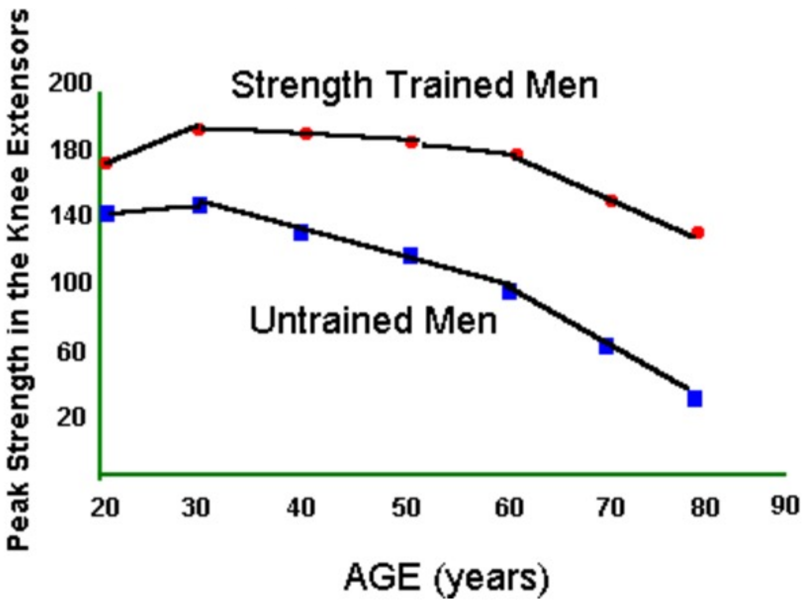
Neuroengineering 2020/21

REHABILITATION ROBOTICS –

Robots for rehabilitation

Context /Impact



Prevalence (US data @2008) :
795000 new stroke every year
- 350000 people with MS
- 250000 with SCI
- 1 million with PD
- 1,7 million with TBI
- 2,8 ‰ children with CP

improvement in acute care
-> more rehabilitation request

Ageing

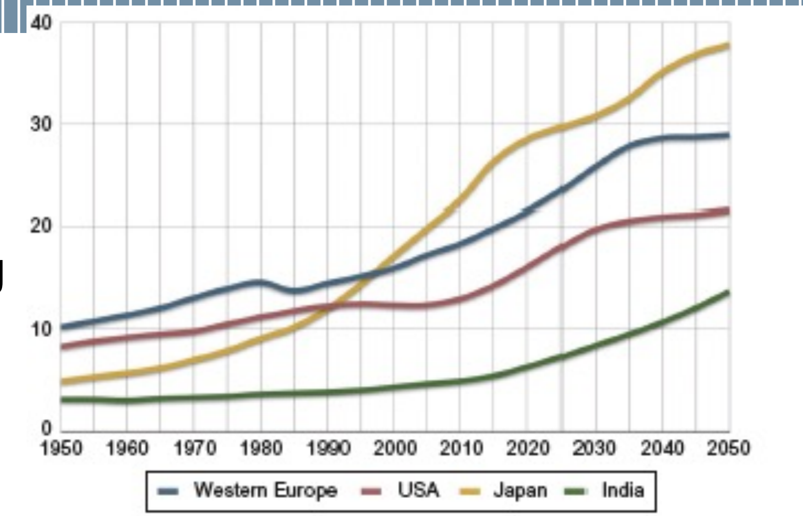
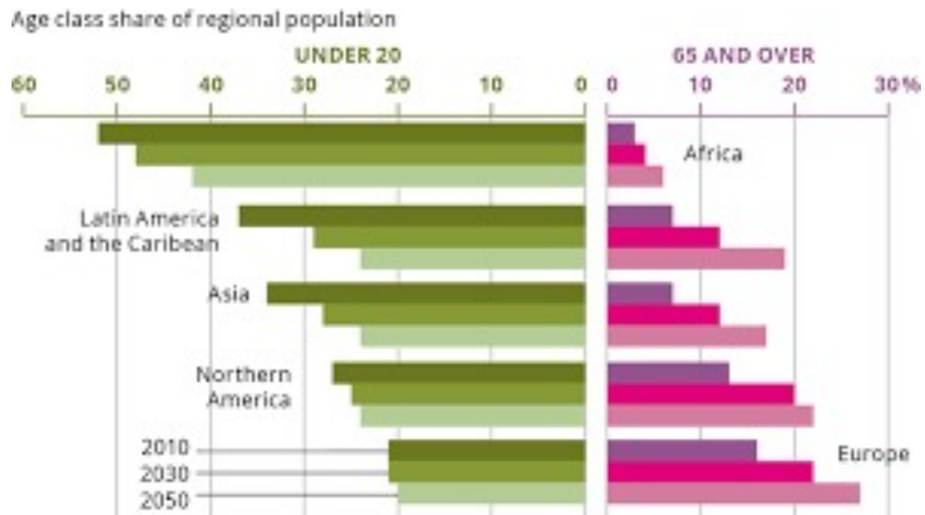


Fig. 23.1. Percentage of population above 65 years of age (UN 2008 Data Series). (Courtesy of IEEE Robotics and Automation Magazine and Professor Henrik Christensen: IEEE, 2010.)



