Feedback mechanisms

originate from:

- Muscles
- Skin
- Vision
- Audition
- Vestibular



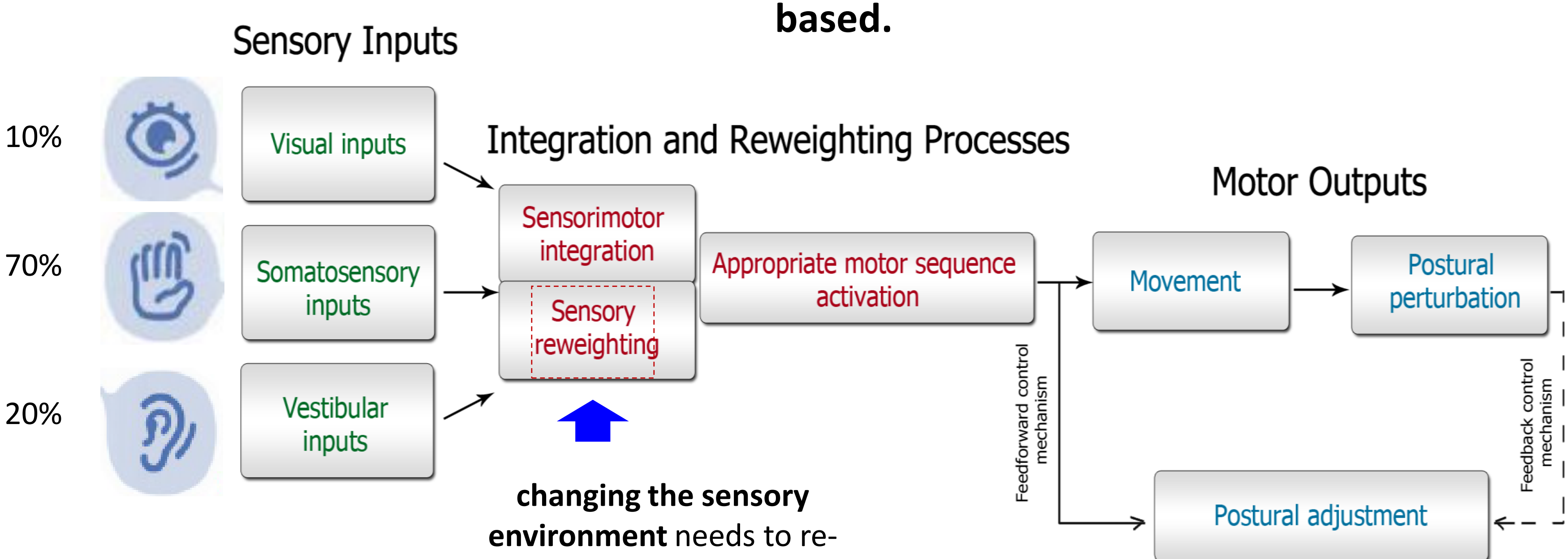


Lucca, Pignolo, Mazzoleni. La robotica in Neuroriabilitazione. Piccin 2016

Integrazione delle informazioni sensoriali

Sensory Strategies

It involves the integration of incoming sensory information from the somatosensory, visual and vestibular systems, which is normally processed to make up the system of coordinates on which the body's postural control is based.

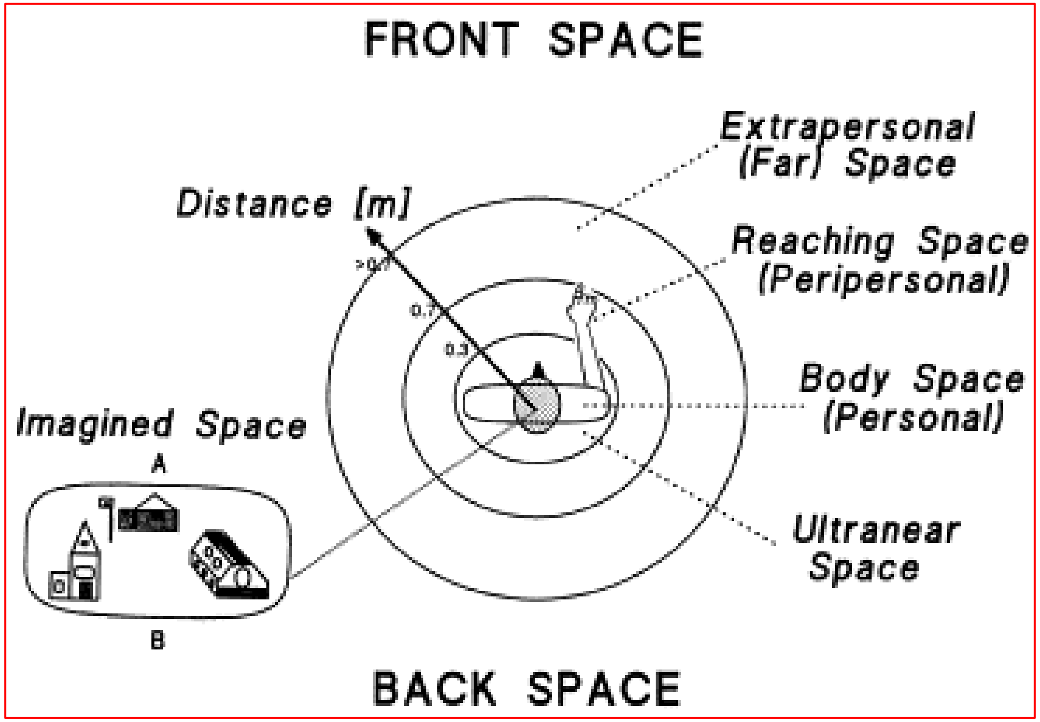


changing the sensory environment needs to re-weight the relative dependence on each of the senses involved

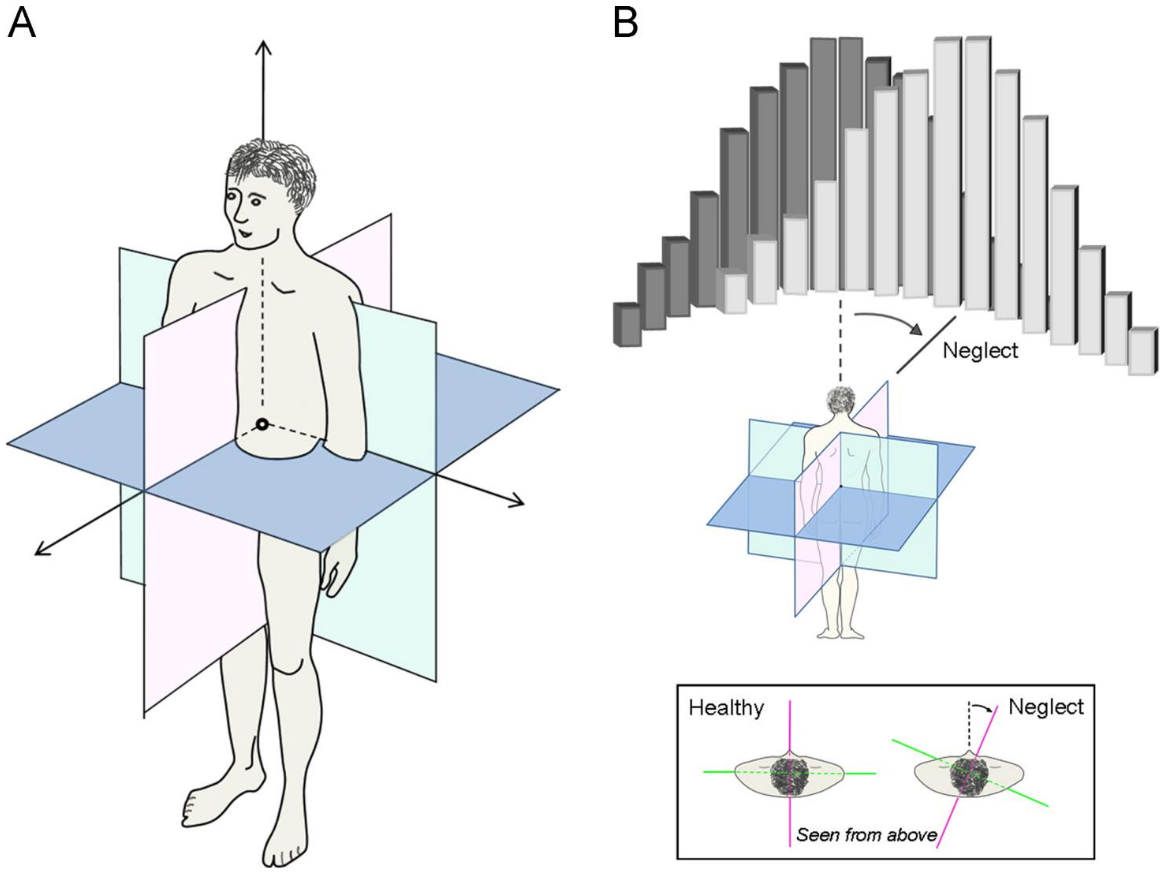
The central integration process allows us **to select a specific response strategy** to maintain postural control according to **external postural displacement**, **goals**, and prior **experience**.

