



# La Robotica: **Luci** e Ombre



**SANTA LUCIA**

NEUROSCIENZE  
E RIABILITAZIONE

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Clinical Laboratory of  
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26/10/2018V

# Le Ombre della Robotica

J. Med. Biol. Eng. (2016) 36:1–11  
DOI 10.1007/s40846-016-0115-2

REVIEW ARTICLE



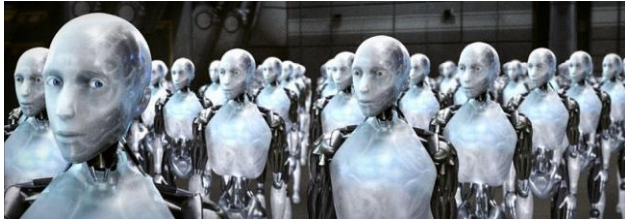
## The Three Laws of Neurorobotics: A Review on What Neurorehabilitation Robots Should Do for Patients and Clinicians

Marco Iosa<sup>1</sup> · Giovanni Morone<sup>1</sup> · Andrea Cherubini<sup>2</sup> · Stefano Paolucci<sup>1</sup>



Iosa et al. 2012; Mehrholz et al. Cochrane Reviews 2017 (Arto inferiore e Robotica), 2018 (Arto superiore e Robotica); Bissolotti et al. 2018; Bragoni et al. 2013

# Definizione di Robot



Un Robot (letteralmente «lavoratore forzato») è un manipolatore programmabile e multifunzione in grado di muovere del materiale con un movimento adattabile ai diversi compiti



*The Robot Institute of America, 2003*

# Caratteristiche di un robot per la neuroriabilitazione

Table 1 Ideal features of neurorobot

Wolbrecht et al. [29]	Morasso et al. [18]	Belda-Lois et al. [28]	Dietz et al. [30]
High mechanical compliance	High mechanical compliance	Repeatability	Standardized training sessions
Ability to assist patients in completing desired movements	Large range of force	Increased training motivation through use of interactive (bio)feedback	Intensive training
Minimum assistance level	Minimum assistance level	Precisely controllable assistance or resistance during movements	Relieves therapist from physically demanding work
	Soft haptic interaction for proprioceptive awareness	Objective and quantifiable measures of subject performance	Objective and quantifiable measures of subject performance
	Adaptive assistance properties		

The Three Laws of Neurorobotics: A Review on What Neurorehabilitation Robots Should Do for...

7

Table 2 Clinical trial phases in drug commercialization and motor rehabilitation

Phase	Drug commercialization	Studies on rehabilitation	Purpose
Phase I	<i>Checking for safety</i> (on 10–20 healthy volunteers)	<i>Consideration-of-concept studies</i> (on 6–12 patients)	To test concepts and related safety on animals or on a small group of patients
Phase II	<i>Checking for efficacy</i> (on about 200 patients)	<i>Development of Concept Trials</i> (>15 patients)	To standardize the new intervention and add a control group, randomization, and masked outcomes. To establish the best dose of therapy. To assess sample size
Phase III	<i>Confirmation of findings in large patient population</i> (>1000 patients for detecting rare side effects)	<i>Demonstration of Concept Trials</i> (on a sample with a properly computed size)	To prove effectiveness and safety of intervention
Phase IV	<i>Testing long-term safety</i> (real life patients)	<i>Proof of concept</i> (multicenter randomized clinical trials)	To establish generalizable efficacy and safety



# Le 3 leggi della Neurorobotica

- 1) Un robot non può recare danno a un essere umano né può permettere che, a causa del proprio mancato intervento, un essere umano riceva danno.
- 2) Un robot deve obbedire agli ordini impartiti dagli esseri umani, purché tali ordini non contravvengano alla Prima Legge.
- 3) Un robot deve proteggere la propria esistenza, purché questa autodifesa non contrasti con la Prima o con la Seconda Legge