Service Robotics

- Rehabilitation robotics
  - tools to assist the clinicians in promoting rehabilitation of an individual so that he/she can interact with the environment unassisted

- Orthotics
  - Aim at improving functions in people with a weak limb due to a neurological disorder who cannot properly control it when interacting with the environment (Assistive technologies)
  - Orthoses are designed to work in cooperation with the intact body and either control or assist movement

Orthotics: Robotic Exoskeletons

- Enhance strength of user
  - Compensate for muscular degenerative disease
  - Provide superhuman capabilities
- Early work
  - 1965: General Electric Research & Development: Hardiman 1
    - Weighed 680 kg
    - Could lift 340 kg
    - Attempting to operate both legs at once leads to “violent and uncontrollable motion”

= fast cerebral functionality loss due to a improvise blood flow interruption or haemorragy.

- Immediatly after the stroke, 80% of the patients is affected by hemiparesis (loss of muscular tone), 35% maintain a partial disability even after the rehabilitation treatment.
- Functional deficit is controlateral in respect of the cerebral lesion.
- Motor functional recovery has an exponential trend.
- Initial recovery is due to resolution of local ischemia, anoxia, diaschisis, and edema reabsorption.
- Afterwards functional recovery occurs at the same time with a dynamic **process of cortical and subcortical reorganization** (post- acute phase - about 6 months after the accident)
- Chronic phase (low and slow recovery)

Neuroplasticity

Brain plasticity defines all the modifications in the organization of neural components occurring in the central nervous system during the entire life span of an individual

Training enhances lesion induced reorganization of the brain (Liepert et al., 2004; Askim et al.,2009; Lindberg et al., 2009)

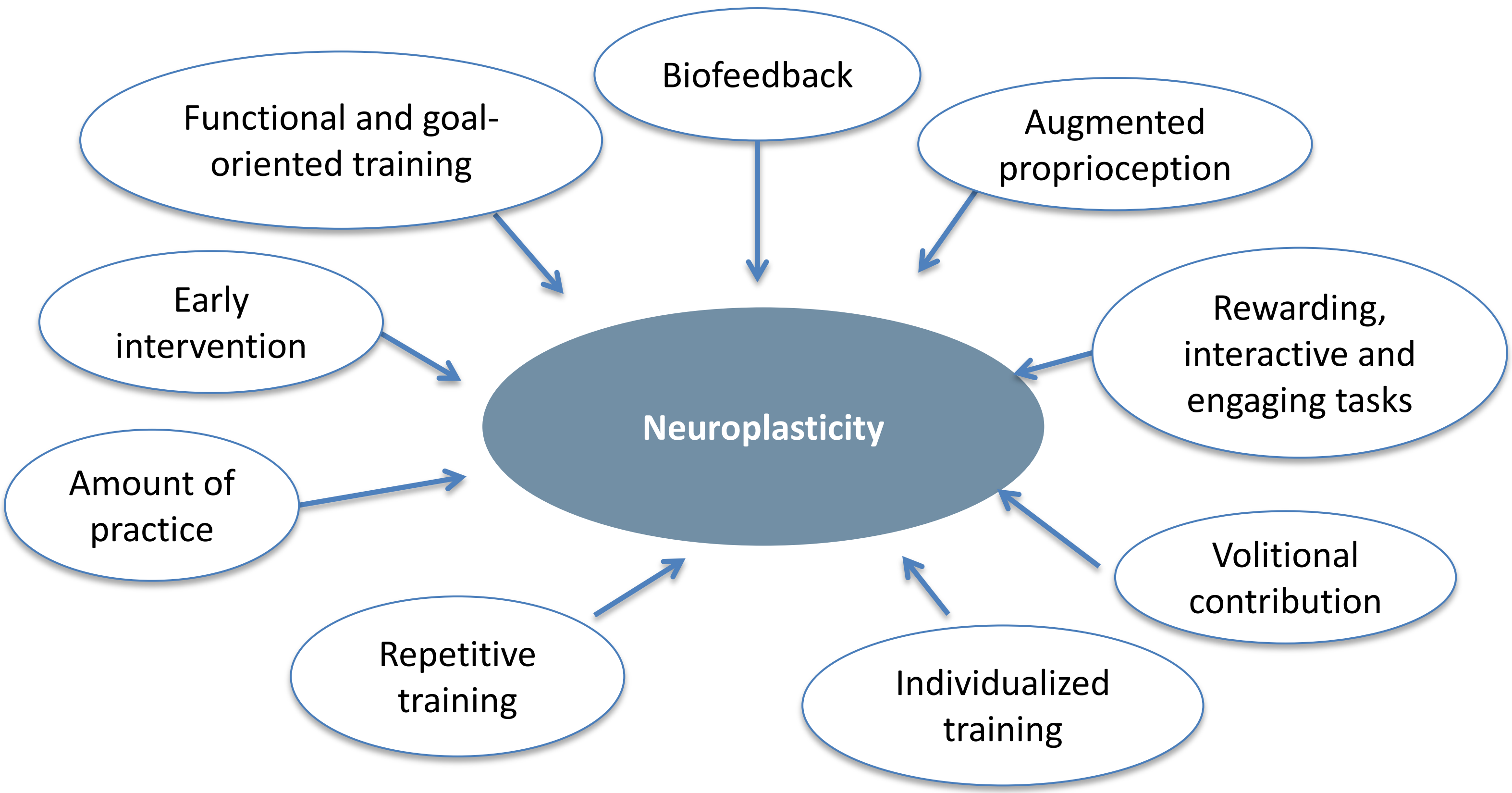
Potential for re-organization persists even in chronic stroke patients (Luft et al., 2004)