Horak FB Age and Aging 2006
Gandolfi M. et al. Minerva Medica 2015

Spazio in relazione all'azione



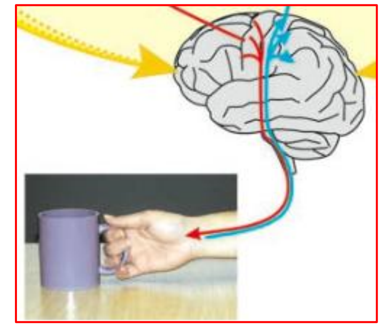
Codifica delle coordinate di riferimento spaziale nelle diverse azioni



Le azioni della vita quotidiana richiedono l’elaborazione di informazioni relative allo spazio in cui vengono attuate

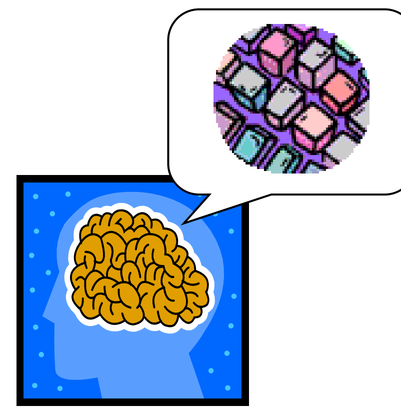
Abbottonarsi polsino

Afferrare una tazza



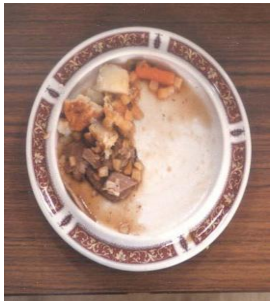
Camminare verso una direzione

Immaginare strada da percorrere



Destrutturazione delle azioni nel neglect

- Si rade a metà



- Lascia cibo nella metà sinistra del piatto

- Collide con ostacoli

- Disorientamento topografico

Spazio peripersonale:
neglect e deficit sensori-motori

Sensory and spatial components of somaesthetic deficits following right brain damage

Nicola Smania, MD, and Salvatore Aglioti, MD

NEUROLOGY 1995;45:1725-1730

Coding of far and near space in neglect patients

Anna Berti, Nicola Smania and Alan Allport

Neuroimage 14, 2001

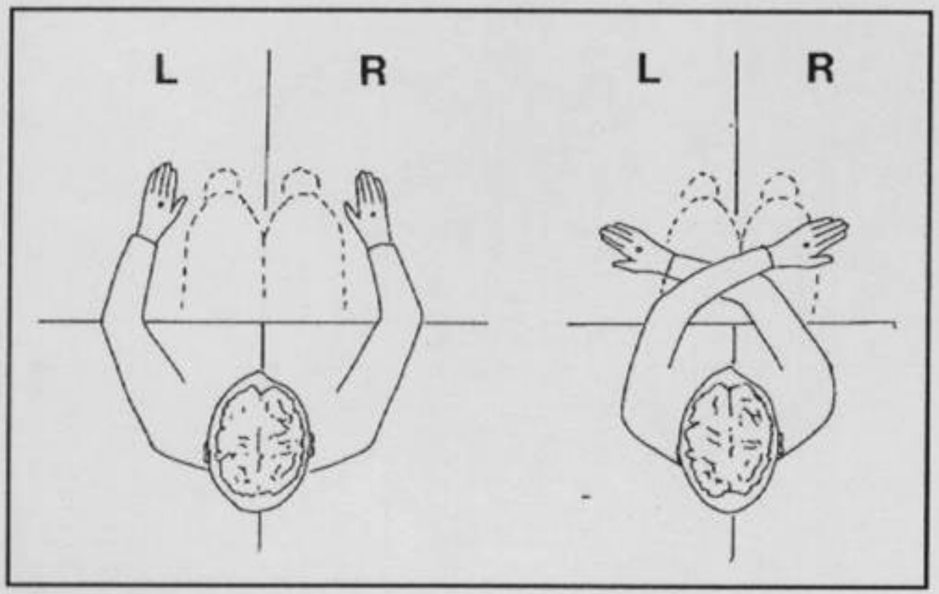


Figure 1. Schematic drawing of patients' position in the two experimental tasks. The small circles on the dorsum of the hands indicate the sites of stimulation. Letters L and R refer to patients' left and right hemispaces.

J Neurol Neurosurg Psychiatry 2004;**75**:13–21

SPAZIO EXTRAPERSONALE: neglect e disturbi della deambulazione

Neuropsychology
2002, Vol. 16, No. 3, 390–399

0894-4105/02/$5.00 DOI: 10.1037//0894-4105.16.3.390

Coding of Far and Near Space During Walking in Neglect Patients

Anna Berti
Università di Torino

Nicola Smania
Ospedale Borgoroma

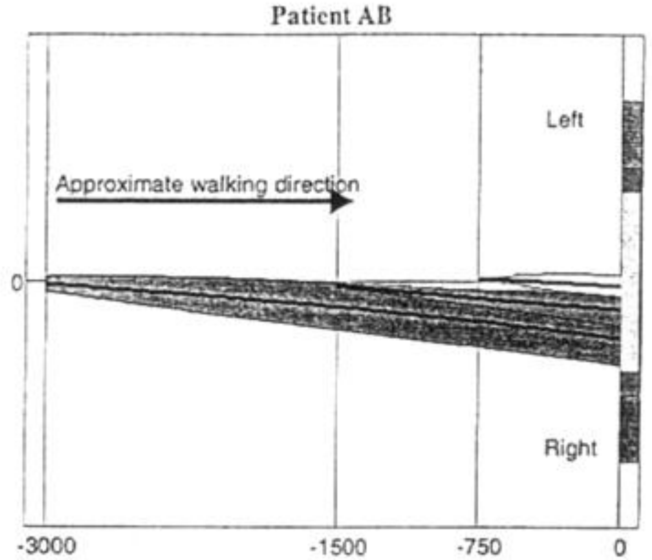


Figure 6. The average walking trajectories of Patient AB in the horizontal plane are shown. The graphical representation agrees with the previous plots about normal trajectories. The right bisection error is evident, particularly for the farthest starting point, along with the rectilinear shapes of the trajectories.

Deficits in Motor Control

Visual and posture coordination during "turning"

Gaze and Postural Reorientation in the Control of Locomotor Steering After Stroke

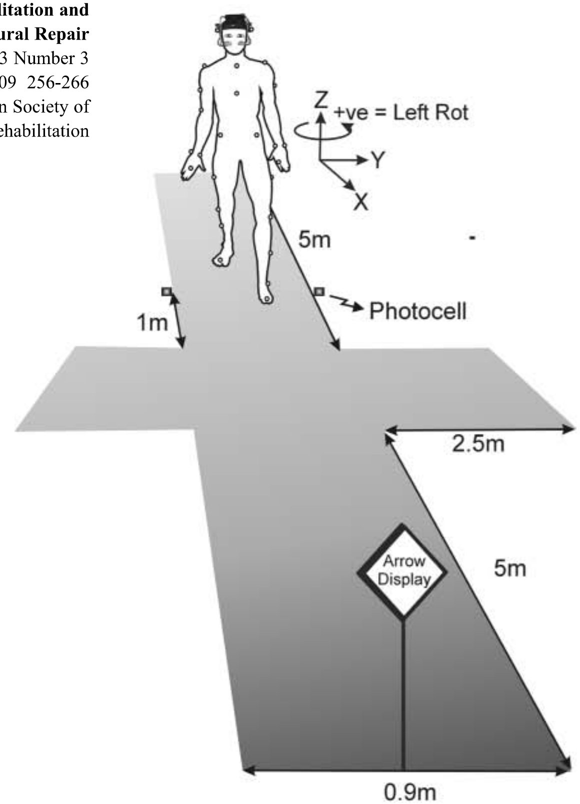
Anouk Lamontagne, PhD, PT, and Joyce Fung, PhD

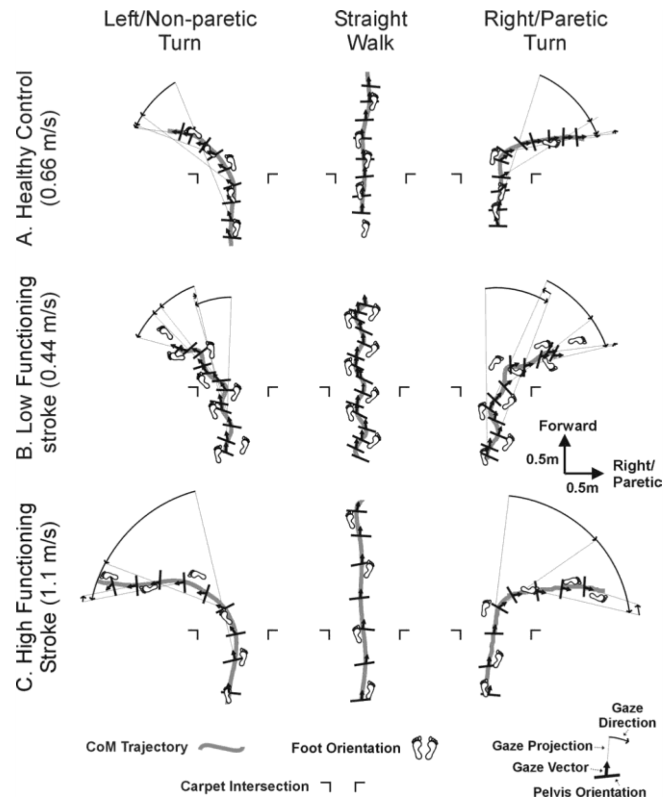
Stroke Affects the Coordination of Gaze and Posture During Preplanned Turns While Walking

Anouk Lamontagne, PhD, PT, Caroline Paquette, MSc, and Joyce Fung, PhD, PT

Neurorehabilitation and Neural Repair 21(1): 2007

Neurorehabilitation and Neural Repair
Volume 23 Number 3
March/April 2009 256-266



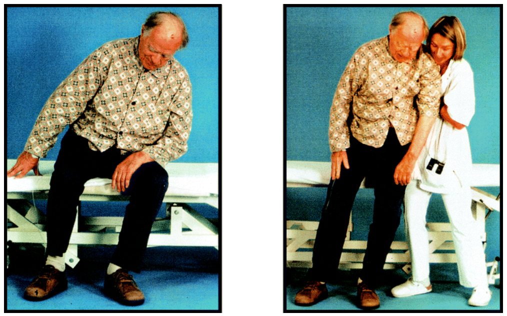


turning to the nonparetic side in 3 of the most severely disabled individuals. *Conclusion.* The results in this convenience sample of slow and faster walkers suggest that stroke alters the stabilizing and orienting behavior during steering of locomotion. Such alterations are not caused by the inherently slow walking speed, but rather by a combination of biomechanical factors and defective sensorimotor integration, including altered vestibulo-ocular reflexes.