Asimov, I Robot, 1950

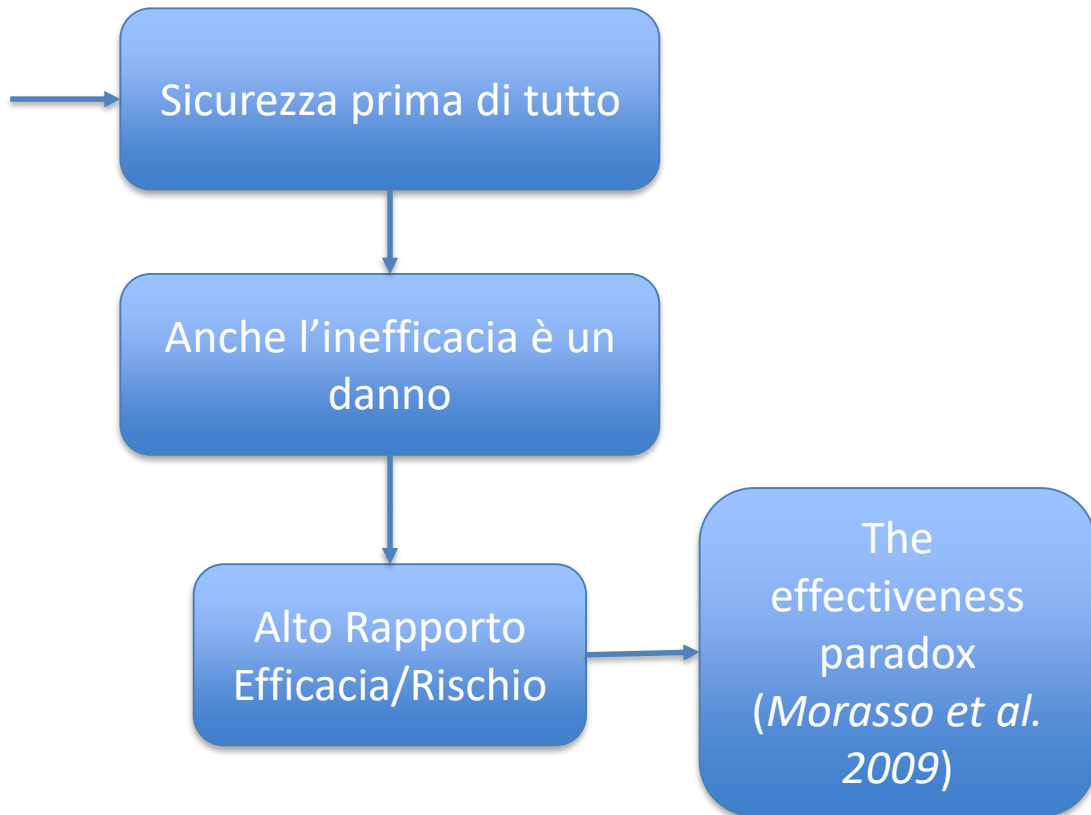
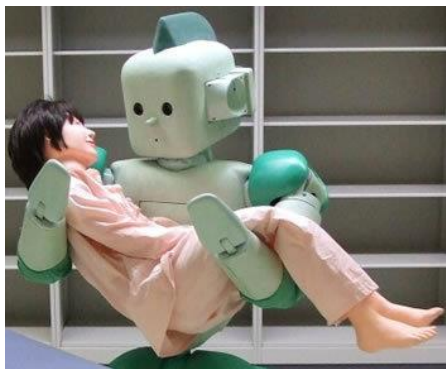
## The Three Laws of Neurorobotics: A Review on What Neurorehabilitation Robots Should Do for Patients and Clinicians

Marco Iosa<sup>1</sup> · Giovanni Morone<sup>1</sup> · Andrea Cherubini<sup>2</sup> · Stefano Paolucci<sup>1</sup>

- 1) Un robot per la neuroriabilitazione non può recare danno ad un paziente o permettere che un paziente abbia un danno
- 2) Un robot deve obbedire agli ordini impartiti dai terapeuti, purché tali ordini non contravvengano alla Prima Legge.
- 3) Un robot deve adattare il suo funzionamento alle abilità del paziente in un modo trasparente purché ciò non contrasti con le prime due leggi.

# La prima legge della Neurorobotica

Un Robot per la neuroriabilitazione non può recare danno ad un paziente o permettere che un paziente abbia un danno



# La domanda non è se è efficace, ma per chi è efficace...?

## Who May Benefit From Robotic-Assisted Gait Training? A Randomized Clinical Trial in Patients With Subacute Stroke

Neurorehabilitation and Neural Repair  
XX(X) 1-9  
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DOI: 10.1177/1545968311401034  
<http://nrr.sagepub.com>  
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Giovanni Morone, MD<sup>1</sup>, Maura Bragoni, PhD<sup>1</sup>, Marco Iosa, PhD<sup>1</sup>,  
Domenico De Angelis, MD<sup>1</sup>, Vincenzo Venturiero, PhD<sup>1</sup>,  
Paola Coiro, MD<sup>1</sup>, Luca Pratesi, MD<sup>1</sup>, and Stefano Paolucci, MD<sup>1</sup>