Active training is better than passive movements (Xiu et al.,2009)

Vicariation, compensatory and substitutive movements can become «Maladaptive plasticity»

How to facilitate brain plasticity?- Drugs; - NIBS/TMS/Tes (increase excitability of damaged areas)

Key ingredients of motor re-learning



[Barsi et al. 2008, Bergquist et al. 2011, Huang et al. 2006, Krakauer et al. 2006]

Key elements for motor recovery

These data indicate that increased practice leads to greater skill, as long as practice is challenging, progressive, and skill based

Key factors

- Functional training
- Active participation
- Self-initiated movements
- Training intensity: regular
- The more practice , the greater success

Stroke patient forced to use his impaired arm for training

Picture courtesy of Rheinburg Klinik Walzenhausen

Lohse et al, Stroke 2014: We interpret these results as strong evidence of a positive relationship between dose and response. We were able to see a positive dose–response relationship across studies rehabilitating different impairments and functions, using different interventions, and measuring outcomes with different tools.

Preferable measures of dose would be active time in therapy or repetitions of an exercise.

Limitations of conventional therapy

- Poor motivation (depending on personal interaction with therapist)
- Limited by availability of therapists (low dose)
- Limited number of repetitions of exercises
- Unclear feedback regarding therapy progress
- Limited modulation of therapy

The goals

The design and clinical translation of **safe, simple, immersive and functional devices** is needed for assuring the maximal recovery during the hospitalization as long as in the continuation of the rehabilitation after discharge (at the point of need) and eventually at home.

Evidence–based **assessment** of rehabilitation therapies' alternatives (including neurorobotics assisted therapy, training adopting neuroprostheses and hybrid assistive devices as well as conventional treatments) is a milestone in the view of the customization of treatments on single patient.

What is rehabilitation robotics? And why?

Rehabilitation robotics is a field of research dedicated to **understanding** and **augmenting** rehabilitation through the application of robotic devices. Rehabilitation robotics includes development of robotic therapies, and the use of robots as therapy aids instead of solely as assistive devices .

(Wikipedia, July 2012, Oct 2021)

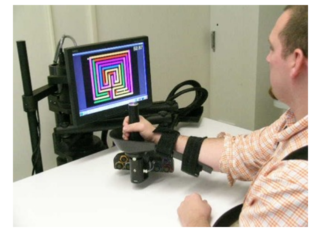
Rehabilitation robots: COMMERCIAL DEVICES

END-EFFECTOR

Definition: apply mechanical forces to the distal segments of the limbs

Advantage: easy to setup and control

Disadvantage: no control of proximal joints, possibility of abnormal movement patterns