STROKE: “Contraversive pushing”

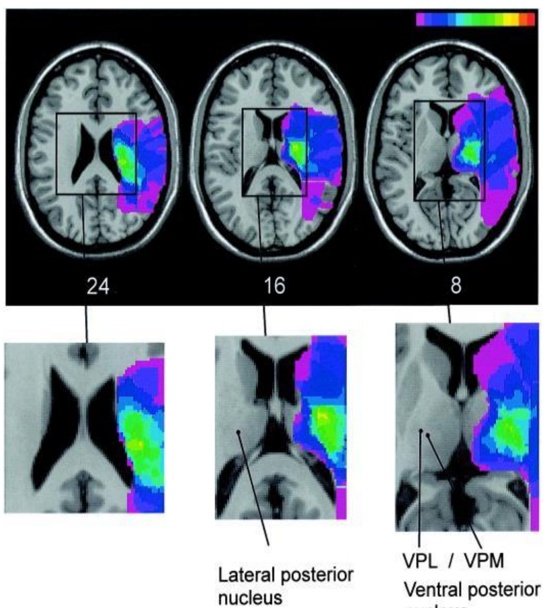
A clinical disorder in which a patient: *“pushes strongly towards the hemiplegic side in all positions and resists any attempt at passive correction of posture”*

Davies, 1985

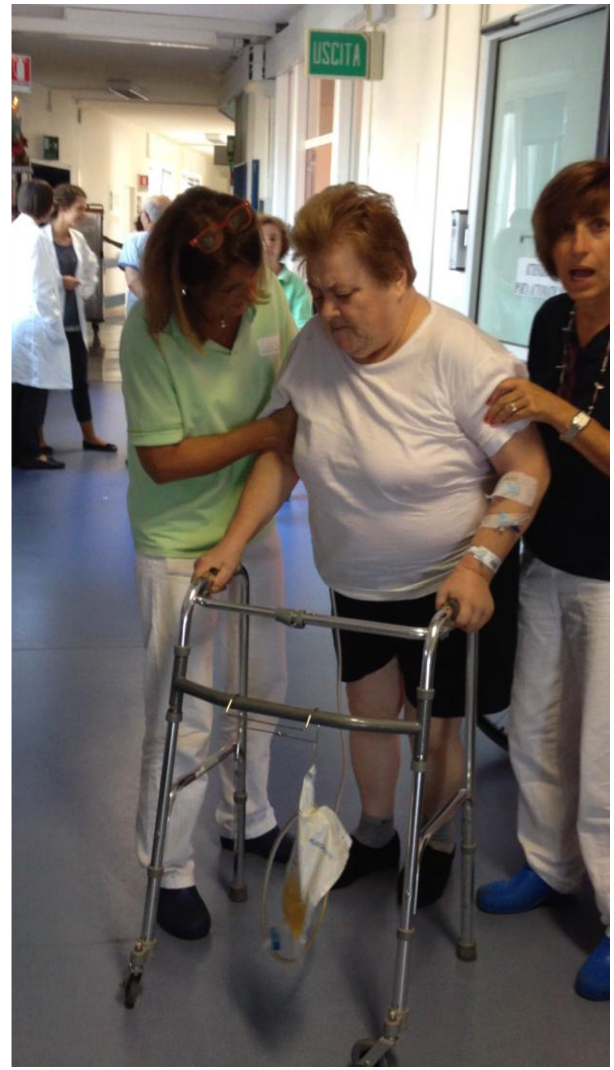


Karnath and Broetz, 2003

Lesioni



Karnath et al, 2000; Pedersen et al, 1996



Different Modalities of Motor Learning
Implicit and Explicit Motor Learning

Implicit learning refers to the learning of information without the ability to verbally describe the knowledge of what is learned.

- skill or experience-based (such as language learning and learning to ride a bicycle);
- **Learning-by-doing;**
- **Inaccessible to conscious awareness;**
- More efficient;
- Basal Ganglia;

It does NOT require a HIGH COGNITIVE LOAD

Explicit learning is related to the ability to describe verbally something that is being learned;

- It is rule-based;
- **Its contents can be expressed by verbal communication;**
- **It is tied to conscious awareness;**
- It forms a mental representation that includes actual information and knowledge that is being learning.
- Frontal lobe, Medial Temporal Lobe;

It requires a HIGH COGNITIVE LOAD

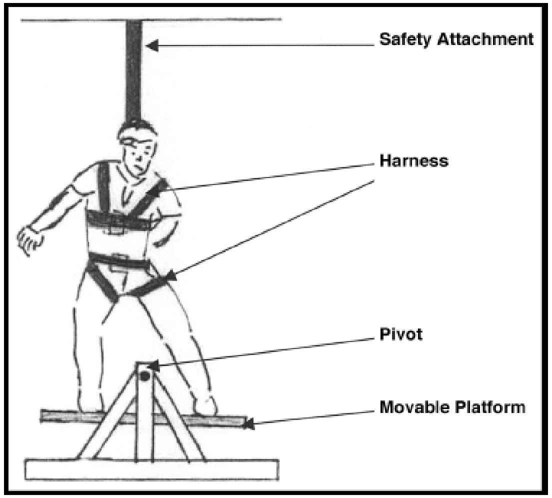
Dietrich A. *Consciousness and Cognition* .2004

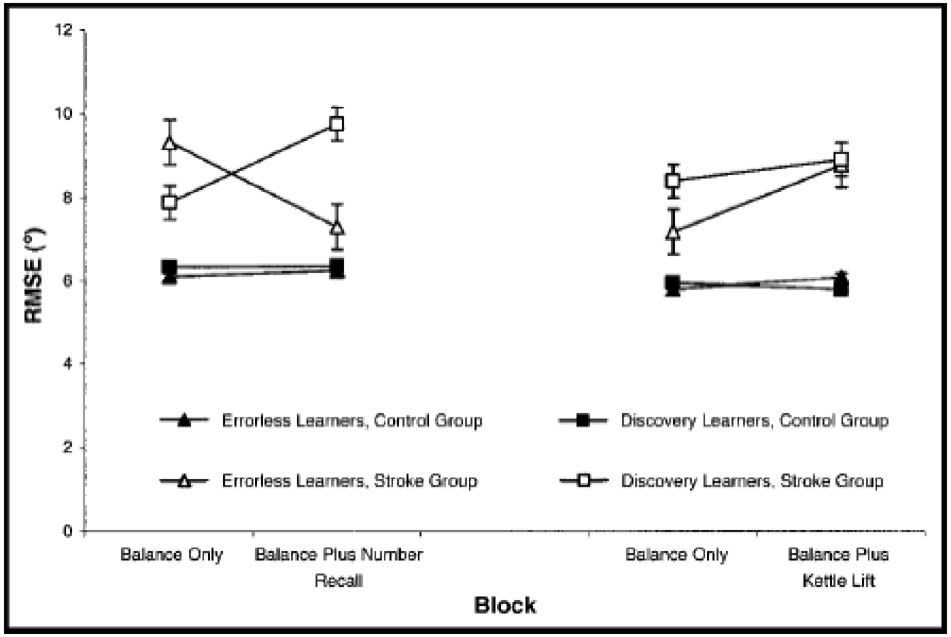
Different Modalities of Motor Learning
Implicit Motor Learning for the Balance Training

Alison J Orrell, Frank F Eves, Rich SW Masters

Motor Learning of a Dynamic Balancing Task After Stroke: Implicit Implications for Stroke Rehabilitation

Physical Therapy . Volume 86 . Number 3 . March 2006

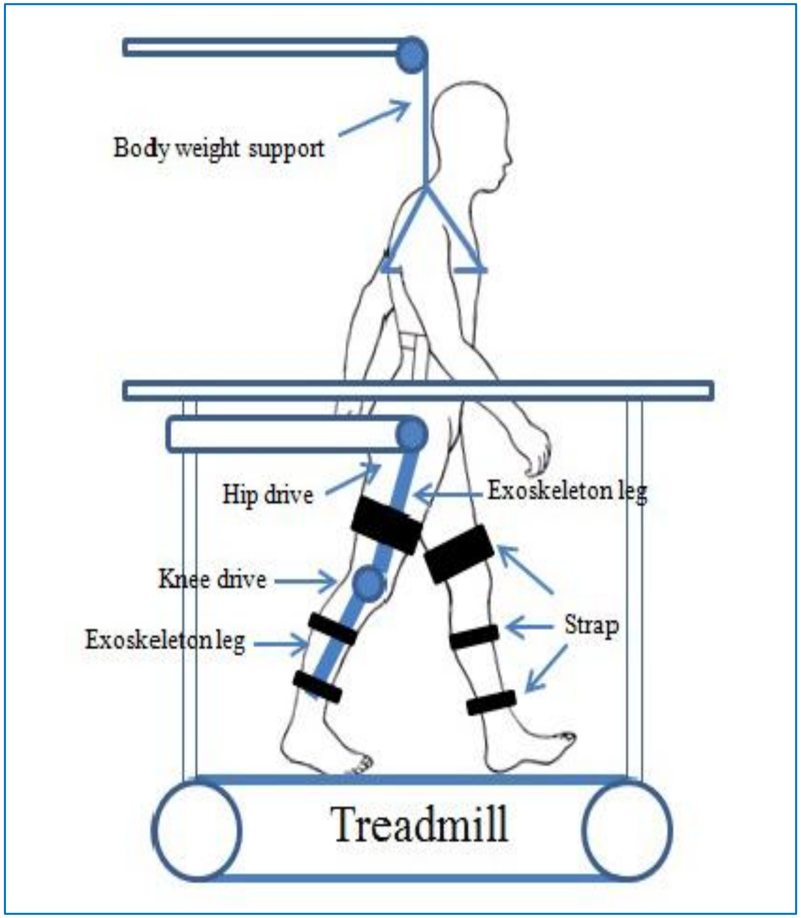




END-EFFECTORS AND EXOSKELETONS

Comparison of Exoskeleton Robots and End-Effector Robots on Training Methods and Gait Biomechanics