# Stroke

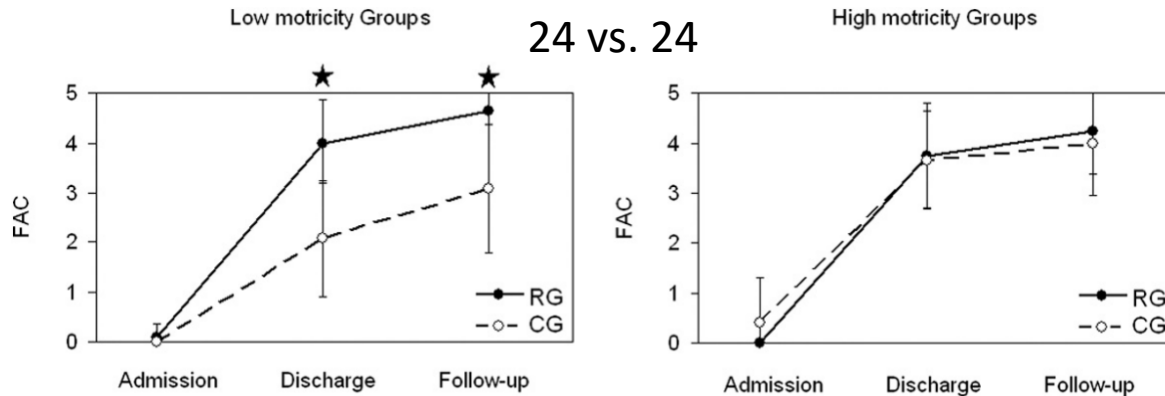
American Stroke  
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JOURNAL OF THE AMERICAN HEART ASSOCIATION

Who May Have Durable Benefit From Robotic Gait Training? : A 2-Year  
Follow-Up Randomized Controlled Trial in Patients With Subacute Stroke  
Giovanni Morone, Marco Iosa, Maura Bragoni, Domenico De Angelis, Vincenzo  
Venturiero, Paola Coiro, Raffaella Riso, Luca Pratesi and Stefano Paolucci

N=48  
24 vs. 24



# La domanda non è se è efficace, ma per chi è efficace...?

## Who May Benefit From Robotic-Assisted Gait Training? A Randomized Clinical Trial in Patients With Subacute Stroke

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Restorative Neurology and Neuroscience 36 (2018) 293–299  
DOI 10.3233/RNN-170799  
IOS Press

Giovanni Morone, MD<sup>1</sup>, Maura Bragoni, PhD<sup>1</sup>, Marco Iosa, PhD<sup>1</sup>,  
Domenico De Angelis, MD<sup>1</sup>, Vincenzo Venturiero, PhD<sup>1</sup>,  
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# Stroke

American Stroke  
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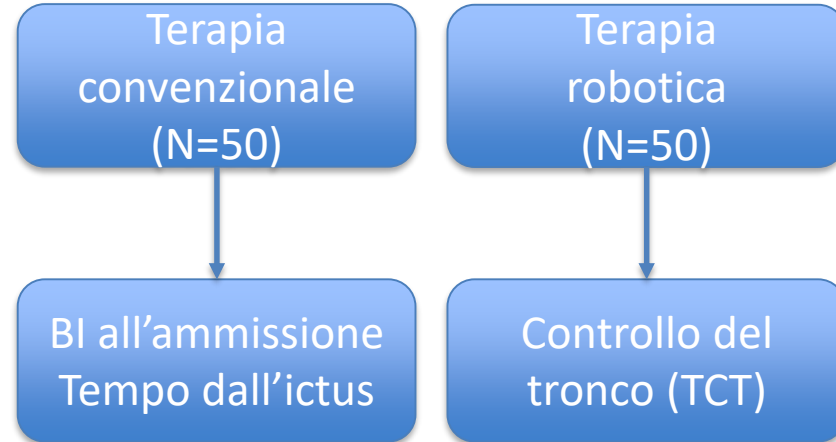
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N=48  
24 vs. 24