MIT manus

Reo Go, Motorika

EXOSKELETON

Definition: robot axes are aligned with the anatomical axes of the subject

Advantage: direct control of individual joints; minimization of abnormal posture

Disadvantage: more complex and expensive

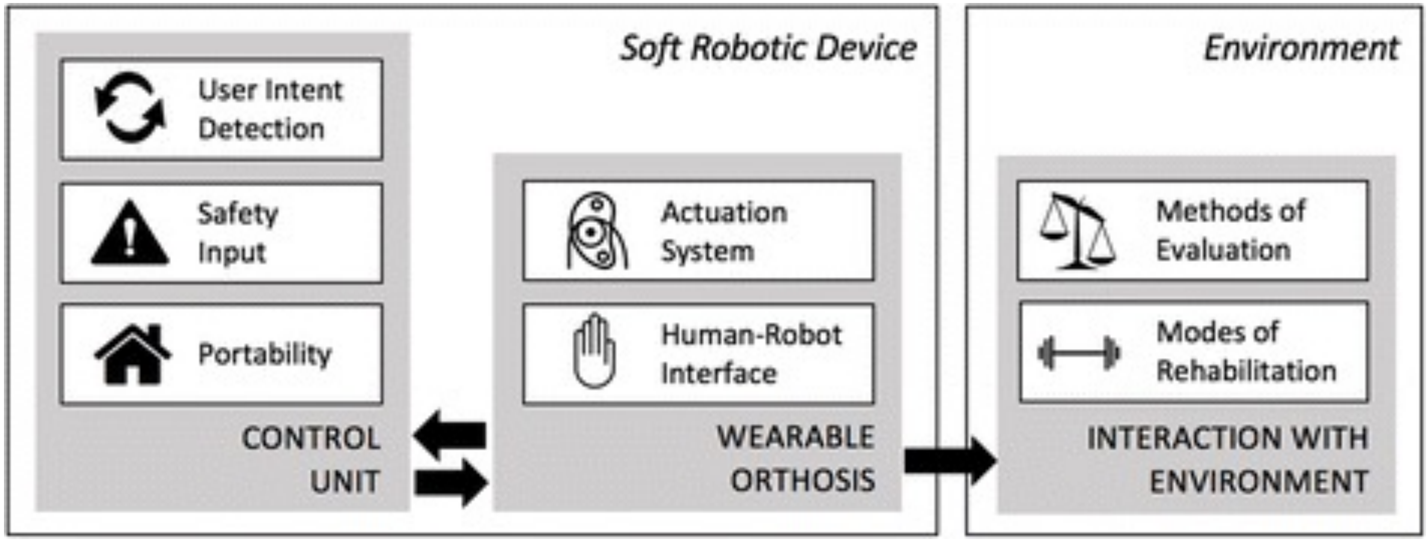
ArmeoPower, HOCOMA

Alex, Wearable robotics

Soft robotics for hand and upper limbs

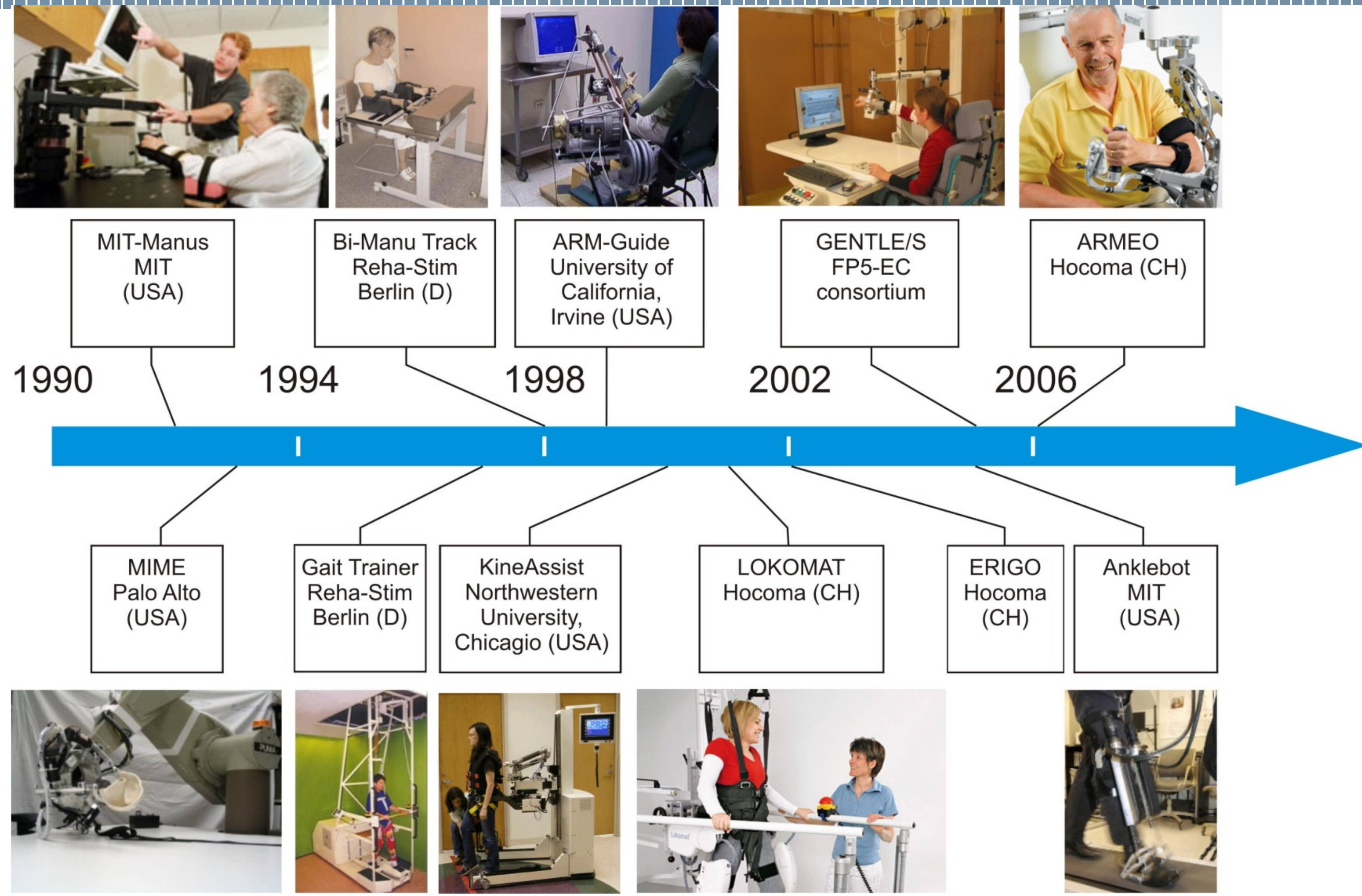
Soft robot: No rigid components on the robot-human interface or minimal rigid components that will not impose physical restraints on joint motions

Our discussion of the schematic is broken into two parts: the first part deals with the design of the robotic device while the second part deals with how the device interacts with the environment.



