CESPEB Centro Studi sulla Storia del Pensiero Biomedico

società italiana di neuroetica e filosofia delle neuroscienze

S.I.R.N.
Società italiana di Riabilitazione Neurologica

HABILITA Hospitals & Research

NEUROETHICS WEEK 2019
Milano, 13-18 maggio 2019

La Riabilitazione robotica:
esoscheletri, protesi e organismi cibernetici

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Martedì 14 maggio 2019

REHABILITATION 2030 a call for action

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Dramatic shifts in the health and demographic profiles of populations are characterizing the 21st century. People are living longer and with disabling chronic conditions that impact on their functioning and well-being. Health systems are confronted with the responsibility of responding to these emerging challenges and health policies are placing increased emphasis on services targeted at increasing functioning, in addition to those that reduce mortality.

World Health Organization

WHO/NMH/NVI/17.3

1. *GBD 2015 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388:1545–602.*
2. *Chatterji S, Byles J, Cutler D, Seeman T, Verdes E. Health, functioning, and disability in older adults-present status and future trends. The Lancet. 2015;385(9967):563-75.*
3. *Taylor. RH. A perspective on medical robotics. Proceedings of the IEEE vol. 94 (9) Sept. 2006*
4. *Wolf SL, Thompson PA, Morris DM, Rose DK, Winstein CJ, Taub E, Giuliani C, Pearson SL. The EXCITE trial: Attributes of the Wolf Motor Function Test in patients with subacute stroke. Neurorehabil Neural Repair. 2005;19(3):194–205.*
5. *Harwin WS et al. Challenges and opportunities for robot-mediated neurorehabilitation. Proceedings of the IEEE 2006:94(9)Sept.*
6. *Cooper RA et al. A perspective on intelligent devices and environments in medical rehabilitation. Med Eng Phys 2008:Dec;30(10):1387-1398.*
7. *Scheidt RA, Reinkensmeyer DJ, Conditt MA, Rymer WZ, Mussa-Ivaldi FA. Persistence of motor adaptation during constrained, multi-joint, arm movements. J Neurophysiol. 2000;84(2):853–62.*
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REHABILITATION
2030
a call for action

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Rehabilitation: key for health in the 21st century

Key messages

- Rehabilitation is essential, along with prevention, promotion, treatment and support, in addressing the full scope of health needs of a population and achieving Sustainable Development Goal 3: Ensure healthy lives and promote well-being for all at all ages.
- Rehabilitation plays an important role among older populations, reducing the risk of falls and hospital admissions, and keeping people independent for longer.
- More people than ever are living with noncommunicable diseases and other chronic conditions. Health systems need to be equipped to provide services that optimize functioning in light of impairments, injuries or health conditions, acute or chronic.
- The benefits of rehabilitation are realized beyond the health sector. Rehabilitation can reduce care costs and enable participation in education and gainful employment.
- Rehabilitation must be integrated into national health plans and budgets. Current epidemiological trends, demographic shifts and expanded access to health care make scaling up rehabilitation services imperative for health systems in the 21st century.
- Coordinated and concerted action is needed to scale up rehabilitation services and address the profound unmet needs that exist.

World Health Organization

WHO/NMH/NVI/17.3

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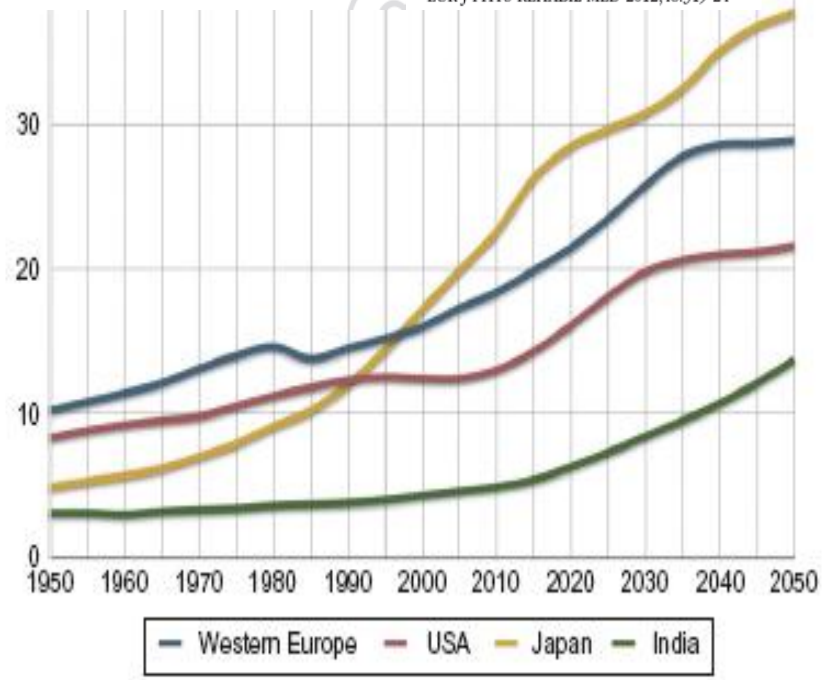
Robotic technology and physical medicine and rehabilitation

H. I. KREBS

EUR J PHYS REHABIL MED 2012;48:319-24



The development of robotic treatments is motivated by the **increasing public health burden** associated with stroke-related disability, and by the current **emphasis on health care cost reductions**, which have resulted in shorter lenght of stay for inpatient rehabilitation.

1. *Faran S, Treger I, Mahoney R, Ring H. Feasibility of a new robot-assisted therapy for neuromuscular training opf subacute stroke patients. AAPM&R 67° Assembly November 9 – 12 , 2006, Hawaii.*
2. *Krebs HI, and Volpe BT. Rehabilitation robotics (Chapter 23). Handbook of Clinical Neurology, Vol. 110 (3rd series). Neurological Rehabilitation M.P. Barnes and D.C. Good, Editors, 2013 Elsevier B.V.*

EDITORIAL (EurMedPhys 2003;39:3-6)

Technology in rehabilitation

Haim Ring

The 21st century finds rehabilitation medicine in rapid growth and development in each and every field of activity. Among them technology plays a central role and it can be safely said that rehabilitation medicine is **by now and can be in the future even more, a very technological profession**.

1. *Weinrich M, Stuart ME. Rehabilitation for the 21st century. J Rehabil Res Develop 2001;38:VII-XII*
2. *Smith RO. Research over the next century: impact of technology. Am J Occup Ther 2001;55:233-234.*

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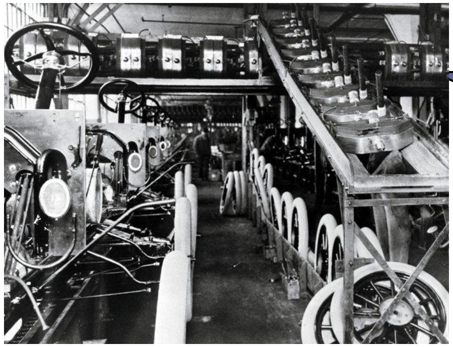
Homo sapiens

Homo faber

Grandi bifacciali acheuliani del Paleolitico inferiore da Terranera, nel bacino di Venosa (Basilicata)

1. *AA. VV., 1986. Il Paleolitico "Le Scienze Quaderni", a cura di Fedele F., Milano, 30.*
2. *BROGLIO A., 1998. Introduzione al Paleolitico, Laterza, Bari.*

… desiderio di conoscenza e possibilità di sfruttare in chiave economica le novità.



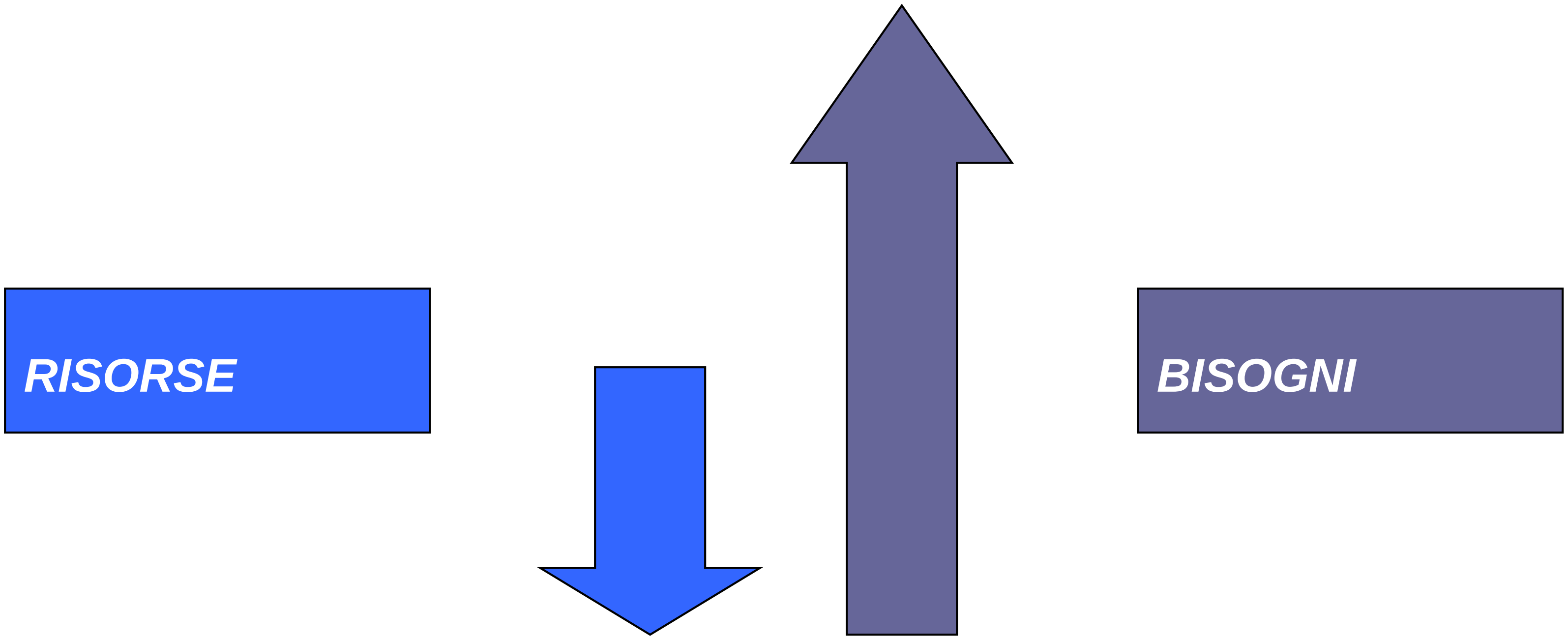
The Ten-Millionth Ford

The 10,000,000th Ford car left the Highland Park factories of the Ford Motor Company June 4. This is a production achievement unapproached in automotive history. Tremendous volume has been the outgrowth of dependable, convenient, economical service.

Ford Motor Company

The Touring Car $295

1. *Catananti C. L'impatto dell'innovazione tecnologica. MONITOR,2004;III(11):34-40.*



Fattori legati all’inflazione

Mutamenti della struttura demografica

Modifiche nei volumi e nell’intensità delle pratiche cliniche

INNOVAZIONE

1. *Catananti C. L’impatto dell’innovazione tecnologica. MONITOR,2004;III(11):34-40.*
2. *Newhouse, Medical Care Costs: How Much Welfare Loss? Journal of Economic Perspectives 6:3, Summer 1992.*
3. *Project HOPE. 2001. The impact of medical techinologiey on the future health care costs: Final Report. Project Hope, Bethesda, Maryland.*

Mechanisms in mediating functional recovery

- **sprouting of new synapses**
- **unmasking of redundant motor networks**
- **re-organization of the areas around the lesion site**

- an **increase in the size of the motor and sensory areas in the lesioned hemisphere** that is dedicated to the impaired limb
- **enhance activity and recruitment in preexisting motor networks in unaffected regions** and those **surrounding the lesion site** and in the **cerebellum**
- a **reduction** the amount **of activity in primary and secondary motor regions** over time, especially **in areas in the hemisphere ipsilateral to the lesion**

1. *Bach-y-Rita P: Late post-acute neurologic rehabilitation: neuroscience, engineering and clinical programs. Arch Phys Med Rehab 2003, 84:1100-1108.*
2. *You SH, Jang SH, Kim YH, Hallett M, Ahn SH, Kwon YH, Kim JH, Lee MY: Virtual reality-induced cortical reorganization and associated locomotor recovery in chronic stroke: an experimenter-blind randomized study. Stroke 2005, 36(7):1625.*
3. *Karni A, Meyer G, Jezzard P, Adams MM, Turner R, Ungerleider LG: Functional MRI evidence for adult motor cortex plasticity during motor skill learning. Nature 1995, 377(6545):155-158.*
4. *Liepert J, Bauder H, Miltner WHR, Taub E, Weiller C: Treatmentinduced cortical reorganization after stroke in humans. Stroke 2002, 31:1210-1216.*
5. *Classen J, Liepert J, Wise S, Hallett M, Cohen LG: Rapid plasticity of human cortical movement representation induced by practice. Journal of Neurophysiology 1998, 79(2):1117-1123.*
6. *Calautti C, Baron J: Functional neuroimaging studies of motor recovery after stroke in adults: A review. Stroke 2003, 34:1553-1566.*
7. *Schaechter JD: Motor rehabilitation and brain plasticity after hemiparetic stroke. Progress in Neurobiology 2004, 73(1):61-72.*
8. *Kleim JA, Hogg TM, VandenBerg PM, Cooper NR, Bruneau R, Remple M: Cortical synaptogenesis and motor map reorganization occur during late, but not early, phase of motor skill learning. J Neuroscience 2004, 24(3):628-633.*