## Clinical features of patients who might benefit more from walking robotic training

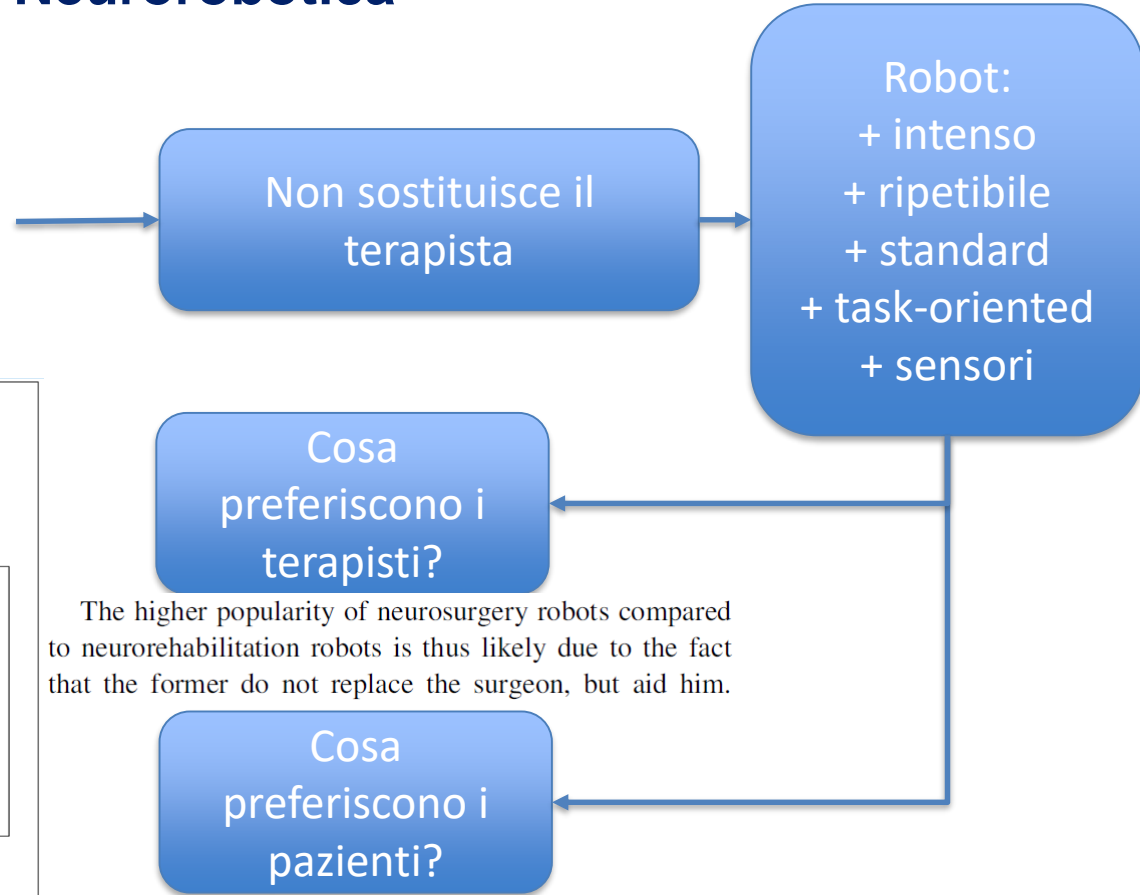
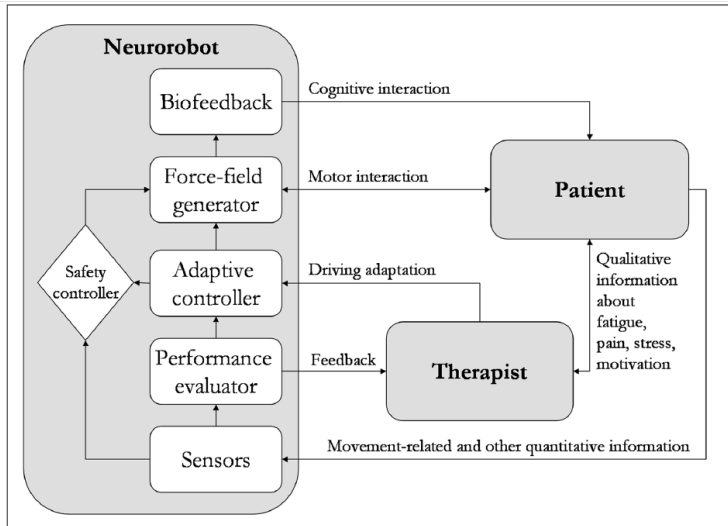
Giovanni Morone<sup>a,b,\*</sup>, Stefano Masiero<sup>c</sup>, Paola Coiro<sup>a</sup>, Domenico De Angelis<sup>a</sup>,  
Vincenzo Venturiero<sup>a</sup>, Stefano Paolucci<sup>a,b</sup> and Marco Iosa<sup>a,b</sup>





# La seconda legge della Neurorobotica

Un robot deve obbedire agli ordini impartiti dai terapeuti, purché tali ordini non contravvengano alla Prima Legge.

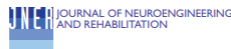


The higher popularity of neurosurgery robots compared to neurorehabilitation robots is thus likely due to the fact that the former do not replace the surgeon, but aid him.