Pi-Ying Cheng, Po-Ying Lai*, *Member, IEEE,* Jiun-Ming Ye



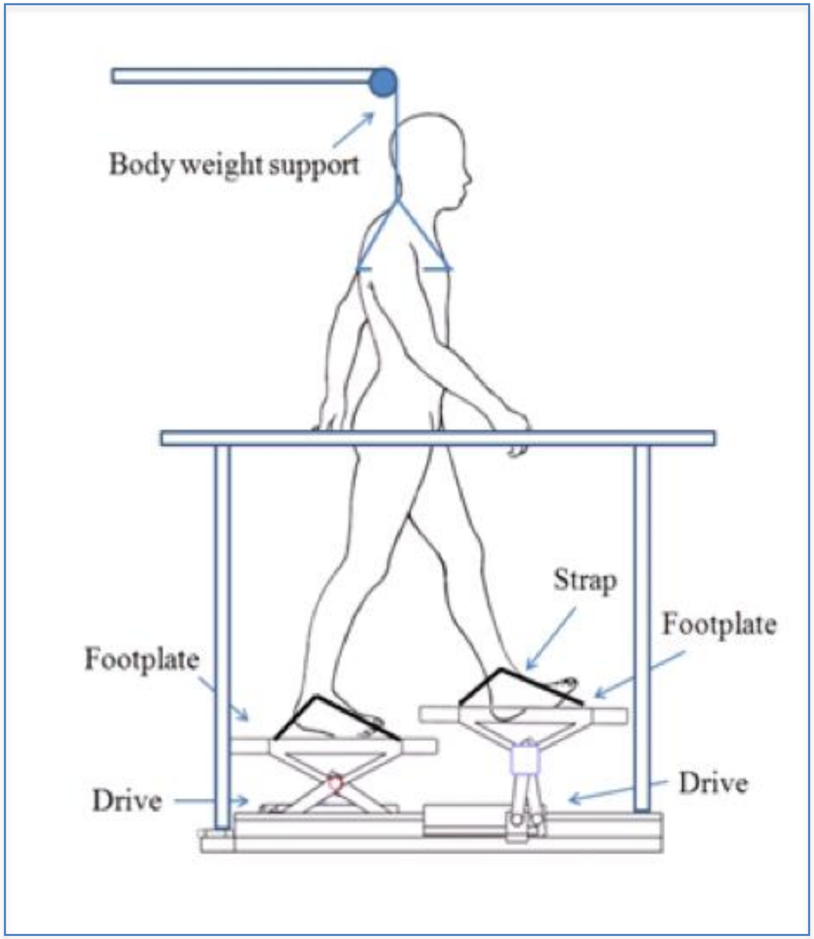
Exoskeletons

- Computer-controlled, actuated devices that **are worn by a person**
- Act in parallel to the human body
- Guide the lower limbs along **well-defined trajectories**
- Ensure precise **control of kinematics**
- Require a **precise correspondence** between the anatomical axes of the patient's joints and those of the robot

END-EFFECTORS AND EXOSKELETONS

Comparison of Exoskeleton Robots and End-Effector Robots on Training Methods and Gait Biomechanics

Pi-Ying Cheng, Po-Ying Lai*, *Member, IEEE,* Jiun-Ming Ye



End-effector devices

- Operational-type machines that restrict the **patient/machine interaction at the end-effector level** (limb attached at a distal point).
- The system designs for the end-effector trajectories **match the limbs' natural trajectory in space** for the required task.
- The **natural synergy** between end-effector and distal limb determines its functional arrangement.
- **They require more control from the patient (and from the PT)**

Stroke rehabilitation

Peter Langhorne, Julie Bernhardt, Gert Kwakkel

THE LANCET

Volume 377, Issue 9778, 14–20 May 2011, Pages 1693-1702

Beneficial or likely to be beneficial

Arm

- CIMT or modified CIMT for arm impairment and motor function;[10,49] selected use (A,B)
- Robot-assisted training for upper limb function;[10,50] selected use (A,B)

Leg

- Electromechanical-assisted gait training for walking;[10,51] selected use (B)
- Task-oriented physical fitness training for walking;[52–54] recommended (A)
- Cardiorespiratory fitness training for walking distance;[55] recommended (A)
- High-intensity therapy for gait recovery;[10,56] recommended (B)
- Repetitive task training for gait speed and transfers;[57] recommended (A,B)
- Speed-dependent treadmill training for gait speed and walking distance;[58] selected use (A,B)

- Promising interventions that could be beneficial to improve aspects of gait include fitness training, **high-intensity therapy**, and **repetitive-task training**
- Repetitive-task training might also improve **transfer functions**

END-EFFECTOR vs EXOSKELETON DEVICES AFTER STROKE

ELECTROMECHANICAL-ASSISTED GAIT TRAINING AFTER STROKE:
A SYSTEMATIC REVIEW COMPARING END-EFFECTOR AND EXOSKELETON DEVICES

Jan Mehrholz, PT, PhD and Marcus Pohl, MD

Objective:
to compare the effects of end-effector and exoskeleton devices used in electromechanical-assisted gait training after stroke in a systematic review with pooled analysis.

The following studies were included:

- over 18 years of age after stroke
- all randomized controlled trials that evaluated electromechanical and robotic-assisted gait training
- studies of automated electromechanical devices used in combination with FES

A **total of 18 trials**, involving **885 patients:**

- **7 trials** with a total of 428 patients used a **end-effector device**
- **11 trials** with a total of 457 patients used an **exoskeleton device**

The primary outcome:
was defined as **the ability to walk independently** at study end.

The ability to walk was measured with the Functional Ambulation Category **(FAC)**

END-EFFECTOR vs EXOSKELETON DEVICES

Mehrlholz et Pohl, 2012

RESULTS

Comparison 1:
Independent walking at the end of intervention phase, comparison between electromechanical devices used

- In the **end-effector subgroup** the test for an overall effect for achieving independent walking was **statistically significant** (***p*** **= 0.003**)
- In the **exoskeleton subgroup** the test for an overall effect was **not significant** (*p* = 0.41).
- The **subgroup comparison** between end-effector and exoskeleton subgroup showed **statistically significant differences** (***p*** **= 0.03**).

Comparison 2:
Acceptability of devices during the intervention phase, comparison between electromechanical devices used

- The calculated **risk differences for drop-out** during intervention phase were **not statistically significant** (*p* = 0.17)
- The subgroup comparison showed **no statistically significant risk differences** between the device groups for dropout during intervention phase (p=0.30)
- In both the end-effector subgroup and the exoskeleton subgroup **the risk of adverse and complications were rare.**

PM R 9 (2017) 839-846

www.pmrjournal.org

Original Research—CME

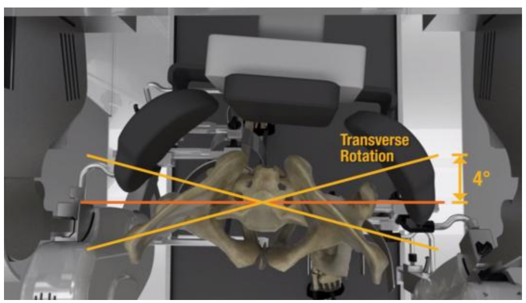
A Comparison of Locomotor Therapy Interventions: Partial-Body Weight—Supported Treadmill, Lokomat, and G-EO Training in People With Traumatic Brain Injury

Alberto Esquenazi, MD, Stella Lee, MPA, Amanda Wikoff, BS, Andrew Packel, MSPT, Theresa Toczylowski, MPT, John Feeley, PT

Conclusions: Locomotor therapy using G-EO, Lokomat, or PBWSTT in individuals with chronic TBI increased SSV and MV without significant changes in gait symmetry. Staffing needed for therapy provision was the least for the Lokomat. A larger study may further elucidate changes in gait symmetry and other training parameters.

FreeD module for pelvic displacement in robot-assisted gait training in the early stages of stroke: a pilot, randomized crossover clinical trial.

P. Burghouwt , A. Mayr , C. Geroin , M. Gandolfi , N. Smania , L. Saltuari



Background. Lateral pelvic displacement(LPD) is an essential characteristic of human walking and results atypical in terms of amplitude and symmetry in stroke patients. Lokomat with FreeD-module(FreeD) is an innovative device conceptualized to enable patients to walk with a more physiological LPD.

Aims: To compare the effects of FreeD over Lokomat without module(LK) in improving gait independence, mobility and body-weight asymmetry in acute stroke patients.

Methods: FreeD and LK were tested using a randomized crossover design in 12 patients. All patients received fifteen 50-minute treatment sessions, five days a week, for three consecutive weeks of each intervention. Patients were pre-and-post treatment with the following outcomes: Functional Ambulation Category(primary) and Tinetti Scale, weight-bearing asymmetry using Tymo and Verbal Rating Scale(secondary).

Results: Between groups comparisons showed no significant differences on primary and secondary outcome measures over time. Within group comparisons showed significant improvements in LK and FreeD group on the Functional Ambulation Category (P=.046;P=.038) and Tinetti Scale (P=.008;P=.006) respectively. A small, but not significant improvement in absolute weight bearing (3.6%) was found in standing position after FreeD.

Lokomat improves gait independence and mobility in the **early stages of stroke**.
Further studies are needed to explore the additional effect of FreeD in improving weight-bearing asymmetry.