Plasticità del Sistema Nervoso indotta da lesione

Modifica strutturale

- **Degenerazione progressiva delle cellule nervose**
- **Variazioni delle connessioni sinaptiche**
- **Riduzione delle spine dendritiche**

Modifica funzionale

- **Bilancio dei mediatori chimici, inibitori o facilitatori, agenti nei network nervosi**

1. *Bach-y-Rita P: Late post-acute neurologic rehabilitation: neuroscience, engineering and clinical programs. Arch Phys Med Rehab 2003, 84:1100-1108.*
2. *You SH, Jang SH, Kim YH, Hallett M, Ahn SH, Kwon YH, Kim JH, Lee MY: Virtual reality-induced cortical reorganization and associated locomotor recovery in chronic stroke: an experimenter-blind randomized study. Stroke 2005, 36(7):1625.*
3. *Karni A, Meyer G, Jezzard P, Adams MM, Turner R, Ungerleider LG: Functional MRI evidence for adult motor cortex plasticity during motor skill learning. Nature 1995, 377(6545):155-158.*
4. *Liepert J, Bauder H, Miltner WHR, Taub E, Weiller C: Treatmentinduced cortical reorganization after stroke in humans. Stroke 2002, 31:1210-1216.*
5. *Classen J, Liepert J, Wise S, Hallett M, Cohen LG: Rapid plasticity of human cortical movement representation induced by practice. Journal of Neurophysiology 1998, 79(2):1117-1123.*
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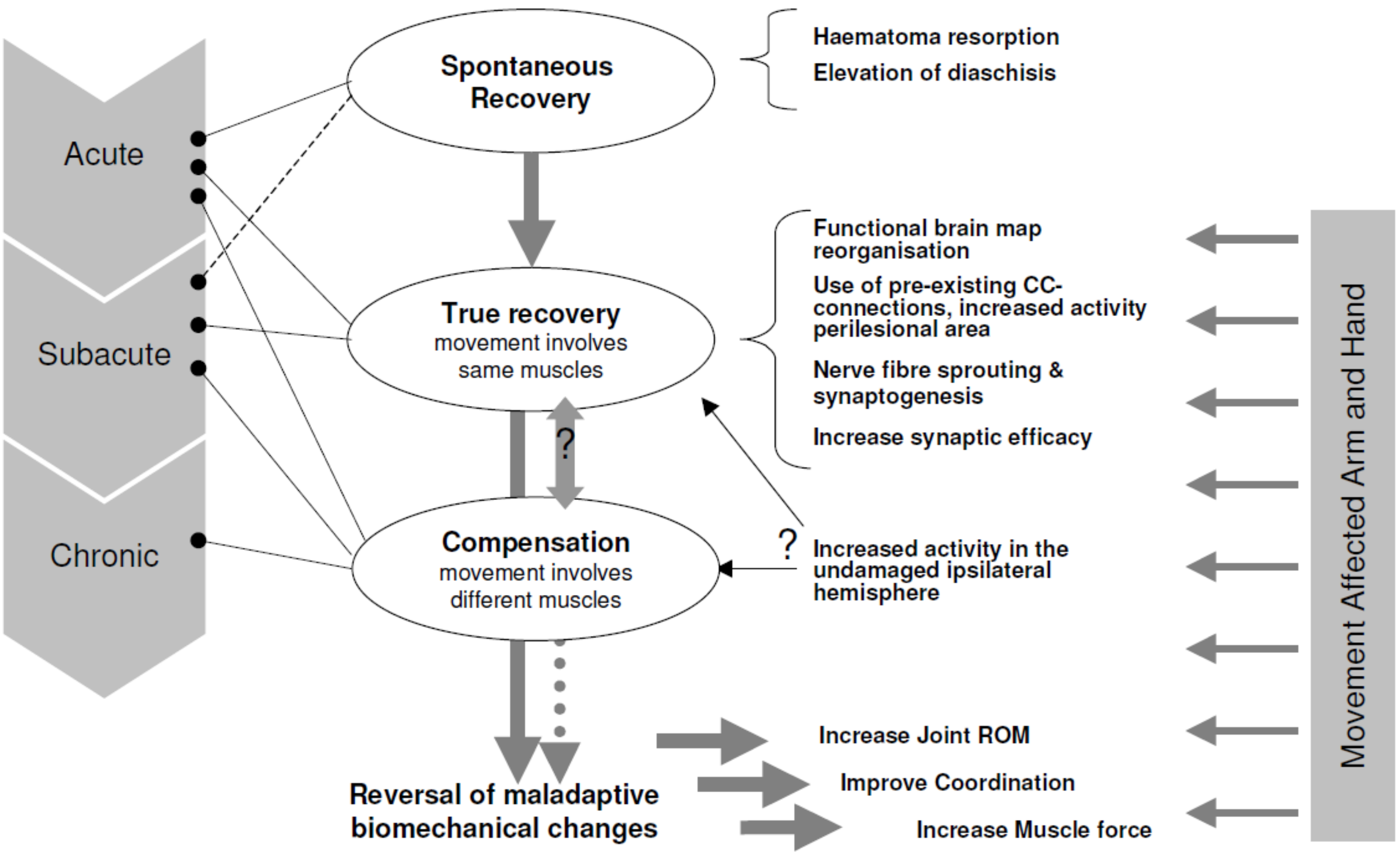
7. *Schaechter JD: Motor rehabilitation and brain plasticity after hemiparetic stroke. Progress in Neurobiology 2004, 73(1):61-72.*
8. *Kleim JA, Hogg TM, VandenBerg PM, Cooper NR, Bruneau R, Remple M: Cortical synaptogenesis and motor map reorganization occur during late, but not early, phase of motor skill learning. J Neuroscience 2004, 24(3):628-633.*

Declarative model of motor recovery



1. Timmermans AAA, Seelen HAM, Willmann RD, Kingma H. Technology-assisted training of arm-hand skills in stroke: concepts on reacquisition of motor control and therapist guidelines for rehabilitation technology design J NeuroEng Rehabil. 2009;6:1.

The effective treatment program

There is strong evidence that **intensity** as well as **task specificity** are the main drivers in an effective treatment program after brain injury. In addition, this training should be **repetitive (active), functional (task-oriented), meaningful, and challenging (motivating)** for a patient.

1. *Van Peppen RP, Kwakkel G, Wood-Dauphinee S, Hendriks HJ, Van der Wees PJ, Dekker J. The impact of physical therapy on functional outcomes after stroke: what's the evidence? Clin Rehabil. 2004;18:833-862.*
2. *Kwakkel G, Kollen BJ, Lindeman E. Understanding the pattern of functional recovery after stroke: facts and theories. Restor Neurol Neurosci. 2004;22:281-299.*
3. *Nudo RJ: Functional and structural plasticity in motor cortex: implications for stroke recovery. Physical Medicine & Rehabilitation Clinics of North America 2003, 14(1):57-76.*
4. *Wu C, Trombly CA, Lin K, Ticke-Degnen L: Effects of object affordances on reaching performance in persons with and without cerebrovascular accident. Am J Occup Ther 1998.*
5. *Bayona NA, Bitensky J, Salter K, Teasell R: The role of task-specific training in rehabilitation therapies. Topics in Stroke Rehabilitation 2005, 12(3):58-65.*
6. *Johnson MJ, Van der Loos HFM, Burgar CG, Shor P, Leifer LJ: Experimental results using force-feedback cueing in robot-assisted stroke therapy. IEEE Trans. on Neural Systems and Rehabilitation Engineering 2005, 13(3):335-348.*
7. *Bach y Rita P, Wood S, Leder R, Paredes O, Bahr D, Bach-y-Rita EW, Murillo N: Computer assisted motivating rehabilitation for institutional, home, and educational late stroke programs. Top Stroke Rehabil 2002, 8(4):1-10.*
8. *Wood SR, Murillo N, Bach-y-Rita P, Leder RS, Marks JT, Page SJ: Motivating, game-based stroke rehabilitation: a brief report. Topics of Stroke Rehabilitation 2003, 10(2):134-40.*

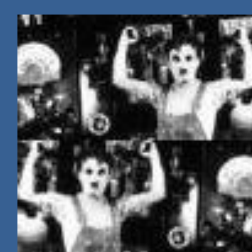
Nell'animale e nell'uomo

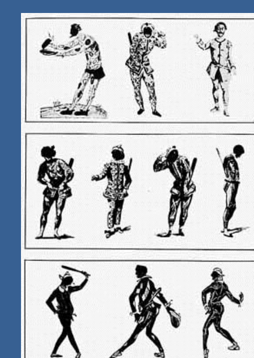
il MOVIMENTO è sopravvivenza,

sia dell'individuo che della specie, ma …

… nell'uomo esprime molto di più:

- … ricerca estetica
- … esplorazione dei propri limiti fisici
- … creatività
- … metalinguaggio





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ICF Components

Body Functions & Structures	Activities & Participation	Environmental Factors
 	 	
Functions	*Capacity*	*Barriers*
Structures	*Performance*	*Facilitators*

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Journal of NeuroEngineering and Rehabilitation

BioMed Central

Journal of NeuroEngineering and Rehabilitation 2006, 3:29

Commentary

Open Access

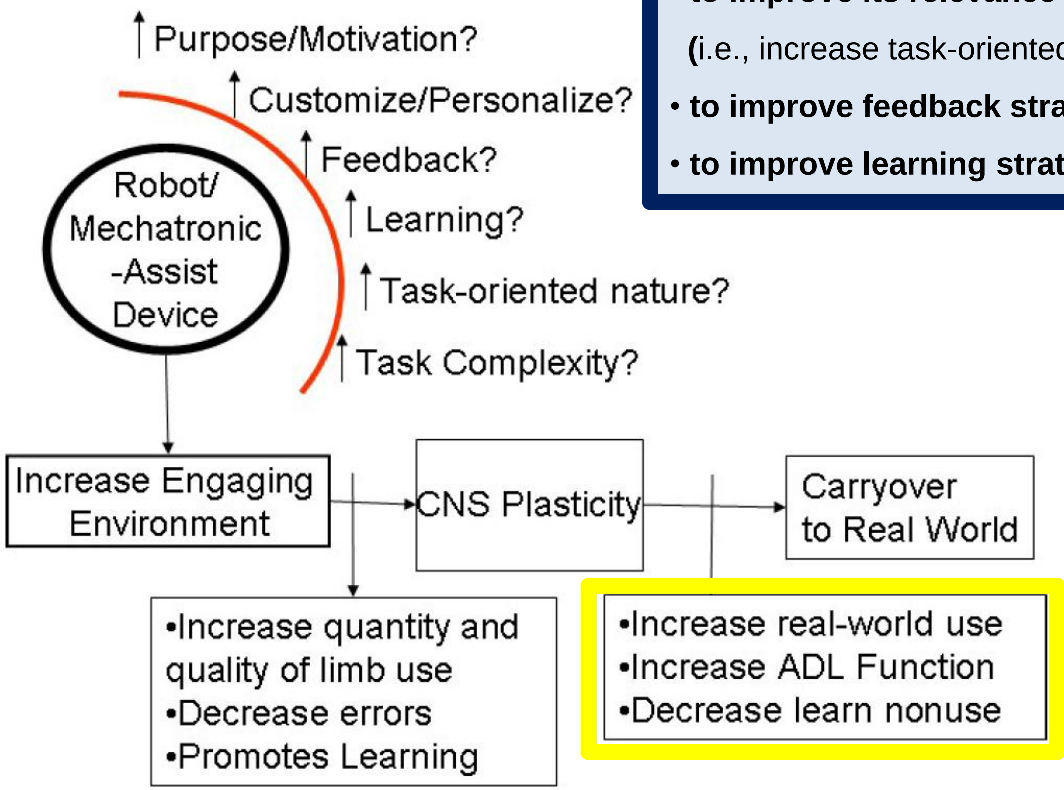
Recent trends in robot-assisted therapy environments to improve real-life functional performance after stroke

Michelle J Johnson*[1,2,3,4]