Fig. 1 Ideal patient-therapist-robot loop

# Cosa preferisce il terapeuta?

Delussu et al. *Journal of NeuroEngineering and Rehabilitation* 2014, 11:54  
<http://www.jneuroengrehab.com/content/11/1/54>



RESEARCH

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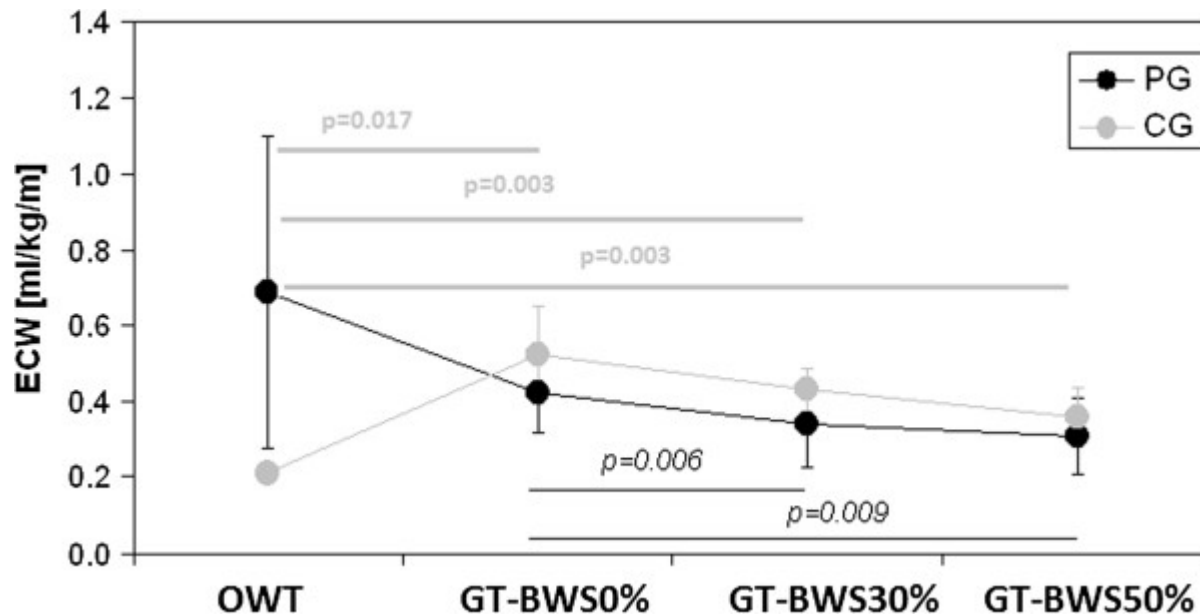
Physiological responses and energy cost of walking on the Gait Trainer with and without body weight support in subacute stroke patients

Anna Sofia Delussu<sup>1</sup>, Giovanni Morone, Marco Iosa, Maura Bragoni, Marco Trallesi and Stefano Paolucci

Research Article

**Concurrent Validity of Physiological Cost Index in Walking over Ground and during Robotic Training in Subacute Stroke Patients**

Anna Sofia Delussu, Giovanni Morone, Marco Iosa, Maura Bragoni, Stefano Paolucci, and Marco Trallesi



# I pazienti si fidano dei Robot?

## ORIGINAL RESEARCH ARTICLE

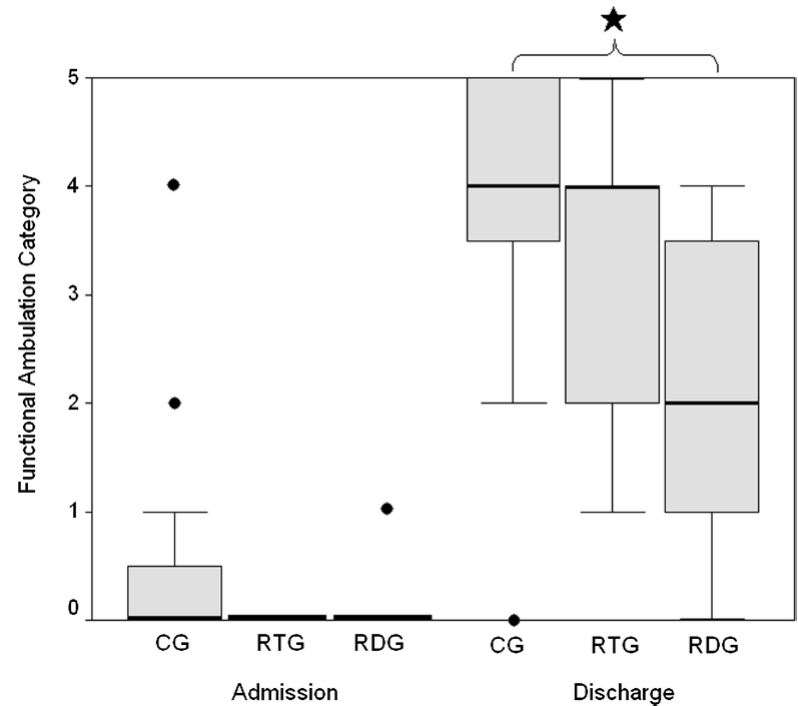
### Influence of Psychologic Features on Rehabilitation Outcomes in Patients with Subacute Stroke Trained with Robotic-Aided Walking Therapy

#### ABSTRACT

Bragoni M, Broccoli M, Iosa M, Morone G, De Angelis D, Venturiero V, Coiro P, Pratesi L, Mezzetti G, Fusco A, Paolucci S: Influence of psychologic features on rehabilitation outcomes in patients with subacute stroke trained with robotic-aided walking therapy. *Am J Phys Med Rehabil* 2013;92(Suppl):e16–e25.