G-EO

Innovative gait robot for the repetitive practice of floor walking and stair climbing up and down in stroke patients

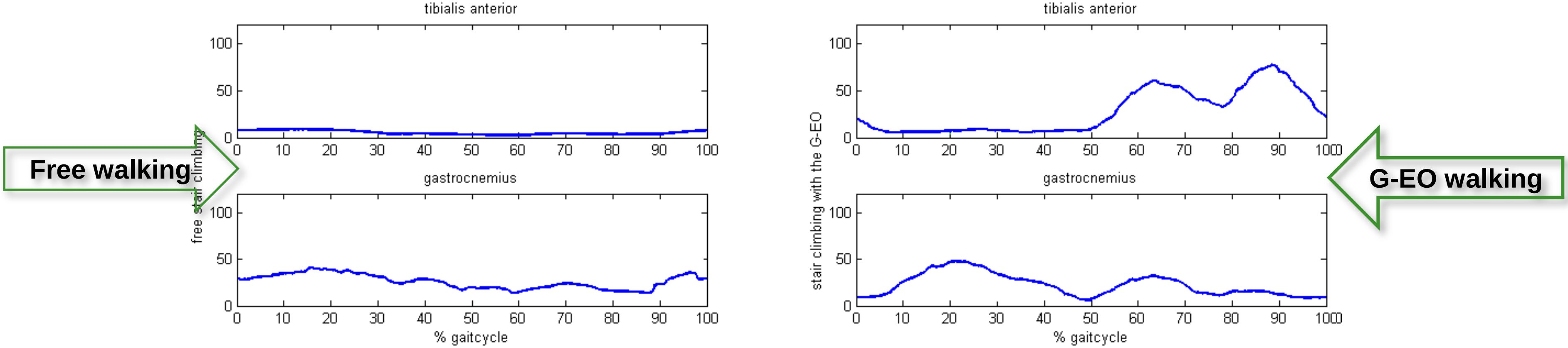
Hesse S, Waldner A, Tomelleri C, J Neuroeng Rehabil. 2010 Jun 28;7:30.

Correct induction of an physiological gait pattern

EMG analysis on ambulatory stroke patients:

Floor walking condition:

•Mm. vastus medialis and lateralis were comparable during both conditions
•Mm. tibialis anterior muscle was silent in both conditions
•Mm. gastrocnemius was tonic during real walking and phasic during simulated walking



Stair climbing condition:

•Thigh muscles were comparable during both conditions
•In 3 out of 6 patients the tibialis anterior muscle was activated timely correct
•Mm. gastrocnemius became more phasic.

CLINICAL REHABILITATION

Clinical Rehabilitation
25(6) 537–548

DOI: 10.1177/0269215510389497
cre.sagepub.com
SAGE

Stroke

Combined transcranial direct current stimulation and robot-assisted gait training in patients with chronic stroke: a preliminary comparison

Christian Geroin[1], Alessandro Picelli[1], Daniele Munari[1], Andreas Waldner[2,3], Christopher Tomelleri[2] and Nicola Smania[1,4]

Results:

- **No differences were found between groups 1 and 2** for all primary outcome measures at the after treatment and follow-up evaluations.

- A **statistically significant improvement** was found after treatment in performance on the **6MWT and the 10MWT in favour of group 1** (6MWT: 205.2061.16 m; 10MWT: 16.207.65 s) and group 2 (6MWT: 182.569.30 m; 10MWT: 17.718.20 s) compared with group 3 (6MWT : 116.3075.40 m; 10MWT: 26.3014.10 s).

- All improvements were **maintained at the follow-up** evaluation.

Conclusions:

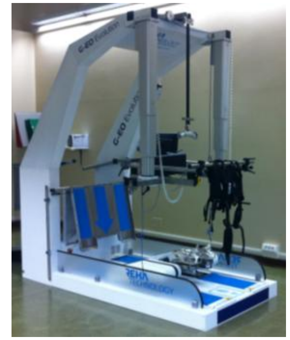
- In the present pilot study transcranial direct current stimulation had **no additional effect on robot-assisted gait training** in patients with chronic stroke.
- Larger studies are required to confirm these preliminary findings.

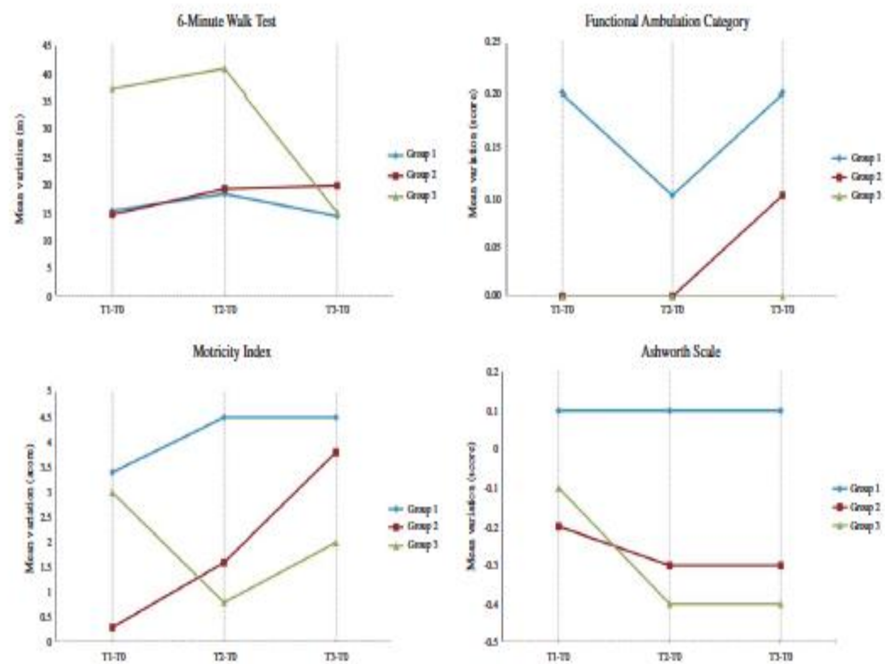
Restorative Neurology and Neuroscience 33 (2015) 357–368
DOI 10.3233/RNN-140474
IOS Press

Stroke

Combined effects of transcranial direct current stimulation (tDCS) and transcutaneous spinal direct current stimulation (tsDCS) on robot-assisted gait training in patients with chronic stroke: A pilot, double blind, randomized controlled trial

Alessandro Picelli[a], Elena Chemello[a], Paola Castellazzi[a], Laura Roncari[a], Andreas Waldner[b], Leopold Saltuari[c,d] and Nicola Smania[a,e,*]





Results:

Significant differences in the 6MWT distance were noted between group 3 and group 1 at the post-treatment and 2-week follow-up evaluations (post-treatment P = 0.015; 2-week follow-up P = 0.001) and between group 3 and group 2 (post-treatment P = 0.010; 2-week follow-up P = 0.015).

No difference was found between group 2 and group 1.

Conclusions:

Our preliminary findings support the hypothesis that **anodal (cerebral) tDCS combined with cathodal (spinal) tsDCS may be useful to improve** the effects of robotic gait training in chronic stroke.

Stroke

EFFETTI DELLA STIMOLAZIONE ELETTRICA TRANSCRANICA A CORRENTE CONTINUA DIRETTA ASSOCIATA ALLA RIABILITAZIONE ROBOTICA SUI DISTURBI SENSO-MOTORI DELL'ARTO SUPERIORE: STUDIO RANDOMIZZATO CONTROLLATO IN PAZIENTI AFFETTI DA ICTUS CEREBRALE

CRRNC Centro di Ricerca in Riabilitazione Neuromotoria e Cognitiva

Modenese A, Gandolfi M, Roncari L, Waldner A, Geroin C, Picelli A, Di Matteo A, Munari D, Ianes P, Smania N.

Valutati per l'arruolamento: 23 soggetti

Esclusi: 2 soggetti

Arruolati: 21 soggetti

Gruppo Sperimentale: 10 soggetti

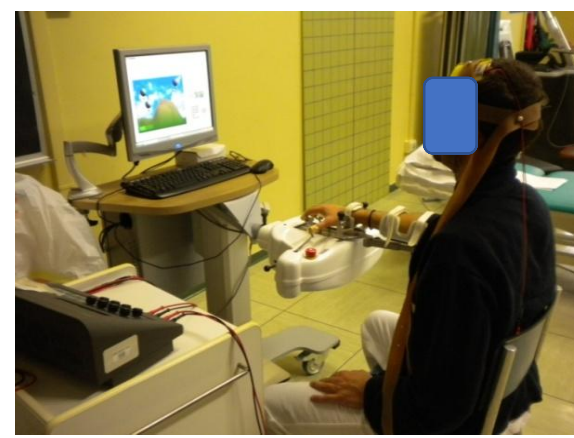
Gruppo di Controllo: 11 soggetti

Analizzati: 10 soggetti

Analizzati: 10 soggetti (1 drop-out)

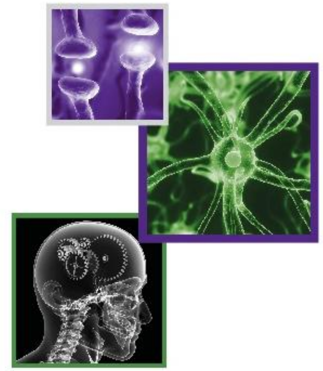
Gruppo sperimentale:
Durante il trattamento con AMADEO® è stato associato l'utilizzo di **tDCS *real*** (anodica)
ANODO: C3 o C4 corrispondenti alla corteccia motoria primaria M1
CATODO: sulla regione sopraorbitaria controlaterale
20 minuti, 1 mA

Gruppo di controllo:
Durante il trattamento con AMADEO® è stato associato l'utilizzo di **tDCS *sham***
applicata con dispositivo erogante corrente in modalità OFF



Entrambi i gruppi hanno mostrato dopo il trattamento e al follow-up miglioramenti statisticamente significativi in tutte le misure di outcome.