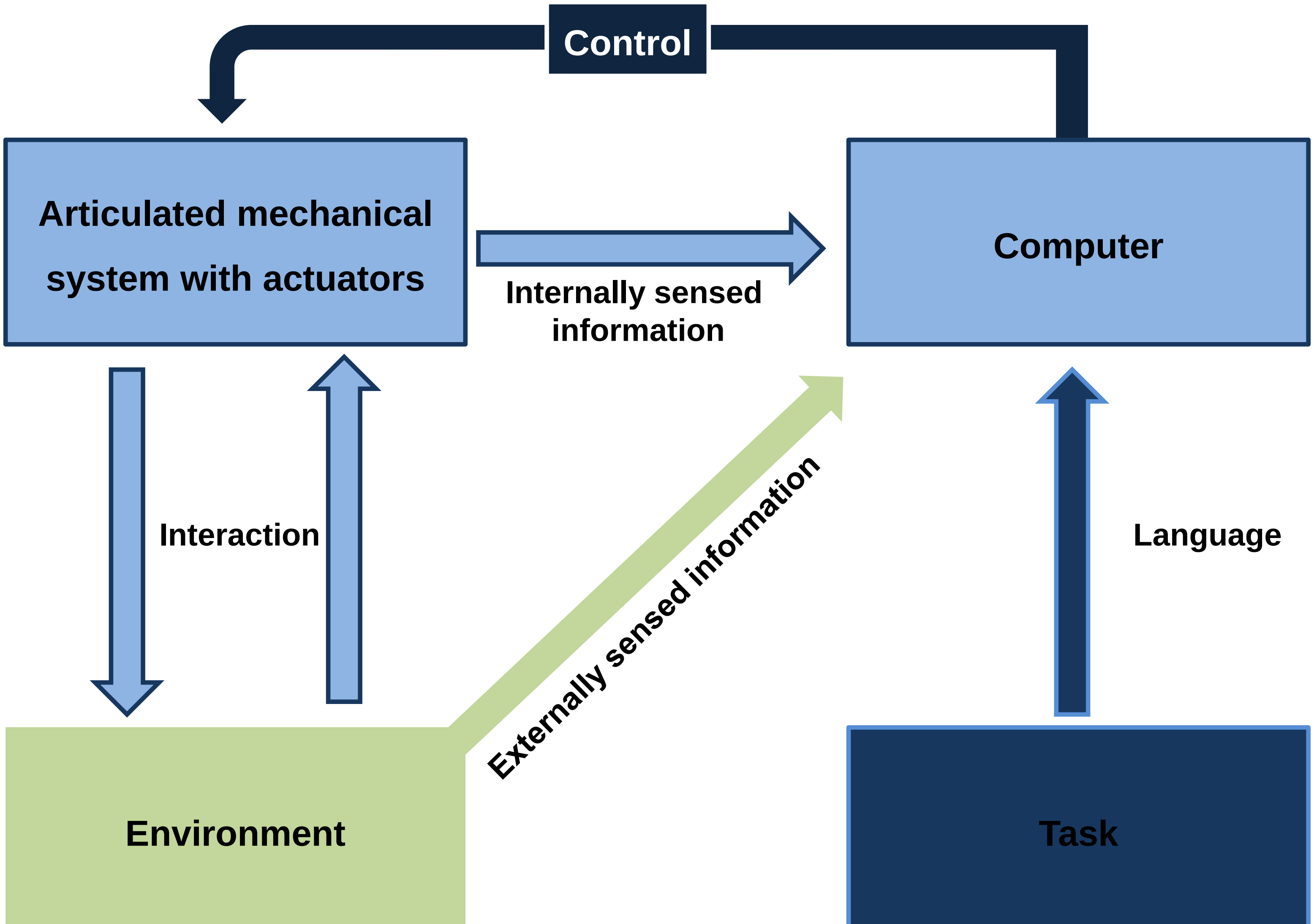
Functional cortical reorganization and carryover of motor gains after stroke seem to be linked to therapies that involve the **intense use** of the impaired limb and involve the **acquisition of new motor skills**. Evidence also suggests that in addition to mass-practice and use of the arm, **enriched environments**, **highly functional and task-oriented practice environment**, and **highly motivating environment that increase task engagement** are important for motor re-learning and recovery after stroke.

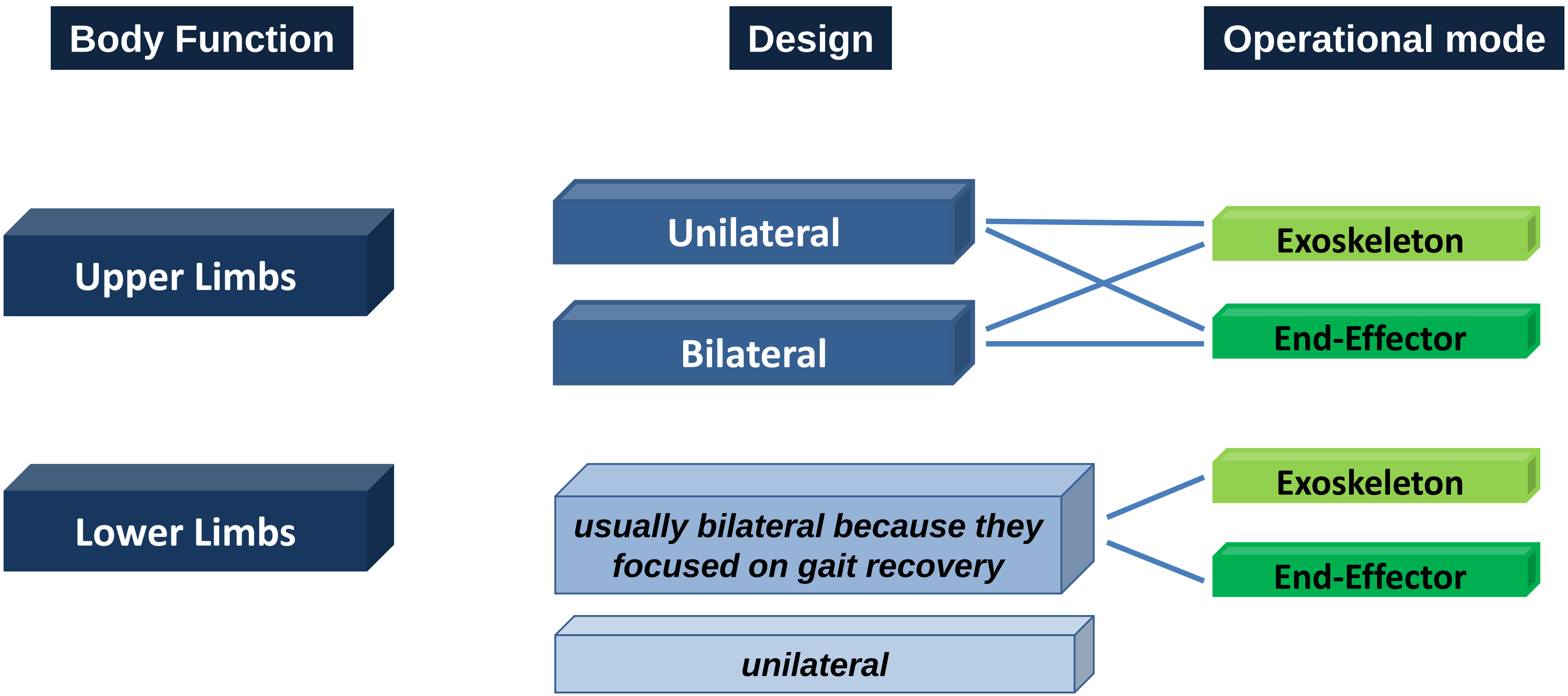
The robot-assisted environment may be modified:

- **to better engage the patient (**e.g., provide extrinsic motivators**)**
- **to improve its relevance to the person and the activities they do in real life (**i.e., increase task-oriented nature, purpose and patient-centered**)**
- **to improve feedback strategies (**i.e., increase feedback of errors and results**)**
- **to improve learning strategies (**i.e., employ new control strategies**)**



1. *Johnson MJ. Recent trends in robot-assisted therapy environments to improve real-life functional performance after stroke. J NeuroEng and Rehabil, 2006,3:29.*


Control
Articulated mechanical system with actuators
Internally sensed information
Computer
Interaction
Externally sensed information
Language
Environment
Task



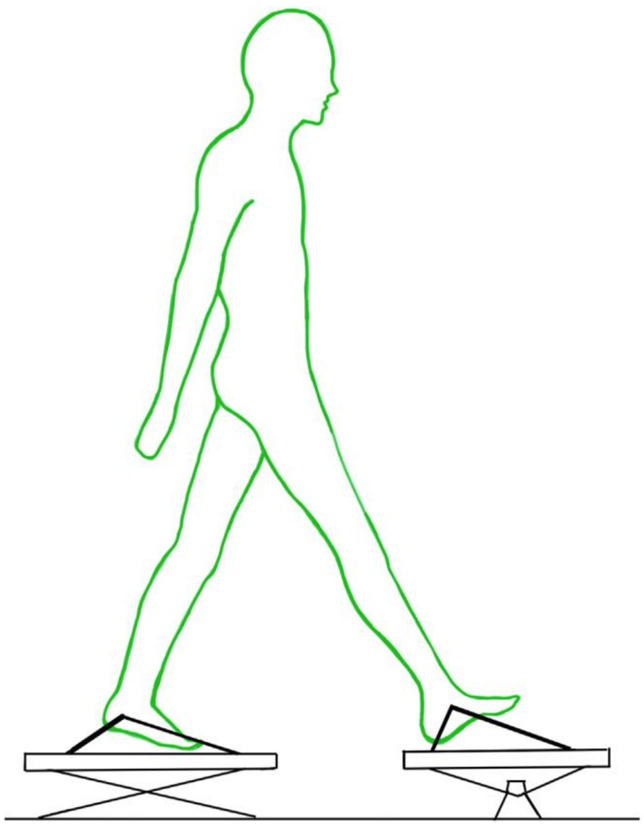
Review Article

Seven Capital Devices for the Future of Stroke Rehabilitation

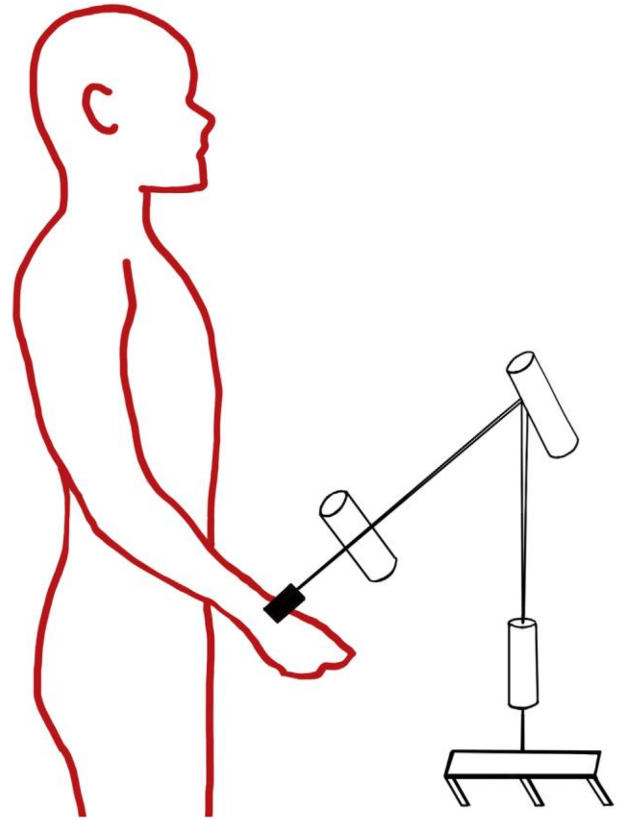
Stroke Research and Treatment Volume 2012,

M. Iosa,[1] G. Morone,[1] A. Fusco,[1] M. Bragoni,[2] P. Coiro,[2] M. Multari,[2] V. Venturiero,[2]
D. De Angelis,[2] L. Pratesi,[2] and S. Paolucci[1,2]

End-Effector



Lower Limbs



Upper Limbs

1. *Molteni F, Gasperini G, Cannaviello G, Guanziroli E. Exoskeleton and End-Effector Robots for Upper and Lower Limbs Rehabilitation: Narrative Review.* PM R 10 (2018) S174-S188