**TABLE 1** Summary of demographic, clinical, physical, and psychologic characteristics of patients and primary caregivers

Patients' Characteristics		CG	RTG	RDG	P
Demographic features	No. subjects	24	11	7	—
	Age, mean ± SD, yrs	66.0 ± 12.0	58.6 ± 13.8	64.7 ± 5.0	0.239
	Sex (male/female), n	16/8	8/3	3/4	0.710
Clinical features, n	Etiology	20/4	11/0	6/1	0.271
	(ischemic/hemorrhagic)				
	Side of hemiparesis (right/left)	12/12	7/4	2/5	1.000
Physical features, median (interquartile range)	BI score	17 (19)	15 (17)	5 (10)	0.292
	FAC score	0 (0)	0 (0)	0 (0)	0.180
Psychologic features, median (interquartile range)	HADS-A	6 (6)	9 (10)	15 (4)	<b>0.008</b>
	HADS-D	7 (5)	8 (6)	7 (9)	0.954
	EPQ/R-E	0.6 (1.1)	-0.4 (1.5)	0.7 (1.1)	<b>0.019</b>
	EPQ/R-N	0.1 (1.7)	0.9 (2.0)	0.6 (1.0)	0.760
	EPQ/R-P	-0.1 (1.9)	-0.4 (1.4)	2.3 (2.1)	0.166
	EPQ/R-L	-0.2 (2.5)	0.0 (1.0)	-0.3 (2.2)	0.844
	RLC	69 (20)	78 (15)	67 (8)	0.234



CG: gruppo controllo, terapia convenzionale  
 RTG: gruppo robotica  
 RDG: gruppo assegnato alla robotica che ha abbandonato

# La terza legge della Neurorobotica

Un robot deve adattare il suo funzionamento alle abilità del paziente in un modo trasparente purché ciò non contrasti con le prime due leggi.

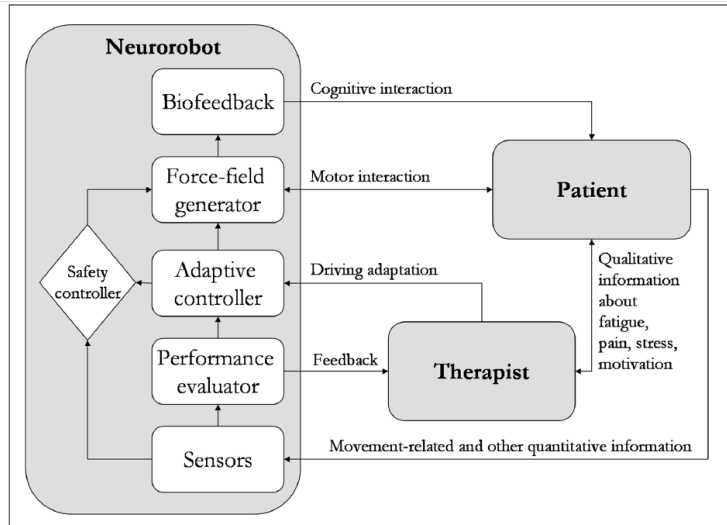
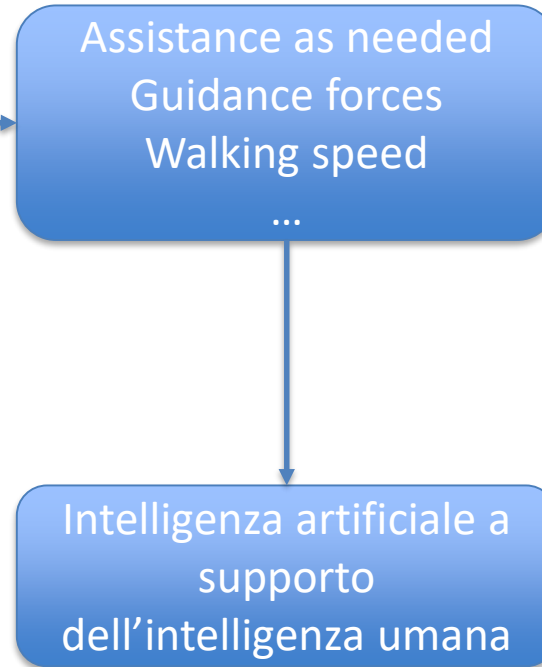