Parkinson Disease



Robot-assisted gait training in patients with Parkinson's disease

Nicola Smania*[1,2], Alessandro Picelli[1], Christian Geroin[1], Daniele Munari[1], Andreas Waldner[3] & Marialuisa Gandolfi[1,2]

Practice Points

- Robot-assisted gait training (RAGT) is effective in improving gait speed, endurance, stride length, leg agility and freezing of gait, as well as in improving balance ability, the level of confidence perceived while performing daily activities and the quality of life of patients with Parkinson's disease (PD).
- Four mechanisms may be advocated in order to support the effects of RAGT in patients with Parkinson's disease: providing external proprioceptive cues; enhancing the automatic spinal control of locomotion; improving postural control during walking; and promoting reconditioning and muscle strengthening of the lower limbs.
- Patients with different levels of impairment may benefit from different types of devices for gait training; RAGT would be more useful in patients with severe impairment (Hoehn and Yahr stage >3), whereas treadmill training and conventional physiotherapy would be more useful in patients with mild-to-moderate impairment (Hoehn and Yahr stage <3).
- Up to now, there has been no consensus about the most effective RAGT protocol in terms of duration, frequency and intensity of therapy, and percentage of bodyweight support. Nevertheless, a frequency of 3 days a week over a 4-week period has been seen in clinical practice to be a well-tolerated protocol in both moderate and severe stages of PD.
- Future research is required in order to compare the effects of different RAGT devices, to address specific training protocols and to evaluate changes in cortical hyperexcitability induced by treatment.
- Finally, an estimate of costs (or savings) due to RAGT in patients with PD should be evaluated.

10.2217/NMT.13.34 © 2013 Future Medicine Ltd *Neurodegen. Dis. Manage.* (2013) 3(4), 321–330 ISSN 1758-2024

Parkinson Disease

Parkinsonism and Related Disorders 18 (2012) 990–993

Short communication

Does robotic gait training improve balance in Parkinson's disease? A randomized controlled trial

Alessandro Picelli [a,b], Camilla Melotti [a], Francesca Origano [a], Andreas Waldner [c], Raffaele Gimigliano [d], Nicola Smania [a,e,*]

Thirty-four patients with PD at Hoehn & Yahr stage 3-4 were randomly assigned into two groups.
All patients received twelve, 40-min treatment sessions, three days/week, for four consecutive weeks.

Treatment effects in all outcome measures.

	Group	Before mean (SD)	After mean (SD)	Follow-up mean (SD)	95% confidence interval		Between group comparisons		Effect size	
					After – before LB; UB	Follow-up – before LB; UB	After/before difference value (*Z*)	Follow-up/before difference *p* value (*Z*)	After	Follow-up
BBS (0–56)	RT	37.88 (3.38)	43.44 (2.73)	42.31 (2.75)	4.28; 6.83	3.02; 5.85	<0.001 (−4.485)*	<0.001 (−4.053)*	0.57	0.51
	PT	37.33 (4.25)	37.27 (5.68)	37.60 (4.84)	−1.72; 1.58	−0.41; 0.94				
Nutt's rating (0–3)	RT	2.13 (0.50)	1.38 (0.50)	1.31 (0.48)	−0.98; −0.51	−1.02; −0.59	0.001 (−3.421)*	0.002 (−3.036)*	−0.53	−0.46
	PT	2.13 (0.64)	2.07 (0.59)	1.93 (0.70)	−0.32; 0.18	−0.57; 0.17				
ABC scale (0–100)	RT	55.72 (8.57)	62.31 (9.16)	62.13 (10.96)	4.54; 8.62	2.01; 10.80	<0.001 (−3.882)*	0.001 (−3.362)*	0.24	0.25
	PT	56.67 (10.18)	57.33 (10.72)	56.46 (10.70)	−0.63; 1.96	−2.64; 2.24				
TUG test (s)	RT	13.04 (1.79)	11.60 (1.37)	11.48 (1.54)	−1.96; −0.91	−2.04; −1.06	<0.001 (−4.092)*	<0.001 (−4.132)*	−0.27	−0.27
	PT	13.67 (6.00)	14.16 (6.32)	13.89 (5.80)	−0.49; 1.02	−0.32; 0.76				
10 MWT (s)	RT	12.94 (1.99)	11.48 (1.62)	11.72 (1.81)	−1.77; −1.15	−1.53; −0.91	0.001 (−3.480)*	0.001 (−3.321)*	−0.07	−0.04
	PT	12.28 (4.77)	12.03 (4.94)	12.04 (4.39)	−1.15; 0.50	−1.08; 0.46				
UPDRS part III (0–108)	RT	46.31 (6.65)	40.00 (6.53)	39.69 (6.93)	−7.61; −5.01	−8.10; −5.14	<0.001 (−4.725)*	<0.001 (−4.732)*	−0.46	−0.46
	PT	47.20 (7.93)	47.33 (7.50)	47.27 (7.60)	−0.64; 0.91	−0.57; 0.71				

Abbreviations: SD, standard deviation; LB, lower bound; UB, upper bound; RT, robotic training; PT, Physical Therapy, BBS, Berg Balance scale; ABC, Activities-Specific Balance Confidence; s, seconds; TUG, Timed Up & Go; 10 MWT, Ten-Meter Walk Test; UPDRS, Unified Parkinson's Disease Rating scale.
* = statistically significant ($p < 0.05$).

!

Robot-assisted gait training may **improve postural instability** in patients with PD at **Hoehn & Yahr stage 3-4.**

Parkinson Disease

Robot-assisted gait training is not superior to balance training for improving postural instability in patients with mild to moderate Parkinson's disease: a single-blind randomized controlled trial

Alessandro Picelli, Camilla Melotti, Francesca Origano, Roberta Neri, Elisa Verzè, Marialuisa Gandolfi, Andreas Waldner and Nicola Smania

- RCT, 66 patients with Parkinson's disease at Hoehn and Yahr Stage 3.
- Intervention: 12, 45-minute treatment sessions (3 days a week, 4 weeks).
- EG: Robot-assisted gait training with progressive gait speed and WBS decreasing.
- CG: balance training aimed at improving postural reactions (Smania et al. NNR 2010).

Table 2. Within-group comparisons of treatment effects in all outcome measures.

	Group	Before	After	Follow-up	Within-group comparisons	
					After–before mean difference ± SD (95% CI)	Follow-up–before mean difference ± SD (95% CI)
BBS (0–56) median (IQR)	RGT	48.00 (43.00; 51.00)	53.00 (49.00; 54.00)	51.00 (50.00; 54.00)	4.82 ±2.36 (3.98; 5.66)*	4.27 ±2.72 (3.31; 5.24)*
	BT	47.00 (45.00; 49.00)	52.00 (49.00; 54.00)	52.00 (50.00; 54.00)	4.48 ±2.97 (3.43; 5.54)*	4.30 ±3.79 (2.96; 5.65)*
ABC (0–100) median (IQR)	RGT	68.75 (58.75; 77.50)	73.75 (63.44; 82.25)	76.25 (64.06; 82.38)	4.63 ±6.95 (3.43; 5.54)*	5.03 ±8.91 (2.96; 5.65)*
	BT	66.25 (56.25; 72.50)	71.25 (61.25; 80.31)	70.63 (60.62; 82.50)	6.18 ±7.47 (3.53; 8.83)*	6.31 ±12.26 (1.96; 10.65)*
TUG (s) mean (SD)	RGT	11.61 (4.57)	10.65 (3.55)	10.77 (3.96)	–0.95 ±1.74 (–1.57; –0.34)*	–0.84 ±1.57 (–1.39; –0.28)*
	BT	12.11 (4.47)	10.83 (3.52)	10.96 (3.97)	–1.28 ±1.71 (–1.89; –0.68)*	–1.15 ±1.40 (–1.65; –0.66)*
UPDRS III (0–108) median (IQR)	RGT	38.00 (32.00; 43.00)	32.00 (26.00; 38.00)	33.00 (26.00; 38.00)	–4.48 ±2.92 (–5.52; –3.45)*	–4.73 ±2.80 (–5.72; –3.74)*
	BT	40.00 (35.00; 42.00)	35.00 (29.00; 39.00)	35.00 (30.00; 40.00)	–4.35 ±5.86 (–6.41; –2.26)*	–4.73 ±5.71 (–6.75; –2.70)*

ABC: Activities-Specific Balance Confidence Scale; BBS: Berg Balance Scale; BT: balance training; CI: confidence interval; IQR: inter quartile range; RGT: robotic gait training; SD: standard deviation; TUG: Timed Up and Go Test; s: seconds; UPDRS: Unified Parkinson's Disease Rating Scale.
*Statistically significant after Bonferroni correction ($P < 0.016$).

Our findings indicate that robotic gait training is not superior to balance training for improving postural instability in patients with mild to moderate Parkinson's disease.

SHORT REPORT **Open Access**

Robot-assisted arm training in patients with Parkinson's disease: a pilot study

Alessandro Picelli[1], Stefano Tamburin[2], Michele Passuello[3], Andreas Waldner[4] and Nicola Smania[1,5]*

JOURNAL OF NEUROENGINEERING AND REHABILITATION

Parkinson Disease

Figure 1 Robot-assisted arm training.