Exoskeleton

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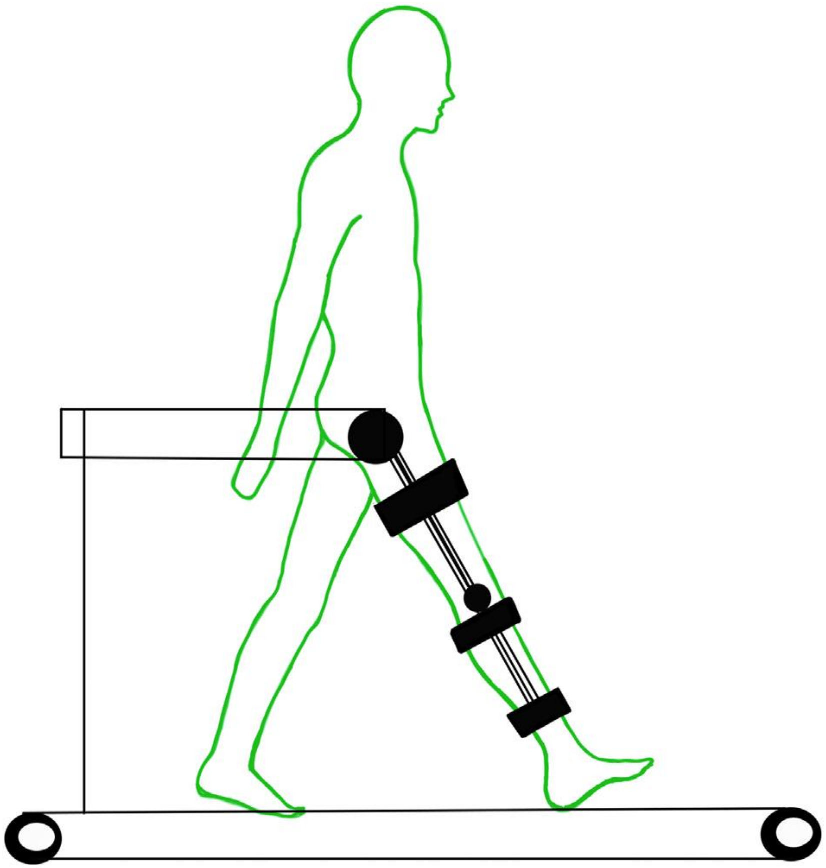
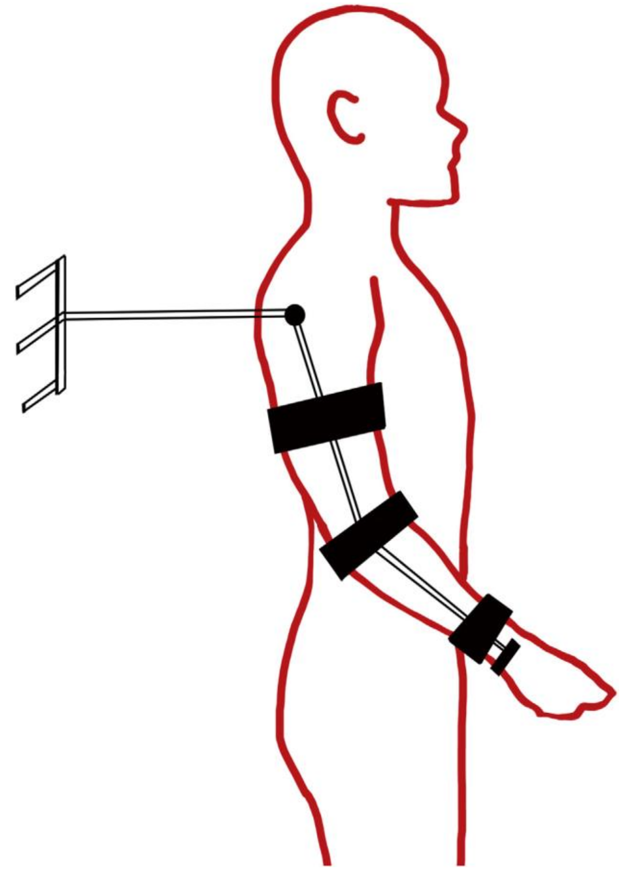


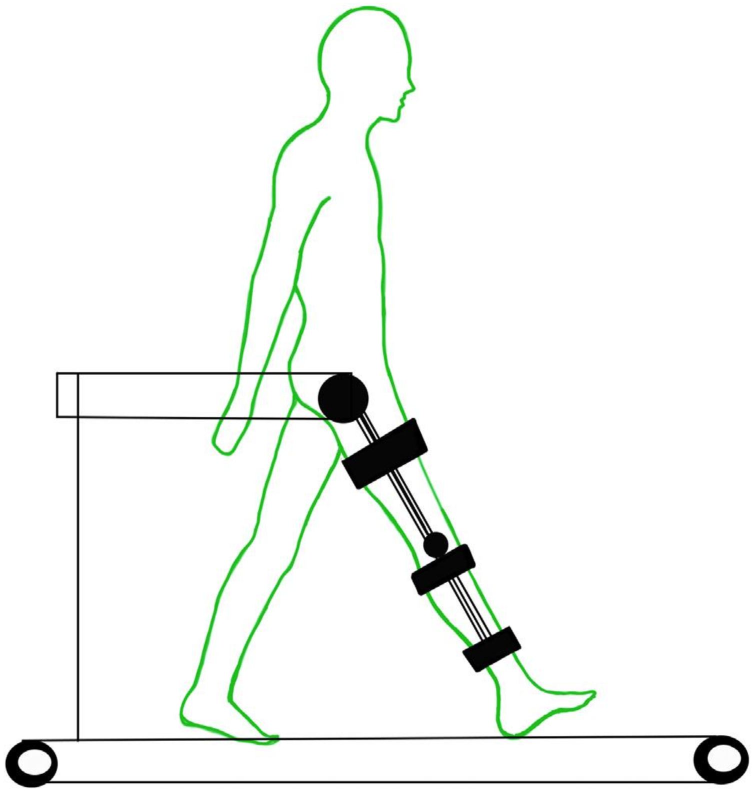
Lower Limbs



Upper Limbs

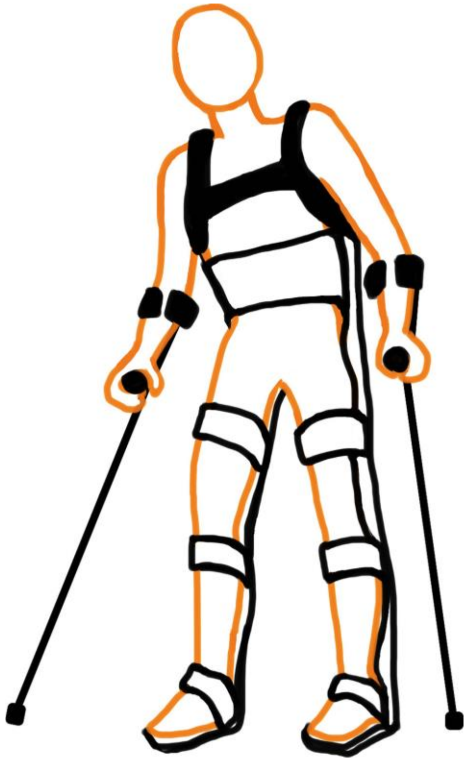
1. *Molteni F, Gasperini G, Cannaviello G, Guanziroli E. Exoskeleton and End-Effector Robots for Upper and Lower Limbs Rehabilitation: Narrative Review.* PM R 10 (2018) S174-S188

«Static»



Body weight support exoskeleton for lower limb

«Overground»



Overground exoskeleton for lower limb

1. *Molteni F, Gasperini G, Cannaviello G, Guanziroli E. Exoskeleton and End-Effector Robots for Upper and Lower Limbs Rehabilitation: Narrative Review.* PM R 10 (2018) S174-S188

Electromedical devices

Active	patients' active assistance to the movement
Passive	nonpowered support to patients' upper and lower limbs
Active-assisted	complete the movement after the user initiates a movement
Resistive	offer an opposition to the subject's movement execution
Interactive	allow the correction of movements with a combination of actuators and control strategies

Review Article

Robotic Technologies and Rehabilitation: New Tools for Stroke Patients' Therapy

Patrizia Poli,[1] Giovanni Morone,[2,3] Giulio Rosati,[4] and Stefano Masiero[1]

BioMed Research International, 2013;15:38-72

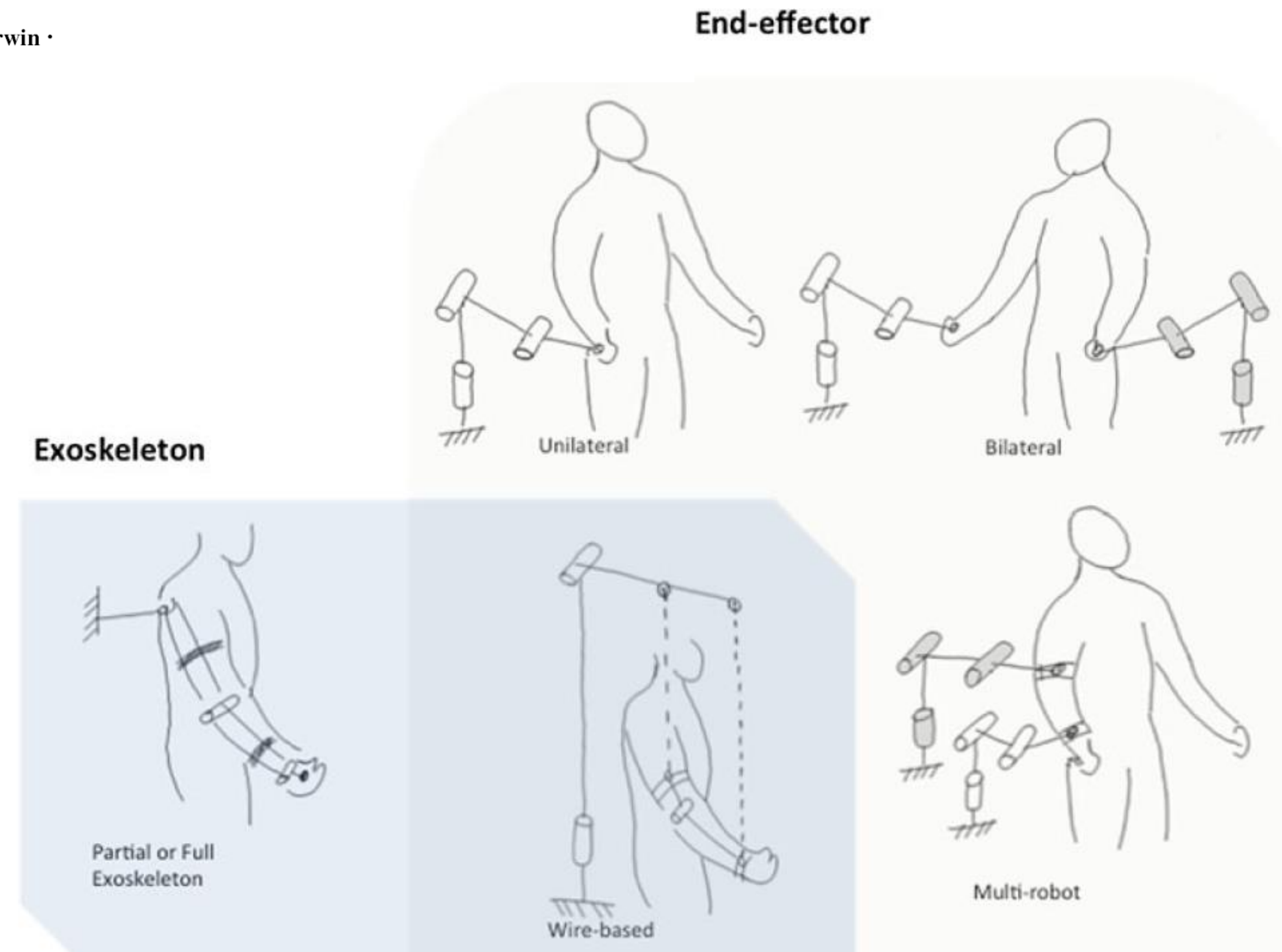
- *Molteni F, Gasperini G, Cannaviello G, Guanziroli E. Exoskeleton and End-Effector Robots for Upper and Lower Limbs Rehabilitation: Narrative Review.* PM R 10 (2018) S174-S188

Med Biol Eng Comput (2011) 49:1103–1118
DOI 10.1007/s11517-011-0797-0

SPECIAL ISSUE - REVIEW

Advances in upper limb stroke rehabilitation: a technology push

Rui C. V. Loureiro · William S. Harwin ·
Kiyoshi Nagai · Michelle Johnson



End-effector-based robotic rehabilitation systems

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System	Developer	Reference	Type	UL seg		
Act 3D	Northwester University, USA	Sukal et al. [103]	Single-point, unilateral	Should		pensated or enhanced. Passive, active esistive modes. Based on the Haptic ot.
ADLER	Medical College of Wisconsin, USA	Johnson et al. [45]	Single-point, bilateral	Should		Gentle/S system. Reaching in any vith real target objects. Used in n with a FES glove for grasping of real
ARM-Guide	Northwester University, USA	Reinkensmeyer, et al. [92]	Single-point, unilateral	Should		gated, reaching in any plane, address use. Passive, active assistive, resistive sed on slide mechanism allowing e movement.
Bi-Manu-Track	Klinik-Berlin/Charite Hospital Germany	Hesse et al. [38]	Multi-robot, bilateral	Forearm + wrist	1 active DOF at one time	Gravity mitigated, address learn non-use and uses mirror image movement. Passive, active assistive, resistive modes.
Braccio di Ferro	University of Genova, Italy	Casadio et al. [14]	Single-point, unilateral	Shoulder + elbow	2 active	Planar reaching. Passive, active assistive, resistive MIT-MANUS system.
Driver SEAT	Rehab Research Develo at VA, USA	Johnson et al.	Steering wheel,	Should		apy (mirror eel. Passive, back.
Gentle/S	Universit UK			Should		direction, ssive, active making.
iPAM	Universit UK			Should		two robots.
MEMOS	Fondazio			Should		e, resistive
MIT-MANUS (InMotion2)	Massachusetts Institute of Technology/ Interactive Motion Technologies, USA	Hogan et al. [40], Krebs et al. 1998	Single-point, unilateral	Shoulder		dress learn stive modes.
MIT-MANUS (InMotion3)		Celestino et al. [15]		Forearm +		upination of nsion of

FIGURE 13: Bi-Manu-Track. Reprinted with permission (http://www.reha-stim.de/).

FIGURE 11: Braccio di Ferro. Reprinted with permission (http://www.iit.it/).