Fig. 1 Ideal patient-therapist-robot loop

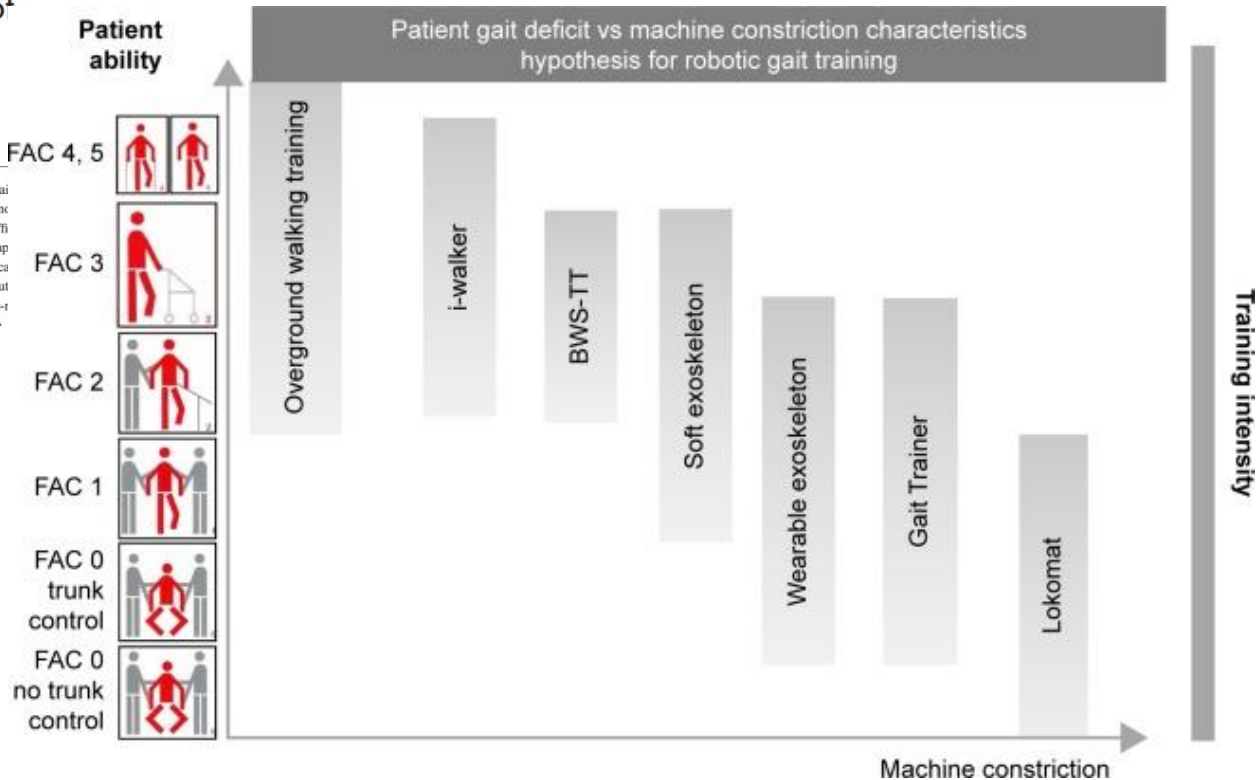
# Il Robot giusto per il Paziente giusto al momento giusto

## Robot-assisted gait training for stroke patients: current state of the art and perspectives of robotics

This article was published in the following Dove Press journal:  
Neuropsychiatric Disease and Treatment  
15 May 2017  
Number of times this article has been viewed

Giovanni Morone<sup>1,2</sup>  
Stefano Paolucci<sup>1,2</sup>  
Andrea Cherubini<sup>3</sup>  
Domenico De Angelis<sup>1</sup>  
Vincenzo Venturiero<sup>1</sup>  
Paola Coiro<sup>1</sup>  
Marco Iosa<sup>1,2</sup>

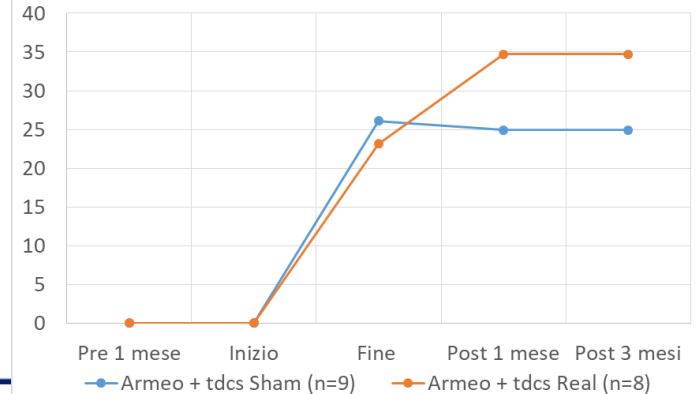
**Abstract:** In this review, we give a brief outline of robot-mediated gait patients, as an important emerging field in rehabilitation. Technological innovation rehabilitation to move toward more integrated processes, with improved efficiency impairments. In particular, robot-mediated neurorehabilitation is a paradigm which uses robotic systems to define new methods for treating neurological stroke. The use of robots in gait training can enhance rehabilitation, but according to well-defined neuroscientific principles. The field of robot-assisted gait training brings challenges to both basic neuroscience and clinical practice.