- 10 patients with Parkinson's disease at Hoehn and Yahr Stage of 2.5 to3.
- Intervention: 45-minute treatment sessions (5 days a week, 2 weeks).
- Robot-assisted arm training performed with Bi-Manu-Track (computer-controlled, repetitive, bilateral, mirror-like practice of forearm pronation/supination and

Outcome measures:

- Nine-hole peg test (NHPT)
- Fugl-Meyer assessment (FM)
- Unified Parkinson's Desease Rating Scale (UPDRS)

Table 2 Treatment effects in all outcome measures

Outcomes	Comparisons			95% Confidence interval		
	Wilcoxon signed ranks test			(Effect size)		
	T1 vs. T0	T2 vs. T0	T2 vs. T1	T1 vs. T0	T2 vs. T0	T2 vs. T1
	P value (Z)	*P* value (Z)	*P* value (Z)	(*r*)	(*r*)	(*r*)
Nine-hole peg test (s)	0.007 (−2.701)*	0.007 (−2.701)*	0.359 (−0.918)	1.90 to 4.78 (−0.60)	1.73 to 4.34 (−0.53)	−1.07 to 0.47 (0.08)
Fugl-Meyer assessment (0–66)	0.012 (−2.527)*	0.018 (−2.371)	0.606 (−0.516)	−6.31 to −1.28 (0.45)	−5.53 to −1.26 (0.41)	−1.62 to 2.42 (−0.07)
UPDRS motor examination (0–108)	0.097 (−1.658)	0.174 (−1.358)	0.334 (−0.966)	−0.34 to 2.54 (−0.14)	−0.40 to 2.00 (−0.11)	−1.05 to 0.45 (0.04)
UPDRS total (0–176)	0.046 (−1.995)	0.037 (−2.082)	0.813 (−0.214)	0.26 to 6.73 (−0.20)	0.54 to 6.65 (−0.20)	−1.30 to 1.50 (−0.01)

Abbreviations: UPDRS Unified Parkinson's Disease Rating Scale.
* = statistically significant after Bonferroni correction ($P < 0.016$).

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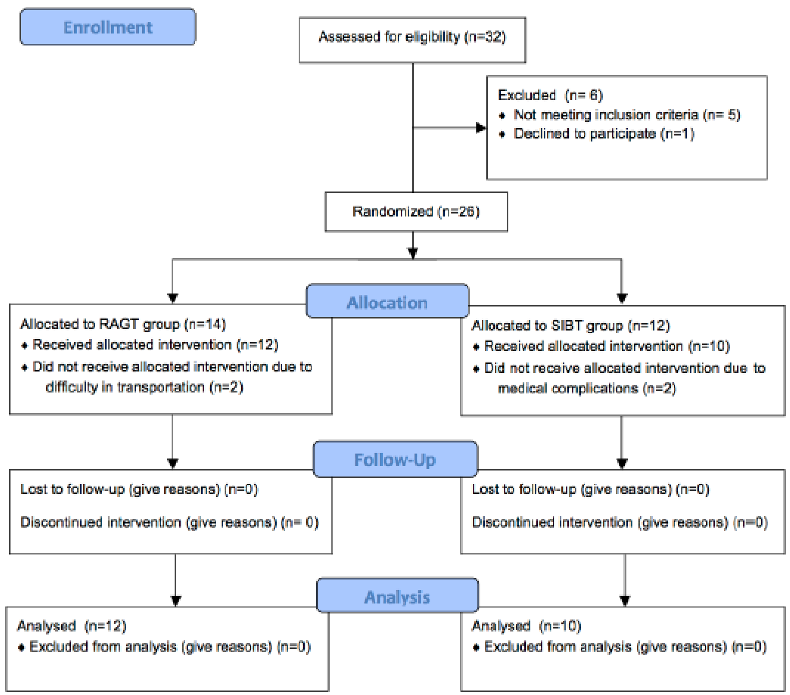
HUMAN NEUROSCIENCE
ORIGINAL RESEARCH ARTICLE
published: xx May 2014
doi: 10.3389/fnhum.2014.00318

Multiple Sclerosis

Robot-assisted vs. sensory integration training in treating gait and balance dysfunctions in patients with multiple sclerosis: a randomized controlled trial

*Marialuisa Gandolfi[1], Christian Geroin[1], Alessandro Picelli[1], Daniele Munari[1], Andreas Waldner[2], Stefano Tamburin[3], Fabio Marchioretto[4] and Nicola Smania[1,5]**

The aim of this study was to compare the effectiveness of end-effector robot-assisted gait training (RAGT) and sensory integration balance training (SIBT) in improving walking and balance performance in patients with MS.



Twenty-two patients with MS (EDSS: 1.5-6.5)

- **The RAGT group** (n= 12): end-effector system training.
- **The SIBT group** (n=10): specific balance exercises.
- Treatment: 12 50-minutes treatment sessions (2 days/week).

Evaluations: before, after, at 1 month
Primary outcomes: walking speed, Berg Balance Scale.
Secondary outcomes: Activities-specific Balance Confidence Scale, Sensory Organization Balance Test, Stabilometric Assessment, Fatigue Severity Scale, gait S/T parameters, Multiple Sclerosis Quality of Life-54.

In press

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HUMAN NEUROSCIENCE

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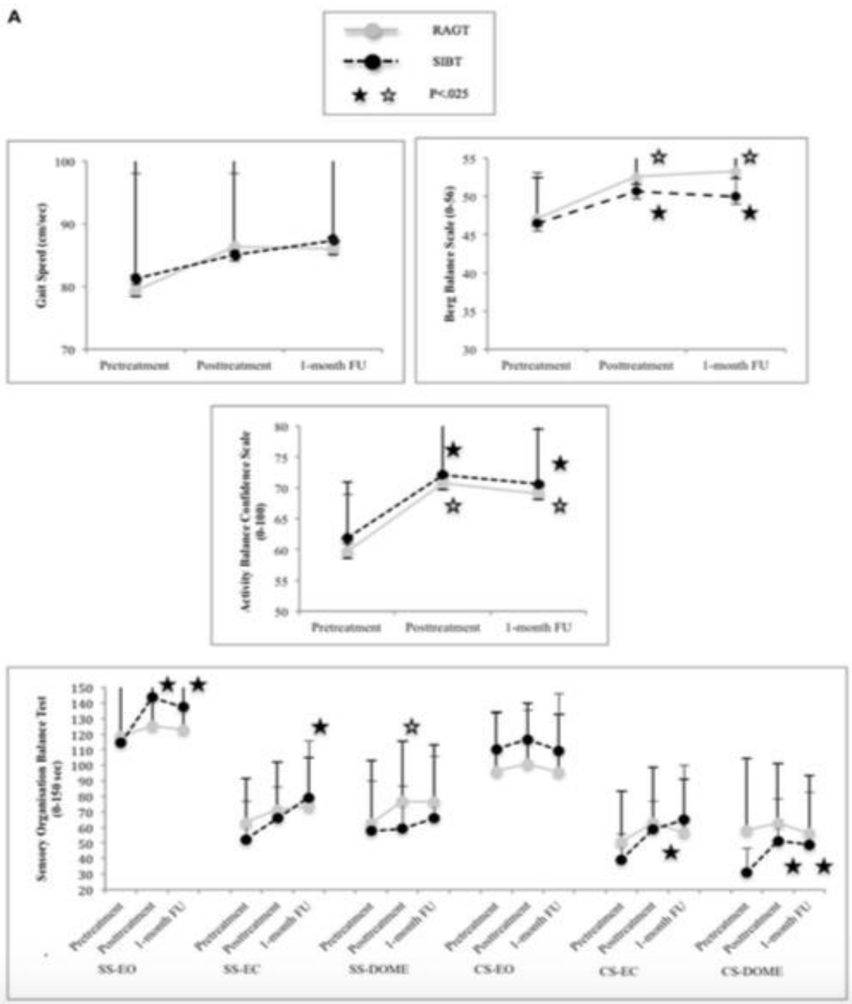


Risultati:
Within-group comparison showed:

- **The RAGT group**: significant changes on gait speed and on BSS over time
- **The SIBT group**: significant changes only on BSS

Electroencephalographic Changes of Brain Oscillatory Activity After Upper Limb Somatic Sensation Training in a Patient With Somatosensory Deficit After Stroke

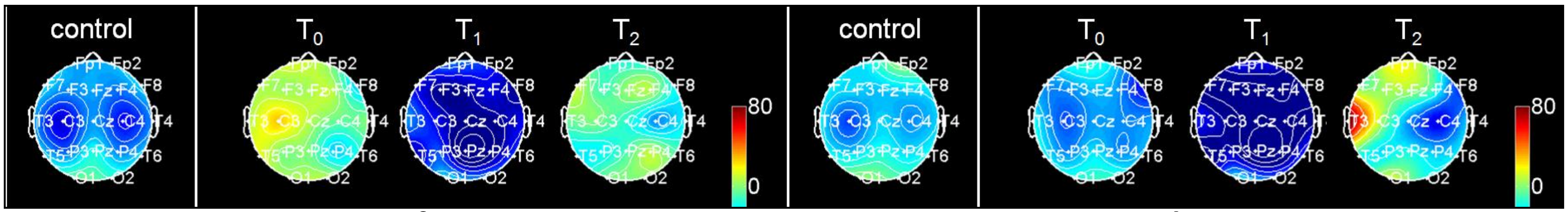
Clinical EEG and Neuroscience
1–6

DOI: 10.1177/1550059414536895
eeg.sagepub.com
SAGE

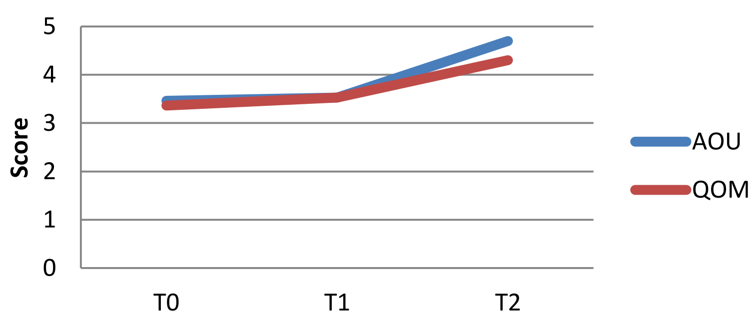
Marialuisa Gandolfi, PhD[1,2], Emanuela Formaggio, PhD[3], Christian Geroin, PT[1,2], Silvia Francesca Storti, PhD[2], Ilaria Boscolo Galazzo, PhD[2], Andreas Waldner, MD[4], Paolo Manganotti, PhD[2,3], and Nicola Smania, MD[1,2]