End-effector-based robotic rehabilitation systems

System	Developer	Reference	Type	UL segment	DOF assisted	Description
Java Therapy	University of California, Irvine, USA	Reinkensmeyer et al. [94]	Joystick, unilateral	Wrist	2 active DOF, 2D space	Limited planar motion and active assistive modes. Game-like visual and audio feedback, telerehabilitation function.
MIME	Rehab Research Development Center at VA, Palo Alto, USA	Lum et al. [71]	Single-point + digitiser bilateral	Shoulder + elbow	3 active DOF, 3D space	Mirror image passive, active assistive and resistive movement therapy. Address learn non-use, can perform also unilateral exercises.
NeReBot	University of Padova, Italy	Masiero et al. [75]	Wire-based, unilateral		3 active DOF, 3D space	Gravity compensated. Passive and active assistive. Visual and audio feedback. Splint, 3 wires and linkages provide arm orientation/position.
REHAROB	Budapest University of Technology and Economics, Hungary	Toth et al. [109]	Multi-robot, unilateral		5 active DOF, 3D space	Passive, single or multijoint coordination, range of motion training to address spasticity. Visual feedback. Based on two 6DOF industrial robots.
Swedish Helparm	Kinsman Enterprises, Inc., USA	Kinsman Enterprises [52]	Wire-based, unilateral/ bilateral		2 passive (unilateral)	Passive sling suspension system.

Loureiro RCV, Harwin WS, Nagai K, Johnson M. Med Biol Eng Comput (2011) 49:1103–1118.

Exoskeleton based robotic rehabilitation systems

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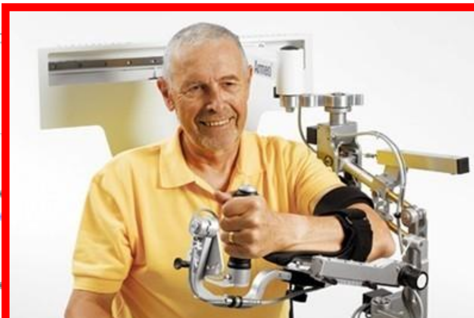
System	Developer	Reference	Type	UL segment	DOF assisted	Description
ARMin	ETH, Zurich, Switzerland	Nef and Riener [84]	Fixed exoskeleton, unilateral	Shoulder + elbow	4 active, 2 passive DOF	Gravity compensated, massed practice with target, visual and audio feedback, passive, active assistive.
Dampace	University of Twente, The Netherlands	Arno et al. 2007	Fixed exoskeleton, unilateral	Shoulder + elbow	5 passive DOF (3 shoulder,	Gravity compensated, visual and audio feedback. and resistive modes.
Hand Mentor	Kinectic Muscles, Inc. USA	Koeneman et al. [53]	Portable, partial exoskeleton, unilateral	Wrist + hand		ystem, EMG and force feedback. active assisted modes. Based on en pneumatic actuators.
HWARD	University of California, Irvine, USA	Takahashi et al. [105]	Fixed, partial exoskeleton, unilateral	Wrist + hand		istive motion combining wrist n with hand grasping and wrist flexion d release. Visual and audio feedback.
KIST	Korea Institute of Science and Technology, Korea	Kim et al. [51]	Portable, exoskeleton, bilateral	Shoulder + elbow + w		ystem, Passive, active assisted modes. n pneumatic and electric brake actuators.
L-EXOS (PERCRO)	Scuola Superiore Sant'Anna, Italy	Montagner et al. [78]	Fixed exoskeleton, unilateral	Shoulder + elbow	4 active, 1 passive DOF	Gravity compensated, massed practice with target, visual and audio feedback, passive, active assistive.
MGA	Georgetwon and Maryland Univ., USA	Car et		+ elbow	4 active, 1 passive DOF	Gravity compensated, visual and audio feedback, passive, active assistive modes.
Myomo e100	Myomo, Inc., USA	Stei [1			1 active DOF	edback.
Pneu-WREX	University of California, Irvine, USA	San [9		+ elbow	4 active, 1 passive DOF	ve. he
RUPERT	Arizona State University, Phoenix, USA	He		+ elbow + wrist	4 active DOF (1 shoulder, 1 elbow, 1 forearm, 1 wrist)	of arm
Rutgers Master II	Rutgers, State University New Jersey, USA	Merians et al. [77]	Partial exoskeleton, unilateral	Hand	4 active DOF (1 thumb, 3 fingers)	haptic matic
T-WREX	University of California, Irvine, USA	Sanchez et al. [97]	Fixed exoskeleton, unilateral	Shoulder + elbow	5 passive DOF (3 shoulder, 2 elbow)	Gravity mitigated, passive functional task training using visual and audio feedback. Based on the Wilmington Robotic Exoskeleton.



Loureiro RCV, Harwin WS, Nagai K, Johnson M. Med Biol Eng Comput (2011) 49:1103–1118.

Feasibility and efficacy of a robotic device for hand rehabilitation in hemiplegic stroke patients: A randomized pilot controlled study.

Vanoglio F, Bernocchi P, Mulè C, Garofali F, Mora C, Taveggia G, Scalvini S, Luisa A.

Clin Rehabil 2016; Apr 7.

OBJECTIVE: The purpose of the study was to evaluate the feasibility and efficacy of robot-assisted hand rehabilitation in improving arm function abilities in sub-acute hemiplegic patients. **DESIGN:** Randomized controlled pilot study. **SETTING:** Inpatient rehabilitation centers. **PARTICIPANTS:** 30 hemiplegic stroke patients (Ashworth spasticity index <3) were recruited and randomly divided into a Treatment group (TG) and Control group (CG). **INTERVENTIONS:** Patients in the TG received intensive hand training with Gloreha, a hand rehabilitation glove that provides computer-controlled, repetitive, passive mobilization of the fingers, with multisensory feedback. Patients in the CG received the same amount of time in terms of conventional hand rehabilitation. **MAIN OUTCOME MEASURES:** Hand motor function (Motricity Index, MI), fine manual dexterity (Nine Hole Peg Test, NHPT) and strength (Grip and Pinch test) were measured at baseline and after rehabilitation, and the differences, (Δ) mean(standard deviation), compared between groups.

RESULTS: Twenty-seven patients concluded the program: 14 in the TG and 13 in the CG. None of the patients refused the device and only one adverse event of rheumatoid arthritis reactivation was reported. Baseline data did not differ significantly between the two groups. In TG, ΔMI 23(16.4), ΔNHPT 0.16(0.16), ΔGRIP 0.27(0.23) and ΔPINCH 0.07(0.07) were significantly greater than in CG, ΔMI 5.2(9.2), ΔNHPT 0.02(0.07), ΔGRIP 0.03(0.06) and ΔPINCH 0.02(0.03)] (p=0.002, p=0.009, p=0.003 and p=0.038, respectively).

CONCLUSIONS: Gloreha Professional is feasible and effective in recovering fine manual dexterity and strength and reducing arm disability in sub-acute hemiplegic patients.

Review Article

A Systematic Review of Bilateral Upper Limb Training Devices for Poststroke Rehabilitation

A. (Lex) E. Q. van Delden,[1] C. (Lieke) E. Peper,[1] Gert Kwakkel,[1,2] and Peter J. Beek[1]

Figure 16: Driver's SEAT. Reprinted with permission (funding: US Department of Veterans Affairs Rehabilitation Research and Development Program).

Figure 17: Adaptive Bimanual Robotic Training. Reprinted with permission.

INVITED REVIEW

Robotic Assessment of Upper Limb Motor Function After Stroke

ABSTRACT

Balasubramanian S, Colombo R, Sterpi I, Sanguineti V, Burdet E: Robotic assessment of upper limb motor function after stroke . Am J Phys Med Rehabil 2012;91:(Suppl):S255–S269.

1. Kinematic measures *quantify the spatial and temporal quality of a subject's movement. They are described either in the endpoint/task space or in the joint space of the arm, depending on the task and type of robot used*.

2. Kinetic measures *are used to quantify force, work, energy consumption, and power associated with a subject's motor behavior.*

3. Neuromechanical measures *of the upper limb, such as the viscoelastic properties or mechanical impedance, which can include the influence of musculoskeletal dynamics and neural feedback.*

INVITED REVIEW

Robotic Assessment of Upper Limb Motor Function After Stroke

ABSTRACT

Balasubramanian S, Colombo R, Sterpi I, Sanguineti V, Burdet E: Robotic assessment of upper limb motor function after stroke . Am J Phys Med Rehabil 2012;91:(Suppl):S255–S269.

TABLE 2 Summary of existing movement measures and their use in studies with specific rehabilitation robots

Movement Measure	Classification	Device	Movements
Active range of motion	Kinematic	ACT3D,[10] AG,[11] RM[12]	Point-to-point
Movement deviation	Kinematic	ME,[13] MM,[14] BdF[15]	Point-to-point, tracking
Movement time	Kinematic	HK,[16] R,[17] MM,[14] KA[18]	Point-to-point
Movement velocity	Kinematic	ME,[13] MM,[14] R,[17] KA[18]	Point-to-point, tracking
Movement smoothness	Kinematic	HK,[16] ME,[13] MM,[19,20] R,[17] BdF[15]	Point-to-point, tracking
Target error	Kinematic	HK,[16] MM,[19] R[17]	Point-to-point
Movement coordination	Kinematic/Kinetic	HC,[21] MM,[22] AI[23]	Point-to-point, tracking, manipulation
Amount of assistance	Kinematic/Kinetic	ME,[13] R[17]	Point-to-point, tracking
Force direction error	Kinetic	AG,[11] ME,[24] MI[25]	Point-to-point, tracking
Arm impedance	Neuromechanical	AG,[26] MM[27]	N/A

AG indicates ARM Guide; RM, reachMAN; ME, MEMOS; MM, Massachusetts Institute of Technology-Manus; BdF, Braccio de Ferro; HK, HapticKnob; R, RUPERT; HC, HandCare; AI, ArmIn III; MI, MIME; KA, KINARM; N/A, not applicable.

From modern concepts of rehabilitation …

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repetitive task-specific approach

higher intensities of walking practice *(resulting in more repetitions trained)*

… new approaches

Treadmill training with and without partial body weight support

Automated electromechanical gait machines (reduce dependence on therapists)

Robot-driven exoskeleton orthosis

(*from an engineering point of view*:

an **exoskeleton approach**)

Electromechanical solution with two driven foot plates simulating the phases of gait

(*from an engineering point of view* :

an **end-effector approach**)

Robotic-assisted gait training in neurological patients: who may benefit?
Schwartz I, Meiner Z.
Ann Biomed Eng 2015; May 43(5):1260 -1269

Exoskeleton

Uso militare: potenziamento di forza e resistenza

Impiego civile e applicazioni in soggetti con limitazioni motorie

End-effector

Dispositivi robotizzati per la riabilitazione

Gait training early after stroke with a new exoskeleton – the hybrid assistive limb: a study of safety and feasibility

Anneli Nilsson[1*], Katarina Skough Vreede[1,2], Vera Häglund[1], Hiroaki Kawamoto[3], Yoshiyuki Sankai[3] and Jörgen Borg[1,2]

Nilsson *et al. Journal of NeuroEngineering and Rehabilitation* 2014, 11:92

Results: Eight patients completed the study. Median time from stroke to inclusion was 35 days (range 6 to 46). Training started by use of the autonomous HAL mode in all and later switched to the voluntary mode in all but one and required one or two physiotherapists. Number of training sessions ranged from 6 to 31 (median 17) and walking time per session was around 25 minutes. The training was well tolerated and no serious adverse events occurred. All patients improved their walking ability during the training period, as reflected by the 10MWT (from 111.5 to 40 seconds in median) and the FAC (from 0 to 1.5 score in median).

Conclusions: The HAL system enables intensive training of gait in hemiparetic patients with severely impaired gait function early after stroke. The system is safe when used as part of an inpatient rehabilitation program for these patients by experienced physiotherapists.

Hybrid Assistive Limb (HAL)

Mobility training using a bionic knee orthosis in patients in a post-stroke chronic state: a case series

Nancy N Byl

Introduction: An emerging area of neurorehabilitation is the use of robotic devices to enhance the efficiency and effectiveness of lower extremity physical therapy post-stroke. Many of the robotic devices currently available rely on computer-driven locomotive algorithms combined with partial bodyweight-supported treadmill training that drive reflex stepping with minimal patient intention during therapy. In this case series, we examined the effect of task-oriented mobility training in patients in a post-stroke chronic state using a novel, wearable, mobile, intention-based robotic leg orthosis.

Case presentation: Three individuals, all of whom had reached a plateau with conventional bodyweight-supported treadmill training, participated in task-oriented mobility therapy (1.5 hours, two to four times per week for four weeks) with a robotic leg orthosis under supervision by a physical therapist. Participant 1 was a 59-year-old Caucasian man, who had an ischemic left stroke six years previously with resultant right hemiparesis. Participant 2 was a 42-year-old Caucasian woman with left hemiparesis after a right stroke 15 months previously. Participant 3 was a 62-year-old Caucasian woman with a history of a right middle cerebral artery aneurysm with third degree sub-arachnoid hemorrhage 10 years ago.
Immediately after training, all participants demonstrated improved gait speed (10 meter walk), stride length and walking endurance (6 minute walk) compared with baseline measurements. Improvements were maintained one month after training. Timed up and go and five times sit-to-stand were maintained for all three participants, with

Conclusions: … may improve **gait speed, endurance and community levels of participation** in select patients in a post-stroke chronic state after plateauing within a bodyweight-supported treadmill training program

… **safely supplemented supervised physical therapy**

Tibion Bionic Leg orthosis

Robot-assisted gait training improves motor performances and modifies Motor Unit firing in poststroke patients

C. CHISARI [1], F. BERTOLUCCI [1], V. MONACO [2], M. VENTURI [1], C. SIMONELLA [1], S. MICERA [2, 3], B. ROSSI [1]

EUR J PHYS REHABIL MED 2015;51:59-69

Timed Up and Go test (TUG), 6 Minute Walking Test (6MWT). Strength and Motor Unit firing rate of *vastus medialis* (VM) were analyzed during isometric knee extension through an isokinetic dynamometer and surface EMG recording.