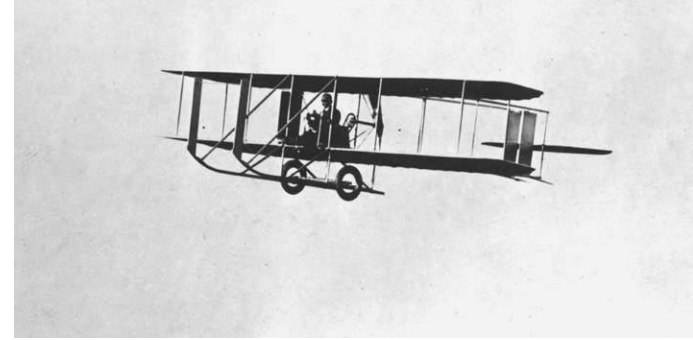
# Se e come inserire il Robot nel Progetto Riabilitativo Individuale



Incremento percentuale Fugl-Meyer

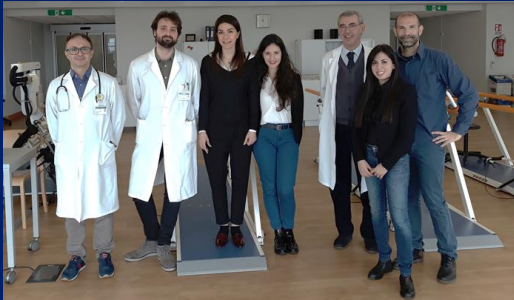


# Conclusione: Quali passi in futuro?



# TAKE HOME MESSAGE

*“If machines produce everything we need, the outcome will depend on how things are distributed (...), the trend seems to be (..) with technology driving ever-increasing inequality.” Stephen Hawking*



Thanks to the people of our  
Clinical Laboratory of Experimental  
Neurorehabilitation

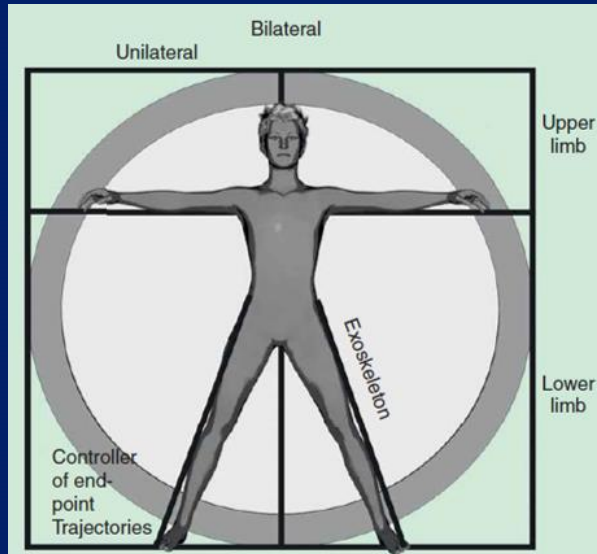


Figure 5. Various robotic therapy approaches for arm and leg as discussed in the review.

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 Meravigliosa Scienza

 marcoiosa

EXPERT  
REVIEWS

## The value of robotic systems in stroke rehabilitation

Expert Rev. Med. Devices Early online, 1–12 (2014)

Stefano Masiero<sup>\*1</sup>,  
Patrizia Poli<sup>1</sup>,  
Giulio Rosati<sup>2</sup>,  
Damiano Zanotto<sup>3</sup>,  
Marco Iosa<sup>4</sup>,  
Sefano Paolucci<sup>4</sup> and  
Giovanni Morone<sup>4,5</sup>

<sup>1</sup>Department of Neuroscience, Univ of

In this paper, we discuss robot-mediated neurorehabilitation as a significant emerging field in clinical medicine. Stroke rehabilitation is advancing toward more integrated processes, using robotics to facilitate this integration. Rehabilitation approaches have tremendous value in reducing long-term impairments in stroke patients during hospitalization and after discharge, of which robotic systems are a new modality that can provide more effective rehabilitation. The function of robotics in rehabilitative interventions has been examined extensively, generating positive yet not completely satisfactory clinical results. This article presents state-of-the-art robotic systems and their prospective function in poststroke rehabilitation of the upper and lower limbs.