Chia-Ye Chu and Rita M. Patterson
Journal of NeuroEngineering and Rehabilitation 2018 **15**:9

Rehabilitation robotics: the first twenty years



Robotics for Upper limbs

Completely different approaches for arm, wrist and hand are available

Tail Wind

YouRehab

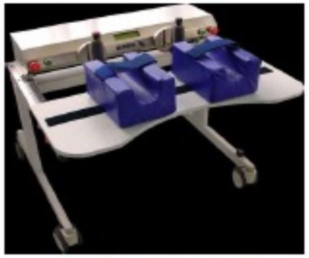
NX

ReJoyce

Reo Go

InMotion

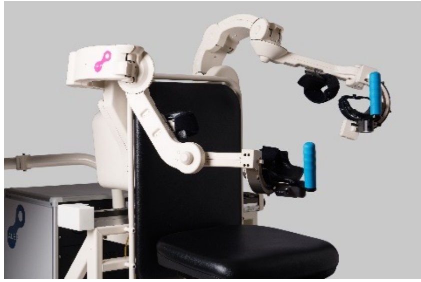
Amadeus



BiManuTrack

Gloreha

Armeo Power



Alex

Rehabilitation robots: a critical view – upper limb

The reasons why…

- High-intensity and high-dosage training
- Task-oriented training
- Individualized training
- Possibility to increase task difficulty
- High level of safety
- Reduced effort for the physiotherapists
- Possibility to assess motor performance while training

But…

No clear evidence from clinical studies

RATULS trial (n=770 patients; Rodgers, H. *et al. Lancet Lond. Engl.* **394**, 51–62 2019)

MIT-manus based **robotic training**

Enhanced Upper Limb Therapy, EULT, in which training specifically focused on daily activities and functional tasks, led to

The reasons why…

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RATULS trial (n=770 patients; Rodgers, H. *et al. Lancet Lond. Engl.* **394**, 51–62 2019)

MIT-manus based **robotic training** led to
- **improvement in upper limb impairment (FMA motor subscale) compared with usual care (Body Structure and Function domain)**
- **not improvements in upper limb function or ADL (Activity domain).**

Enhanced Upper Limb Therapy, EULT, led to
- **improvements compared with usual care** for **both Body Structure and Activity domains (FMA motor subscale and SIS)**

International Classification of Functioning, Disability and Health (ICF)

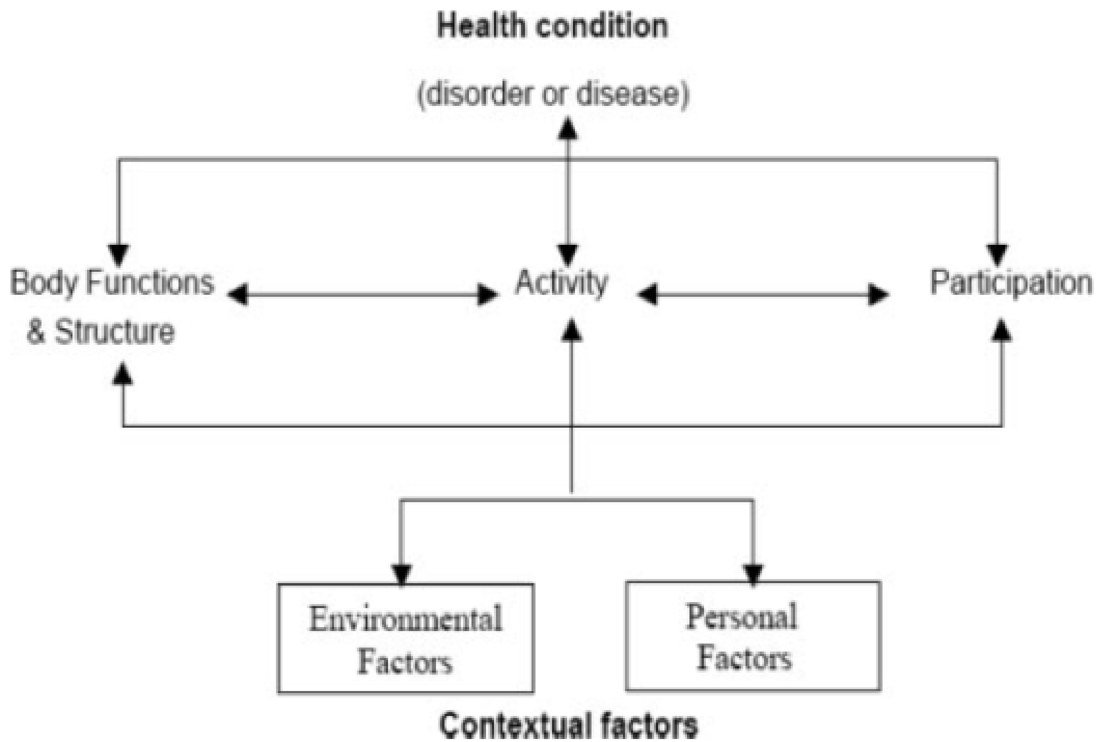
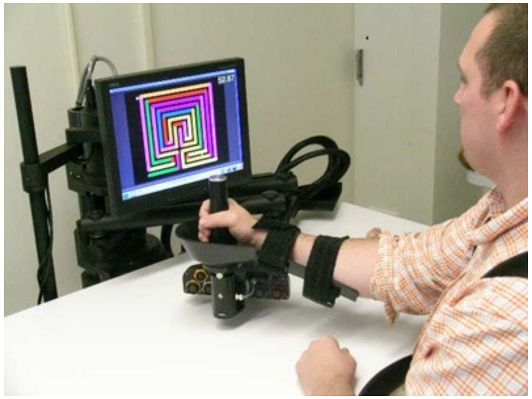


Figure. Diagrammatic representation of the WHO's ICF,[8] reflecting interactions between the consequences of disease and contextual factors.