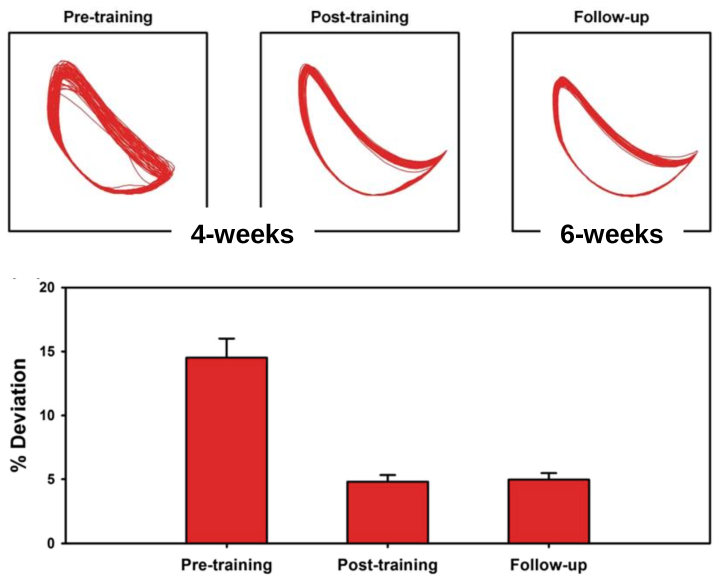
***Results*. An increase of duration and covered distance, a decrease of body weight support and guidance force on the paretic side along the sessions were observed. The FMMS, the BBS, the TUG and the 6MWT demonstrated a significant improvement after the training. No increase of force was observed whereas a significant increase of firing rate of VM was recorded.**

***Conclusion*. The evidence that the improvement of walking ability observed in our study determines a significant increase of firing rate of VM not accompanied by an increase of force could suggest an effect of training on motorneuronal firing rate that thus contributes to improve motor control.**

Active robotic training improves locomotor function in a stroke survivor

Chandramouli Krishnan[1,2,3*†], Rajiv Ranganathan[1†], Shailesh S Kantak[1], Yasin Y Dhaher[1,2] and William Z Rymer[1,2]

Journal of NeuroEngineering and Rehabilitation 2012, 9:57



Results: Active robotic training resulted in considerable increase in target-tracking accuracy and reduction in the kinematic variability of ankle trajectory during robot-aided treadmill walking. These improvements also transferred to overground walking as characterized by larger propulsive forces and more symmetric ground reaction forces.

ERIGO

- tavolo basculante (da 0° a 80°)
- meccanismo di movimento arti inferiori a controllo elettronico

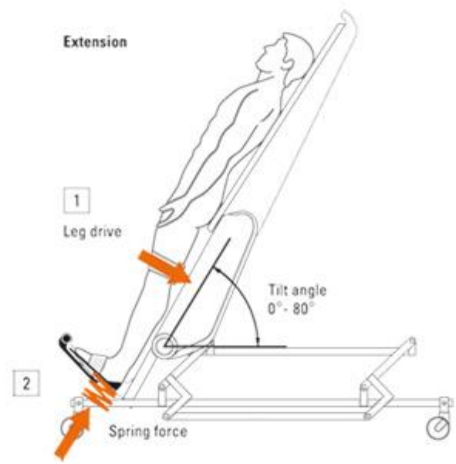
Supino 0° ⟶ Verticalizzazione 80°

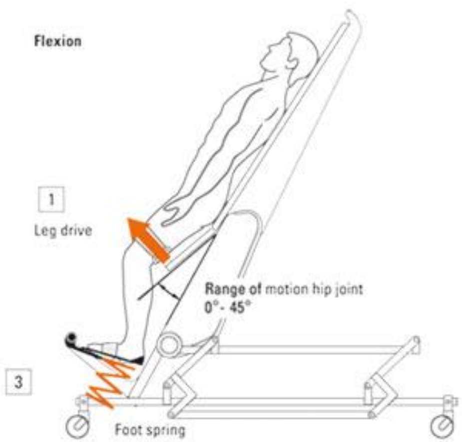
vantaggi rispetto al tavolo basculante tradizionale

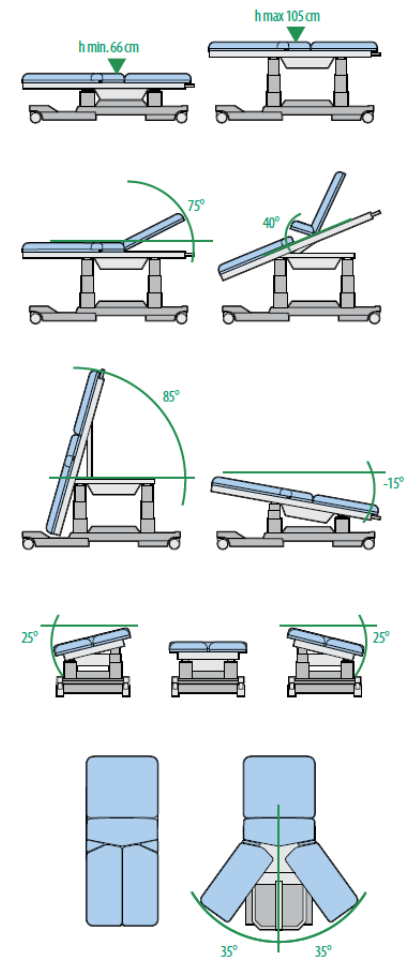
- verticalizzazione del paziente + movimento passivo degli arti inferiori;
- alterna carico e scarico degli arti inferiori del paziente;
- movimento adattato alle esigenze del paziente per l'arto inferiore destro e sinistro.

indicazioni

- circolazione instabile
- spasticità delle estremità inferiori
- mobilizzazione in caso di gravi lesioni cerebrali
- insufficienza respiratoria (polmonare)







BTS ANYMOV

Letto di degenza robotizzato per la mobilizzazione precoce del paziente con ictus

BTS ANYMOV è altamente raccomandato per pazienti che necessitano di continuità nella terapia di riabilitazione, come nel caso di patologie del sistema nervoso o di ospedalizzazione a lungo termine dei pazienti con deficit motori di vario tipo.

- Esiti post ictus
- Malattia di Alzheimer
- Encefalopatia multi-infartuale
- Degenerazione cerebrale senile
- Paraplegia
- Tetraplegia
- Malattia di Parkinson
- Insufficienza respiratoria cronica
- Disturbi alimentari gravi
- Gravi disturbi della coscienza

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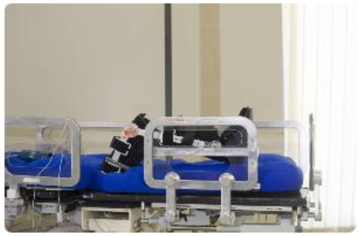

ULISSE

Rehalife
hi-tech devices for rehabilitation

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Dan Med J 60/12 | December 2013 | DANISH MEDICAL JOURNAL

Patients with severe acquired brain injury show increased arousal in tilt-table training

Christian G. Riberholt[1], Jonas B. Thorlund[2], Jesper Mehlsen[3] & Annette M. Nordenbo[1]

Participant characteristics (n = 16).

	Age, years	Sex	Days since injury	Days since admission to rehabilitation	Aetiology	GCS	FIM	EFA	Level of consciousness
Patient ID									
1	66	M	25	3	TBI	8	18	29	VS
3	56	M	93	50	Stroke	12	20	47	MCS
4	41	M	81	49	TBI	10	18	37	MCS
6	54	F	34	7	Stroke	10	18	29	MCS
7	18	M	12	7	TBI	11	18	28	MCS
8	67	F	24	3	TBI	6	18	30	VS
9	34	F	61	21	TBI	7	18	30	MCS
10	60	M	26	14	TBI	15	20	36	Aware
11	61	M	21	11	Stroke	12	18	39	Aware
12	45	M	33	11	Anoxia	14	18	38	MCS
13	71	F	56	5	Stroke	14	18	44	MCS
14	44	M	33	12	TBI	11	20	39	MCS
15	19	F	35	7	TBI	7	18	24	VS
16	20	M	44	13	TBI	12	18	38	MCS
17	20	F	47	9	TBI	11	18	32	MCS
18	74	M	21	8	TBI	8	18	27	MCS
Mean (± SD)	47 (± 20)	–	40 (± 22)	14 (± 14)					
Median (range)	–	–	–		–	11 (6-15)	18 (18-20)	34 (24-47)	–

	Before tilt	During tilt	After tilt	p-value
Time with open eyes/total evaluation time, sec., mean (± SD)	398 (± 454)/1,800	572 (± 414)/904 (± 409)	–	
Proportion of time, %, mean (± SD)	22.1 (± 25.2)	66.0 (± 40.7)	–	0.01[a]
Right ankle (n = 15)[c], n				0.52[b]
MAS = 0	10	–	12	
MAS = 1	4	–	3	
MAS > 1	1	–	0	
Left ankle (n = 15)[c], n				0.59[b]
MAS = 0	10	–	11	
MAS = 1	4	–	4	
MAS > 1	1	–	0	
Right elbow (n = 16), n				0.47[b]
MAS = 0	10	–	10	
MAS = 1	3	–	5	
MAS > 1	3	–	1	
Left elbow (n = 16), n				0.56[b]
MAS = 0	11	–	13	
MAS = 1	2	–	2	
MAS > 1	3	–	1	

MAS = Modified Ashworth Scale; SD = standard deviation.
a) Paired sample t-test.
b) χ^2-test.
c) 1 patient had contracture and 1 patient had an amputation of the 1st toe, which made testing impossible.

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2. *Luther MS, Krewer C, Müller F et al. Comparison of orthostatic reactions of patients still unconscious within the first three months of brain injury on a tilt table with and without integrated stepping. A prospective, randomized crossover pilot trial. Clin Rehab 2008;22:1034-41.*

RESEARCH ARTICLE **Open Access**

Sympathetic activity and early mobilization in patients in intensive and intermediate care with severe brain injuries: a preliminary prospective randomized study

A. Rocca[1*], J.-M. Pignat[2], L. Berney[2], J. Jöhr[2], D. Van de Ville[3], R. T. Daniel[1], M. Levivier[1], L. Hirt[4], A. R. Luft[5], E. Grouzmann[6] and K. Diserens[2]

Rocca *et al. BMC Neurology* (2016) 16:169
DOI 10.1186/s12883-016-0684-2

Abstract

Background: Patients who experience severe brain injuries are at risk of secondary brain damage, because of delayed vasospasm and edema. Traditionally, many of these patients are kept on prolonged bed rest in order to maintain adequate cerebral blood flow, especially in the case of subarachnoid hemorrhage. On the other hand, prolonged bed rest carries important morbidity. There may be a clinical benefit in early mobilization and our hypothesis is that early gradual mobilization is safe in these patients. The aim of this study was to observe and quantify the changes in sympathetic activity, mainly related to stress, and blood pressure in gradual postural changes by the verticalization robot (Erigo®) and after training by a lower body ergometer (MOTOmed-letto®), after prolonged bed rest of minimum 7 days.

Methods: Thirty patients with severe neurological injuries were randomized into 3 groups with different protocols of mobilization: Standard, MOTOmed-letto® or Erigo® protocol. We measured plasma catecholamines, metanephrines and blood pressure before, during and after mobilization.

Results: Blood pressure does not show any significant difference between the 3 groups. The analysis of the catecholamines suggests a significant increase in catecholamine production during Standard mobilization with physiotherapists and with MOTOmed-letto® and no changes with Erigo®.

Conclusions: This preliminary prospective randomized study shows that the mobilization of patients with severe brain injuries by means of Erigo® does not increase the production of catecholamines. It means that Erigo® is a well-tolerated method of mobilization and can be considered a safe system of early mobilization of these patients. Further studies are required to validate our conclusions.

Trial registration: The study was registered in the ISRCTN registry with the trial registration number ISRCTN56402432. Date of registration: 08.03.2016. Retrospectively registered.

Keywords: Mobilization, Catecholamines, Robotic, Neurovegetative disorders, Subarachnoid hemorrhage, Brain injuries

Early mobilization does not increase the production of catecholamines and is a well-tolerated method of mobilization.