Alpha band **Active movements** Beta band

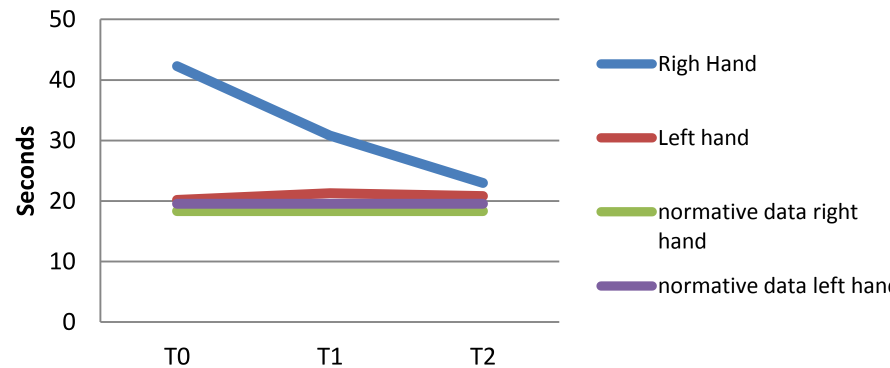
Right hand



Motor Activity Log performance (Score: 0-5*)



Nine Hole Peg Test



HUMAN-ROBOT INTERACTION

Cognitive Interaction

RESEARCH Open Access

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

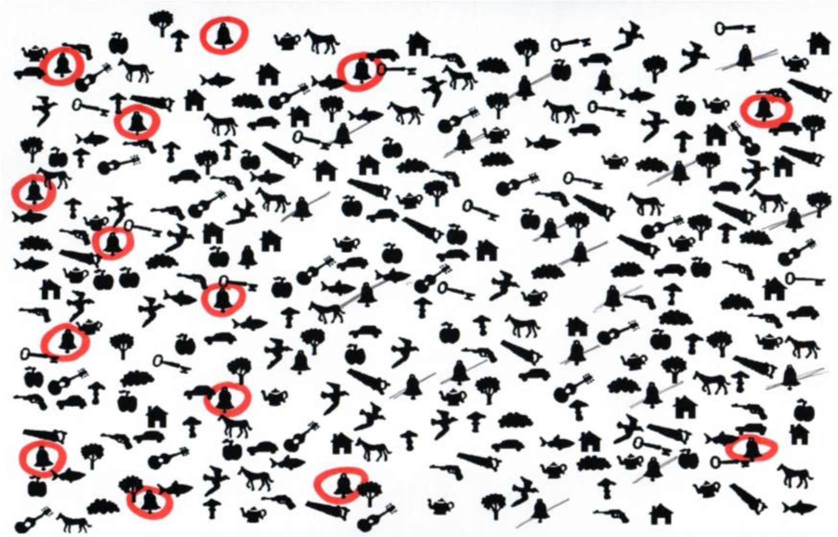
Valentina Varalta[1], Alessandro Picelli[1], Cristina Fonte[1], Giulia Montemezzi[1], Elisabetta La Marchina[1] and Nicola Smania[1,2*]

Objective:

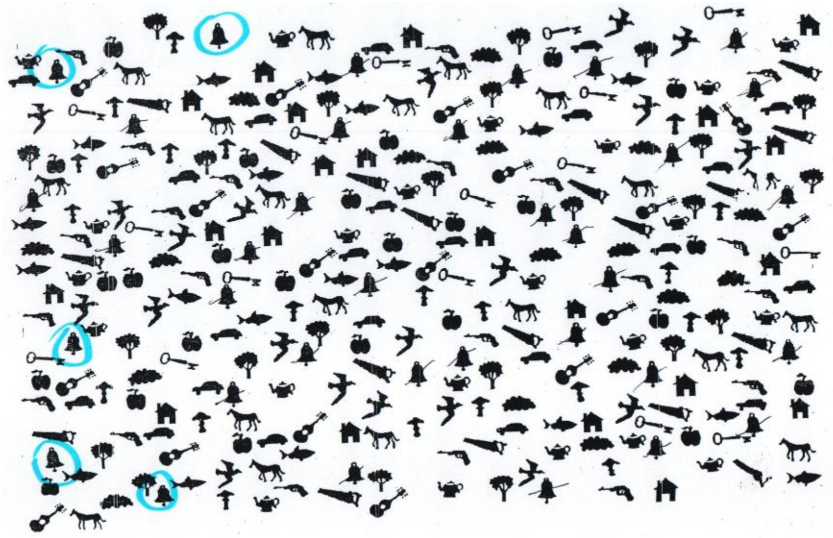
to determine whether **robot-assisted** left (contralesional) **hand activation** alone could
lead to **an improvement in hemispatial neglect** following stroke.

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

pre-trattamento



post-trattamento

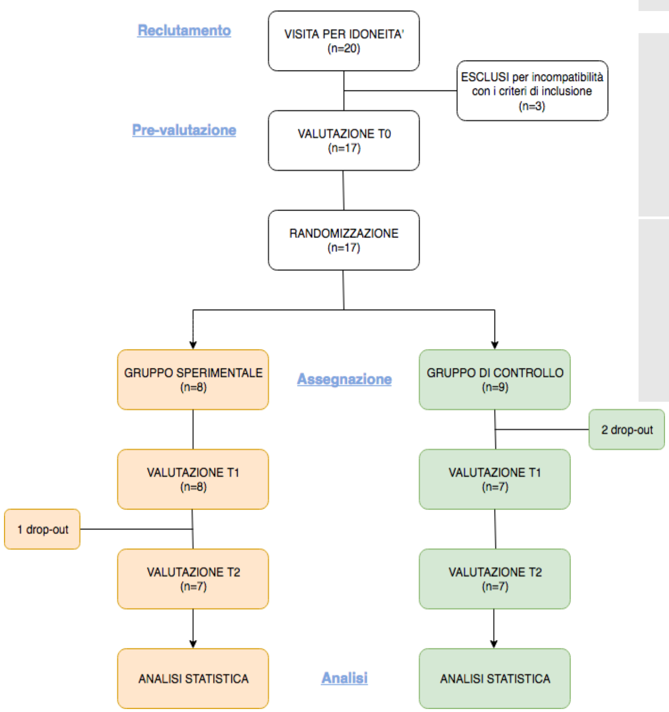


CONCLUSIONS

- Some caution is warranted when interpreting our results, as the responses to the intervention were variable and might have been due to a placebo effect or fluctuating clinical conditions.
- However, **robot-assisted hemispatial neglect therapy** might be useful in stroke patients.
- Larger-scale investigations are needed to confirm our preliminary findings.

GLI EFFETTI DI UN TRATTAMENTO ROBOTICO ASSOCIATO A REALTA' VIRTUALE SUL CAMMINO E SULLE FUNZIONI COGNITIVE IN PAZIENTI CON SCLEROSI MULTIPLA: STUDIO PILOTA RANDOMIZZATO CONTROLLATO

	Gruppo	Pre-trattamento	Post-Trattamento	Follow-Up	Pre-trattamento vs Post-trattamento	Pre-trattamento vs Follow Up
		Media ± DS	Media ± DS	Media ± DS	p value (Z)	p value (Z)
BBS (0-56)	**GS**	40,88± 5,96	43,13± 5,25	43,86± 4,60	**0,028 (-2,203)**	0,088 (-1,706)
	GC	43,44± 4,72	44,43± 5,44	45,86± 5,81	0,713 (-0,368)	0,340 (-0,954)
MSQOL-P	GS	55,38± 19,81	57,98± 21,18	64,56± 12,65	0,324 (-0,986)	0,397 (-0,847)
	GC	45,04± 12,17	49,81± 12,95	49,03± 15,50	**0,027 (-2,207)**	0,237 (-1,183)
MSQOL-M	GS	67,81± 22,86	70,5±2 0,83	77,3±1 3,14	0,498 (-0,677)	0,290 (-1,057)
	GC	68,08± 7,73	69,92± 7,77	69,81± 9,86	0,248 (-1,156)	0,463 (-0,734)



Un allenamento di 12 sedute, eseguito con RAGT in combinazione ad una RV è un **trattamento sicuro e ben tollerato** da pazienti con SM

Dai risultati ottenuti emerge che un RAGT associato a RV può essere efficace in pazienti con SM in termini di **equilibrio** e di alcune componenti delle **funzioni esecutive**

Take home messages for robotic training

1. **In generale gli strumenti robotici per la deambulazione determinano un miglioramento pei parametri spazio-temporali della deambulazione**
2. **Non ci sono forti evidenze riguardo gli effetti della robotica nel training degli arti superiore**
3. **Importanza della "ripetizione" del movimento ed "intensità" del training**
4. **E' importante considerare le potenzialità delle nuove tecnologie alla luce delle conoscenze riguardo le differenze nel controllo motorio degli arti superiori ed inferiori**

1. **I sistemi robotici dovrebbero consentire anche l'effettuazione di:**
2. **Exercises stressing cognitive functions and visuo-motor coordination during walking (i.e.)**
   - Controlling a virtual environment during walking
   - Searching for a stationary or a moving object in the virtual scene during walking
3. **Balance training during walking or graduated stairs climbing**
   - By reducing the level of body weight support during walking
   - Stairs climbing *per se* stimulates balance control
4. **Training sensory integration capability**
   - Walking or stairs climbing training while blindfolded
   - Virtual scenes generating graduated sensory conflicts

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UNIVERSITÀ DEGLI STUDI DI VERONA

LA RIABILITAZIONE INTERDISCIPLINARE
della disabilità complessa
fra presente e futuro

24 novembre 2017
Centro congressi "Auditorium Monsignor Capretti"

Grazie per l’attenzione!