One point of view…

Body Structure and Function → Activity Domains → Participation

In clinical settings robotic therapy should focus on impairment training , combined with therapist transition-to-task training, to translate the impairment gains into function



Duret, C., Grosmaire, A.-G. & Krebs, H. I. Robot-Assisted Therapy in Upper Extremity Hemiparesis: Overview of an Evidence-Based Approach. *Front. Neurol.* **10**, 412 (2019).

Some commercial devices….

Robotics for Gait training

Product

- Re Ambulator, Autoambulator (Motorika)
- Gait Trainer (Reha-Stim)
- Gait system, G-EO-System (Reha Technologies)
- LokoHelp (LokoHelp Group)
- Walkbot (P& S Mechanics)
- Robogait

The Armeo® Therapy Concept

Hocoma

Improved arm and hand rehabilitation

1. Arm Weight Support in 3D workspace
2. Augmented Performance Feedback
3. Self-initaited, active, repetitive Training
4. Improved therapy efficiency
5. Assessment Tools
6. Modular Therapy Concept

Sensory – Locomotor learning

Hocoma

Key facts

- Functional training helps recover function
- More training leads to greater success
- Training beyond the present capability
- Afferent feedback is stimulating reorganization of the CNS
- Active participation
- Motivation is the key!

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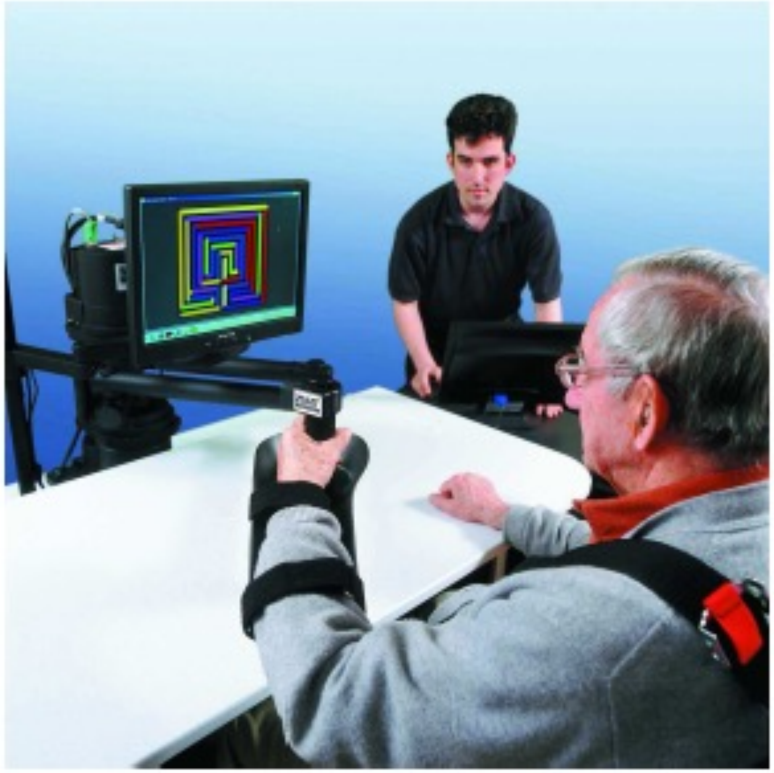
Free Walking Device

- HAL from Cyberdyne
- ReWalk from ARGO MedTec
- Ekso-Bionics from Berkeley
- . . .

ReWalk: Structure



InMotion2 Shoulder-Elbow Robot

- End-effector based, driven system , no guidance for elbow and shoulder
- 2D workspace
- No pro-/supination
- Only assessment of end-point performance possible

ReoGo

- End-effector based, driven system, no guidance for elbow and shoulder
- Limited 3D workspace
- Pro-/supination & grip sensing as additional accessories
- Only assessment of end-point performance possible

Myomo **mPower 1000**
not CE approved
at the moment

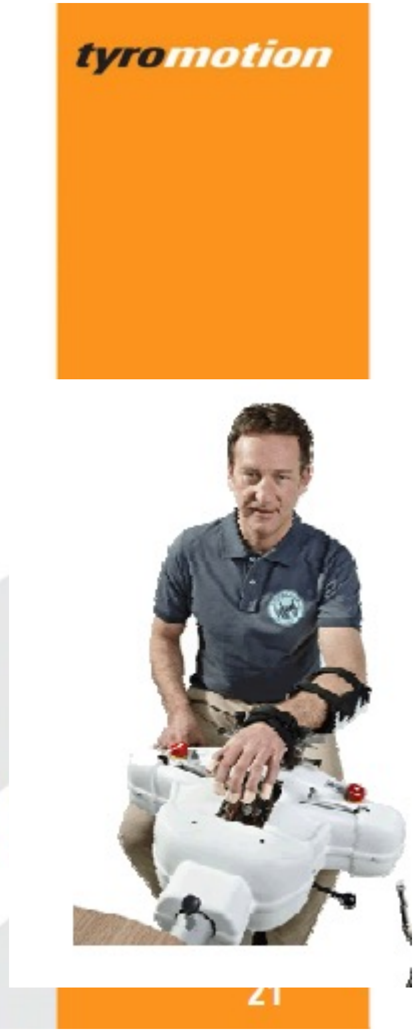
The mPower 1000 is a neuro-robotic arm brace that fits like a sleeve on a person's arm. The arm brace has sensors that sit on the skin's surface and detect even a very faint muscle signal. When a person with a weak or partially paralyzed arm tries to move their arm and a muscle signal fires, the robotics in the mPower 1000 engage to assist in completing the desired movement