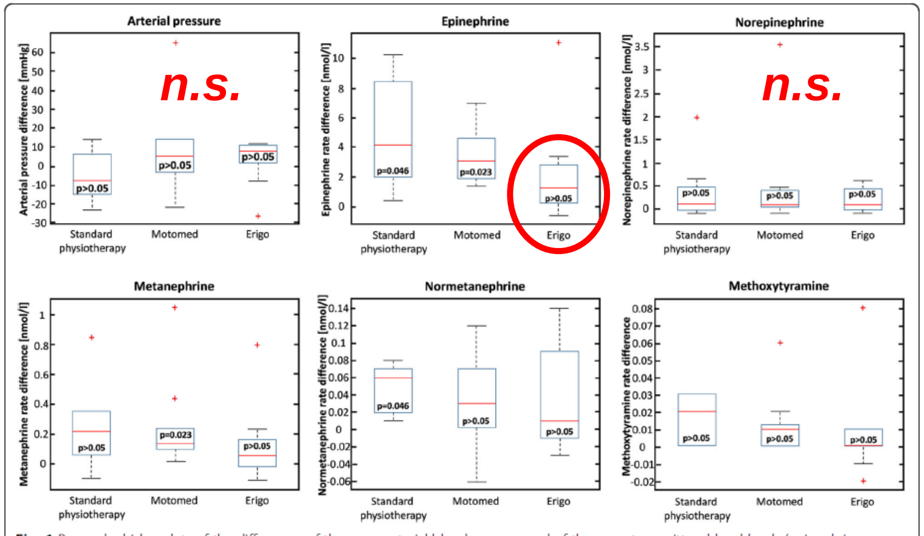


Fig. 1 Box and whisker plots of the differences of the mean arterial blood pressure and of the neurotransmitters blood levels (epinephrine, norepinephrine, metanephrine, normetanephrine, methoxytyramine) between T2 (immediately before mobilization) and T3 (during mobilization) for the three modalities (standard physiotherapy, MOTOmed®, Erigo®). Null hypothesis of the Wilcoxon non-parametric test is tested for a symmetric distribution with zero median; significance level is 0.05 after Bonferroni-Holm correction for multiple comparisons. Legends: the red line inside the box represents the median, the blue edges of the box the 25th and 75th percentiles, the black lines the 1st and 99th percentiles, and the red crosses the outliers

Cardiovascular response to functional electrical stimulation and dynamic tilt table therapy to improve orthostatic tolerance ☆

Lorne Chi [a,b], Kei Masani [a,b], Masae Miyatani [a,b], T. Adam Thrasher [c], K. Wayne Johnston [a],
Alexandra Mardimae [d,e], Cathie Kessler [e], Joseph A. Fisher [d,e], Milos R. Popovic [a,b,*]

Journal of Electromyography and Kinesiology 18 (2008) 900–907

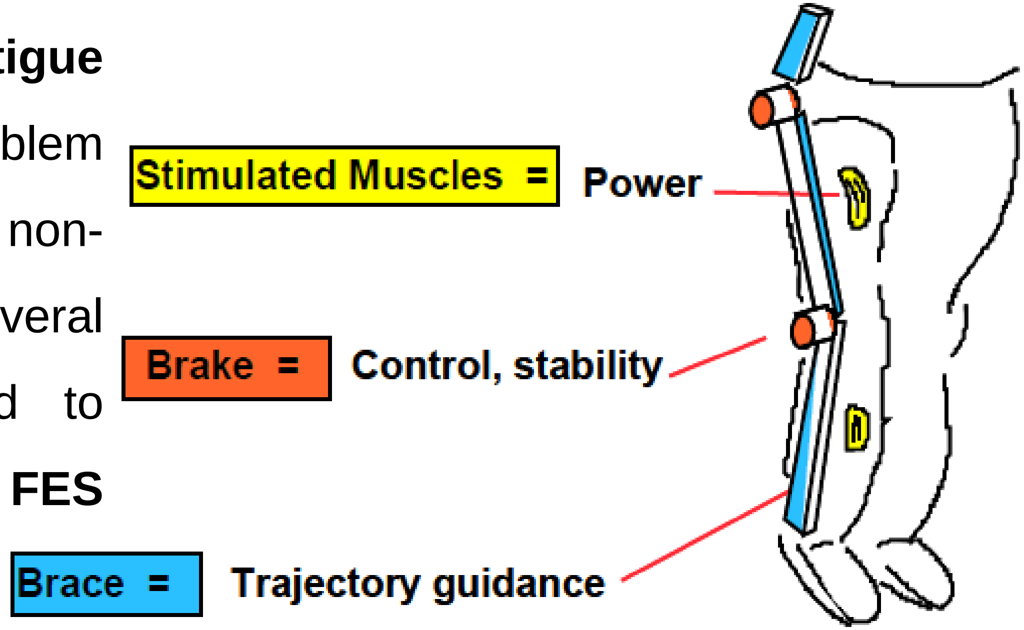
This study compared the use of functional electrical stimulation (FES) and passive leg movements to improve orthostatic tolerance during head-up tilt. **Four trial conditions were assessed during head-up tilt**: (1) **rest** (2) **isometric FES of the hamstring, gastrocnemius and quadriceps muscle group** (3) **passive mobilization using the Erigo dynamic tilt table** and (4) **dynamic FES (combined 2 and 3)**.

Ten healthy male subjects experienced 70 head-up tilt for 15 min under each trial condition. Heart rate, blood pressure and abdominal echograms of the inferior vena cava were recorded for each trial. Passive mobilization and dynamic FES resulted in an increase in intravascular blood volume, while isometric FES only resulted in elevating heart rate. No significant differences in blood pressure were observed under each condition.

We **conclude that FES combined with passive stepping movements may be an effective modality to increase circulating blood volume and thereby tolerance to postural hypotension in healthy subjects.**

... new solutions for gait assistance

To tackle the **problem of fatigue** that limits gait time and the problem of poor control that leads to non-repeatable stepping motions, several research groups have turned to **hybrid systems** that **combine FES with a mechanical orthosis.**



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THE COCHRANE COLLABORATION®

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Transcranial direct current stimulation (tDCS) for improving activities of daily living, and physical and cognitive functioning, in people after stroke.

Elsner B, Kugler J, Pohl M, Mehrholz J.

Cochrane Database Syst Rev 2016;Mar;21:3:CD009645.

MAIN RESULTS: **We included 32 studies involving a total of 748 participants** aged above 18 with acute, postacute or chronic ischaemic or haemorrhagic stroke. We also identified **55 ongoing studies**. The risk of bias did not differ substantially for different comparisons and outcomes.

AUTHORS' CONCLUSIONS: At the moment, evidence of very low to moderate quality is available on the effectiveness of tDCS (anodal/cathodal/dual) versus control (sham/any other intervention) for improving ADL performance after stroke.

However, there are many ongoing randomised trials that could change the quality of evidence in the future. Future studies should particularly engage those who may benefit most from tDCS after stroke and in the effects of tDCS on upper and lower limb function, muscle strength and cognitive abilities (including spatial neglect). Dropouts and adverse events should be routinely monitored and presented as secondary outcomes. They should also address methodological issues by adhering to the Consolidated Standards of Reporting Trials (CONSORT) statement.

Hospitals & Research

LITERATURE REVIEW

OPEN

Combining Dopaminergic Facilitation with Robot-Assisted Upper Limb Therapy in Stroke Survivors

A Focused Review

ABSTRACT

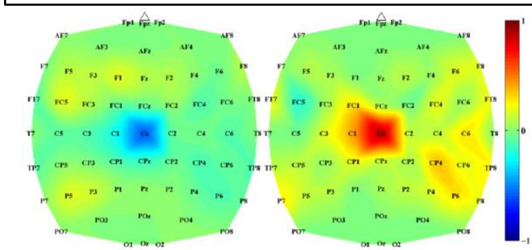
Tran DA, Pajaro-Blazquez M, Daneault J-F, Gallegos JG, Pons J, Fregni F, Bonato P, Zafonte R: Combining dopaminergic facilitation with robot-assisted upper limb therapy in stroke survivors: a focused review. Am J Phys Med Rehabil 2016;95:459–474.

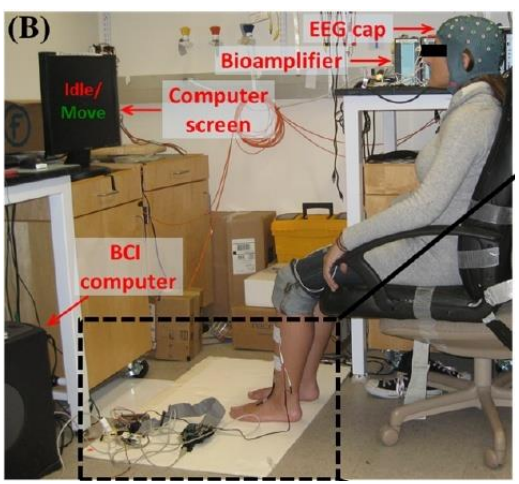
RESEARCH Open Access

Brain-Computer Interface Controlled Functional Electrical Stimulation System for Ankle Movement

An H Do[1,2*], Po T Wang[3], Christine E King[3], Ahmad Abiri[4] and Zoran Nenadic[3,4*]

Journal of NeuroEngineering and Rehabilitation 2011, 8:49





Background: Brain-computer interface (BCI) is a relatively novel technology with a potential to restore, substitute, or augment lost motor behaviors in patients with neurological injuries. We describe the first **successful integration of a noninvasive electroencephalogram (EEG)-based BCI with a noninvasive functional electrical stimulation (FES) system that enables the direct brain control of foot dorsiflexion** in able-bodied individuals.

Conclusions: This study suggests that the integration of a noninvasive BCI with a lower-extremity FES system is feasible. With additional modifications, the proposed BCI-FES system may offer a novel and effective therapy in the neuro-rehabilitation of individuals with lower extremity paralysis due to neurological injuries.

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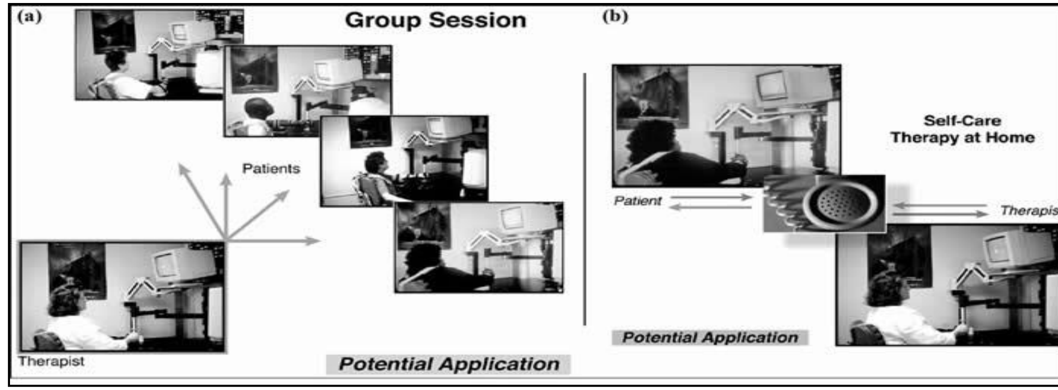
Future developments



JRRD
Journal of Rehabilitation Research & Development
Volume 43 Number 5, August/September 2006
Pages 695 — 710

Telerehabilitation robotics: Bright lights, big future?

Craig R. Carignan, ScD;[1*] Hermano I. Krebs, PhD[2]

[1]Georgetown University, Washington, DC; [2]Massachusetts Institute of Technology, Cambridge, MA

Abstract — The potential for remote diagnosis and treatment over the Internet using robotics is now a reality. The state of the art is exemplified by several Internet applications, and we explore the current trends in developing new systems. We review the technical challenges that lie ahead, along with some potential solutions. Some promising results for a new bilateral system involving two InMotion2 robots are presented. Finally, we discuss the future direction and commercial outlook for rehabilitation robots over the next 15 years.

Scientific evidences

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1 ☐ **Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke**

Jan Mehrholz, Marcus Pohl, Thomas Platz, Joachim Kugler, Bernhard Elsner

Show Preview Intervention Review 3 September 2018 New search Conclusions changed

2 ☐ **Electromechanical-assisted training for walking after stroke**

Jan Mehrholz, Simone Thomas, Cordula Werner, Joachim Kugler, Marcus Pohl, Bernhard Elsner

Show Preview Intervention Review 10 May 2017 New search Conclusions changed

3 ☐ **Interventions for improving upper limb function after stroke**

Alex Pollock, Sybil E Farmer, Marian C Brady, Peter Langhorne, Gillian E Mead, Jan Mehrholz, Frederike van Wijck

Show Preview Overview Review 12 November 2014

4 ☐ **Locomotor training for walking after spinal cord injury**

Jan Mehrholz, Joachim Kugler, Marcus Pohl

Show Preview Intervention Review 14 November 2012 New search

Cochrane Library

Electromechanical-assisted training for walking after stroke (Review)

Mehrholz J, Elsner B, Werner C, Kugler J, Pohl M

The Cochrane Library 2013, Issue 7

Background

Electromechanical and robotic-assisted gait training devices are used in rehabilitation and might help to improve walking after stroke. This is an update of a Cochrane Review first published in 2007.

Authors' conclusions

People who receive electromechanical-assisted gait training in combination with physiotherapy after stroke are more likely to achieve independent walking than people who receive gait training without these devices. Specifically, people in the first three months after stroke and those who are not able to walk seem to benefit most from this type of intervention. The role of the type of device is still not clear. Further research should consist of a large definitive, pragmatic, phase III trial undertaken to address specific questions such as the following: What frequency or duration of electromechanical-assisted gait training might be most effective? How long does the benefit last?

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Electromechanical and robot-assisted arm training for improving generic activities of daily living, arm function, and arm muscle strength after stroke (Review)

Mehrholz J, Hädrich A, Platz T, Kugler J, Pohl M

Main results

We included ***19 trials (involving 666 participants)*** in this update of our review. Electromechanical and robot-assisted arm training did improve:
- ***activities of daily living*** (SMD 0.43, 95% confidence interval (CI) 0.11 to 0.75, P = 0.009, I2 = 67%)
- ***arm function*** (SMD 0.45, 95% CI 0.20 to 0.69, P = 0.0004, I2 = 45%),
but arm muscle strength ***did not improve*** (SMD 0.48, 95% CI -0.06 to 1.03, P = 0.08, I2 = 79%). Electromechanical and robot-assisted arm training did not increase the risk of patients to drop out (RD 0.00, 95% CI -0.04 to 0.04, P = 0.82, I2 = 0.0%), and adverse events were rare.

Authors' conclusions

Patients who receive electromechanical and robot-assisted arm training after stroke are more likely to improve their generic activities of daily living. Paretic arm function may also improve, but not arm muscle strength. However, the results must be interpreted with caution because there were ***variations between the trials in the duration and amount of training, type of treatment, and in the patient characteristics***.

Neuroprosthesis with electromyographic control

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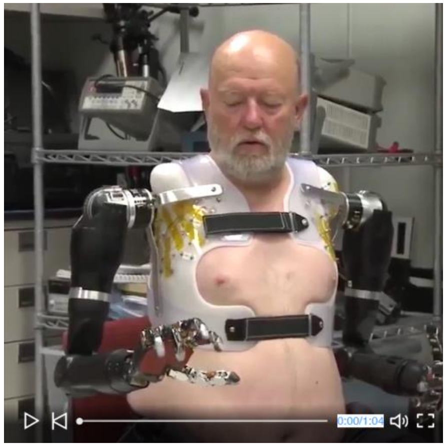

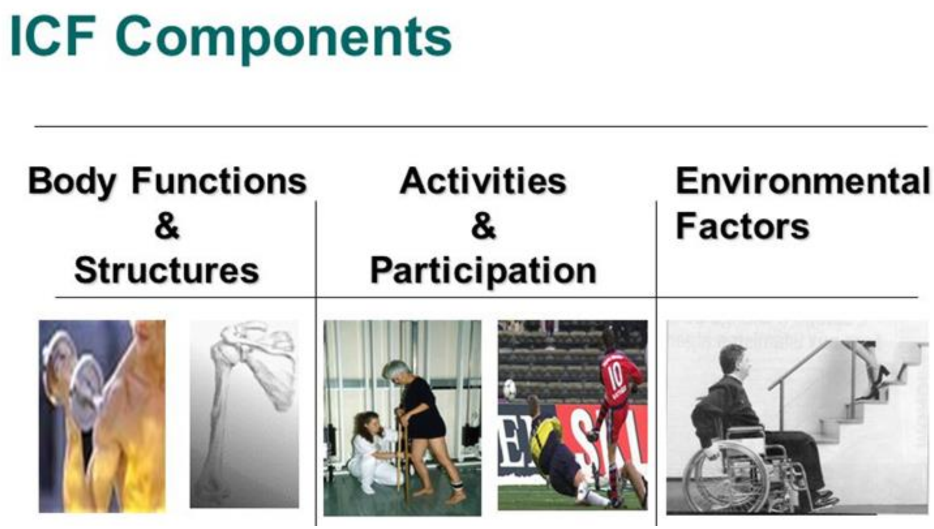

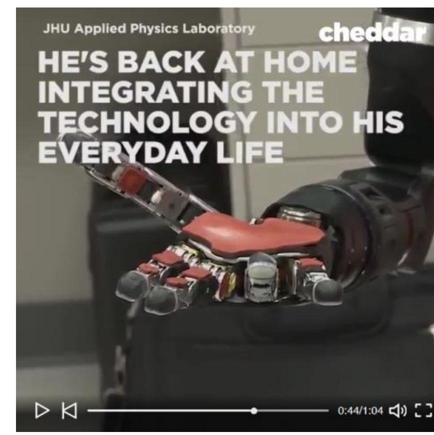

The cybernetic rehabilitation aid: preliminary results for wrist and elbow motions in healthy subjects.

Akdogan E, Shina K, Kataoka H, Hasegawa M, et al.

IEEE Trans Neural Syst Rehabil Eng, 2012;20(5):697-707.

… EMG signals measured from a patient are analyzed using a log-linearized Gaussian mixture network that can classify motion patterns and compute the degree of similarity between the patient's measured EMG patterns and the desired pattern provided by the therapist. Tactile stimulators are used to convey motion instructions from the therapist or the system to the patient, and a rehabilitation robot can also be integrated into the developed prototype to increase its rehabilitation capacity. **A series of experiments performed using the developed prototype demonstrated that the CRA (Cibernetic Rehabilitation Aid) can work as a human-human, human-computer and human-machine system.** The experimental results indicated that the healthy (able-bodied) subjects were able to follow the desired muscular contraction levels instructed by the therapist or the system and perform proper joint motion without relying on visual feedback

Multidisciplinary approach to biotechnologies

Rehabil Nurs. 2005 Mar-Apr;30(2):40-3.

The ethics of using cybernetics and cyborg technologies: what every rehabilitation nurse should know.

Moore LW[1], Rieg LS.

Author information

Abstract

Cybernetics and cyborg technologies are rapidly developing in the field of biotechnology. Such developments have yielded a wide variety of devices and prosthetics that have promoted the quality of life for many individuals with physical limitations and generally have been applauded by society and the rehabilitation field. However, such rapid developments have given rise to multiple ethical concerns. Understanding these ethical concerns and the implications they have for rehabilitation nurses is imperative. While the potential benefits of advances in technology are great for those with disabilities and chronic conditions, ethicists suggest that skepticism must be balanced with the zeal that often accompanies cutting-edge developments. As Hook notes, "We must show not a fear of technology, but a courageous control of technology, and refuse to let technology control us" (2002, p. 67).

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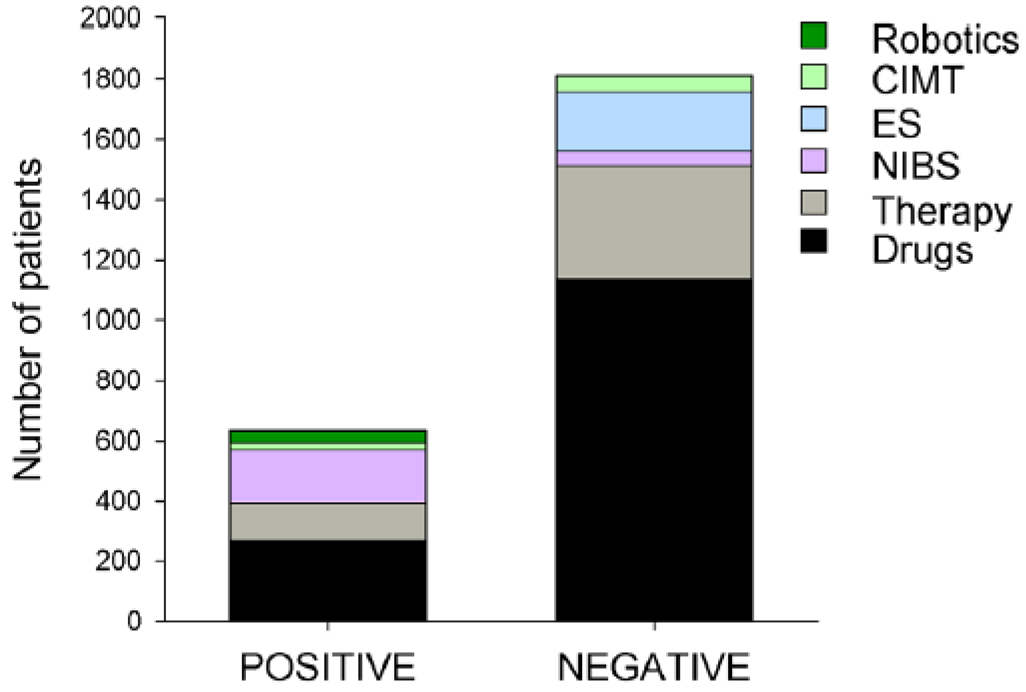
ELSEVIER

Acceptability of robotic technology in neuro-rehabilitation: Preliminary results on chronic stroke patients

Stefano Mazzoleni[a,b,*], *Giuseppe Turchetti*[c], *Ilaria Palla*[c], *Federico Posteraro*[b,d], *Paolo Dario*[a]

During the last decade, different robotic devices have been developed for motor rehabilitation of stroke survivors. These devices have been shown to improve motor impairment and contribute to the understanding of mechanisms underlying motor recovery after a stroke. The assessment of the robotic technology for rehabilitation assumes great importance. The aim of this study is to present preliminary results on the assessment of the acceptability of the robotic technology for rehabilitation on a group of thirty-four chronic stroke patients. The results from questionnaires on the patients' acceptability of two different robot-assisted rehabilitation scenarios show that the robotic approach was well accepted and tolerated by the patients.

Journal Computer Methods and Programs in Biomedicine 2014;116(2):116-122.



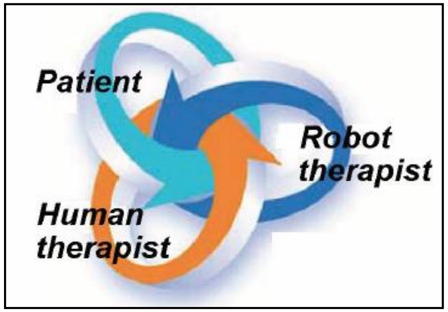
Number of patients in **good quality early studies, with positive or negative primary outcomes.** CIMT indicates constraint-induced movement therapy; drugs, pharmacological agents ES, electrostimulation; NIBS, noninvasive brain stimulation; and therapy, variations of standard physiotherapy.

1. *Stinear C, Ackerlev S, Byblow W. Rehabilitation is Initiated Early After Stroke, but Most Motor Rehabilitation Trials Are Not. A Systematic Review. Stroke 2013;44:2039-2045.*

Conclusioni

1. Lo sviluppo e l'impiego di tecnologie in riabilitazione potrebbe rappresentare una possibile via per aumentare l'intensità del trattamento e migliorare i risultati, contenendo i costi.

2. La realtà dei robot in riabilitazione non è destinata a rimpiazzare il lavoro del terapista, "deumanizzando" l'intervento riabilitativo, ma piuttosto rappresenta uno strumento aggiuntivo per incrementare l'intensità delle terapie, in linea con i moderni principi della riabilitazione.



3. **L'attività riabilitativa svolta attraverso le tecnologie dovrebbe essere considerata alla stregua di un "farmaco", come "opzione terapeutica" da integrare nel contesto biologico, neurobiologico ed epigenetico.**

Conclusioni

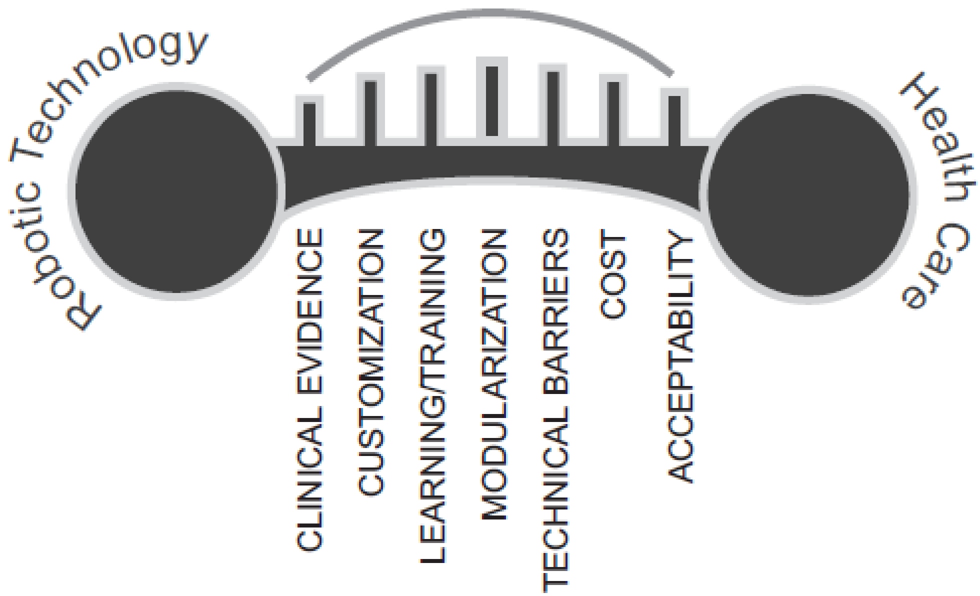


Fig. 3. Key identified variables that should be taken into account in the process of bridging the gap between robotic technology and health care.

Review

Bridging the gap between robotic technology and health care

Adriano O. Andrade[a,*], Adriano A. Pereira[a], Steffen Walter[b], Rosimary Almeida[c], Rui Loureiro[d], Diego Compagna[e], Peter J. Kyberd[f]

Biomedical Signal Processing and Control 10 (2014) 65–78