Amadeo®

- Hand rehabilitation system for stroke survivors
  - Passive motion
  - Assistive motion
  - Active motion
- Force measurement
- Biofeedback

Possibilities

- Adaptable to every type of hand
  - Spactic
  - Limb
- Adaptable to every patient
  - Wheelchair user friendly
- Created on newest medical knowledge
- 6 independet axes
- Motivating therapy programmes



www.kineadesign.com

Computer controlled device that:

- Follows patient from behind in over-ground walking
- Provides body weight support
- Allows independent motion of torso and pelvis
- Allows therapist's free access to legs
- Complementary to treadmill training

KineAssist™ technology benefits:

Assist clinicians in gait & balance training, in a functional context

Challenge clients to their maximum limits without increasing the risk of falls

Maintain consistency with current practice and infrastructure

Allow more therapy, by minimizing set up time

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Currently being developed for the market, but no CE Mark or EU presence

Motorika

Features

- Sophisticated software powers the ReoAmbulator through its integrated computer system, while sensors track numerous functions, continuously monitoring and adjusting power and speed according to each patient's physical requirements.

- Allow the patients to contribute to the movement but provide remaining force necessary for walking
- Adjust the amount of weight bearing
- Walking speed can be varied

Reha-Stim, Reha Technologies

IISART

Gait Trainer **(Reha-Stim)**

Gait system, G-EO-System **(Reha Technologies)**

LokoHelp Group

LokoHelp (LokoHelp Group)

MotionMakerTM is a medical device intended for handicapped and hemiplegic patients so that maximum mobility and autonomy are recovered. It is a stationary device, a robotic system with electro-stimulation for an active mobilisation of the lower limbs.

Its main functions are investigation, diagnostics, training and rehabilitation of musculare strength and endurance, as well as articular mobility and movement coordination.

ZeroG is the most advanced gait and balance training system in the world. With ZeroG, patients can begin practicing a wide range of walking activities, balance tasks, and other Activities of Daily Living early after neurological injuries in a safe controlled environment.

P & S Mechanics

Walkbot (P& S Mechanics)

Eu roadmap Robotics for health care [Butter et al., Tech Rep. 2008]

- Robotic assisted motor therapy
- Robot assisted physical training
- robot assisted mental, cognitive and social therapy

individually adjust the rehabilitative training protocol with accuracy, replication and congruity with residual motor function and treatment targets [Krebs et al. IEEE Trans Rehabil Eng, 1998; Casadio et al. Clin Rehab, 2009]

quantitatively assess baseline conditions and monitor changes during training

extend the application at home under remote control, reducing costs and making the access possible to patients who are technology illiterates [Krebs et al. J Rehabil Res De, 2000].

Reccomendations level of evidence- Guidelines AHA 2016

Table 1. Applying Classification of Recommendations and Level of Evidence

SIZE OF TREATMENT EFFECT

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT

	CLASS I	CLASS IIa	CLASS IIb	CLASS III *No Benefit* or CLASS III *Harm*
	Benefit >>> Risk Procedure/Treatment **SHOULD** be performed/ administered	*Benefit >> Risk* *Additional studies with focused objectives needed* **IT IS REASONABLE** to perform procedure/administer treatment	*Benefit ≥ Risk* *Additional studies with broad objectives needed; additional registry data would be helpful* Procedure/Treatment **MAY BE CONSIDERED**	Procedure/Test / Treatment COR III: No benefit — Not Helpful / No Proven Benefit COR III: Harm — Excess Cost w/o Benefit or Harmful / Harmful to Patients
LEVEL A Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
LEVEL B Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is useful/effective ■ Evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Evidence from single randomized trial or nonrandomized studies
LEVEL C Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard of care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard of care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard of care
Suggested phrases for writing recommendations	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated	may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	COR III: No Benefit is not recommended is not indicated should not be performed/ administered/ other is not useful/ beneficial/ effective COR III: Harm potentially harmful causes harm associated with excess morbidity/mortality should not be performed/ administered/ other
Comparative effectiveness phrases†	treatment/strategy A is recommended/indicated in preference to treatment B treatment A should be chosen over treatment B	treatment/strategy A is probably recommended/indicated in preference to treatment B it is reasonable to choose treatment A over treatment B		

Recommendations: Rehabilitation Interventions in the Inpatient Hospital Setting	Class	Level of Evidence
It is recommended that early rehabilitation for hospitalized stroke patients be provided in environments with organized, interprofessional stroke care.	I	A
It is recommended that stroke survivors receive rehabilitation at an intensity commensurate with anticipated benefit and tolerance.	I	B
High-dose, very early mobilization within 24 hours of stroke onset can reduce the odds of a favorable outcome at 3 months and is not recommended.	III	A

Recommendations: Nondrug Therapies for Cognitive Impairment, Including Memory (Continued)	Class	Level of Evidence
Exercise may be considered as adjunctive therapy to improve cognition and memory after stroke.	IIb	C
Virtual reality training may be considered for verbal, visual, and spatial learning, but its efficacy is not well established.	IIb	C
Anodal tDCS over the left dorsolateral prefrontal cortex to improve language-based complex attention (working memory) remains experimental.	III	B

Recommendations: Assessment of Motor Impairment, Activity, and Mobility	Class	Level of Evidence
Motor impairment assessments (paresis/muscle strength, tone, individuated finger movements, coordination) with standardized tools may be useful.	IIb	C
Upper extremity activity/function assessment with a standardized tool may be useful.	IIb	C
Balance assessment with a standardized tool may be useful.	IIb	C
Mobility assessment with a standardized tool may be useful.	IIb	C
The use of standardized questionnaires to assess stroke survivor perception of motor impairments, activity limitations, and participation may be considered.	IIb	C
The use of technology (accelerometers, step-activity monitors, pedometers) as an objective means of assessing real-world activity and participation may be considered.	IIb	C
Periodic assessments with the same standardized tools to document progress in rehabilitation may be useful.	IIb	C

AHA guidelines 2016: spasticity and balance

Recommendations: Spasticity	Class	Level of Evidence
Targeted injection of botulinum toxin into localized upper limb muscles is recommended to reduce spasticity, to improve passive or active range of motion, and to improve dressing, hygiene, and limb positioning.	I	A
Targeted injection of botulinum toxin into lower limb muscles is recommended to reduce spasticity that interferes with gait function.	I	A
Oral antispasticity agents can be useful for generalized spastic dystonia but may result in dose-limiting sedation or other side effects.	IIa	A
Physical modalities such as NMES or vibration applied to spastic muscles may be reasonable to improve spasticity temporarily as an adjunct to rehabilitation therapy.	IIb	A
Intrathecal baclofen therapy may be useful for severe spastic hypertonia that does not respond to other interventions.	IIb	A
Postural training and task-oriented therapy may be considered for rehabilitation of ataxia.	IIb	C
The use of splints and taping are not recommended for prevention of wrist and finger spasticity after stroke.	III	B

Recommendations: Balance and Ataxia	Class	Level of Evidence
Individuals with stroke who have poor balance, low balance confidence, and fear of falls or are at risk for falls should be provided with a balance training program.	I	A
Individuals with stroke should be prescribed and fit with an assistive device or orthosis if appropriate to improve balance.	I	A
Individuals with stroke should be evaluated for balance, balance confidence, and fall risk.	I	C
Postural training and task-oriented therapy may be considered for rehabilitation of ataxia.	IIb	C

AHA guidelines 2016: Mobility (gait)

Recommendations: Mobility	Class	Level of Evidence
Intensive, repetitive, mobility- task training is recommended for all individuals with gait limitations after stroke.	I	A
An AFO after stroke is recommended in individuals with remediable gait impairments (eg, foot drop) to compensate for foot drop and to improve mobility and paretic ankle and knee kinematics, kinetics, and energy cost of walking.	I	A
Group therapy with circuit training is a reasonable approach to improve walking.	IIa	A
Incorporating cardiovascular exercise and strengthening interventions is reasonable to consider for recovery of gait capacity and gait-related mobility tasks.	IIa	A
NMES is reasonable to consider as an alternative to an AFO for foot drop.	IIa	A
Practice walking with either a treadmill (with or without body-weight support) or overground walking exercise training combined with conventional rehabilitation may be reasonable for recovery of walking function.	IIb	A
Robot-assisted movement training to improve motor function and mobility after stroke in combination with conventional therapy may be considered.	IIb	A
Mechanically assisted walking (treadmill, electromechanical gait trainer, robotic device, servo-motor) with body weight support may be considered for patients who are nonambulatory or have low ambulatory ability early after stroke.	IIb	A
There is insufficient evidence to recommend acupuncture for facilitating motor recovery and walking mobility.	IIb	B

Recommendations: Mobility (Continued)	Class	Level of Evidence
The effectiveness of TENS in conjunction with everyday activities for improving mobility, lower extremity strength, and gait speed is uncertain.	IIb	B
The effectiveness of rhythmic auditory cueing to improve walking speed and coordination is uncertain.	IIb	B
The usefulness of electromyography biofeedback during gait training in patients after stroke is uncertain.	IIb	B
Virtual reality may be beneficial for the improvement of gait.	IIb	B
The effectiveness of neurophysiological approaches (ie, neurodevelopmental therapy, proprioceptive neuromuscular facilitation) compared with other treatment approaches for motor retraining after an acute stroke has not been established.	IIb	B
The effectiveness of water-based exercise for motor recovery after an acute stroke is unclear.	IIb	B
The effectiveness of fluoxetine or other SSRIs to enhance motor recovery is not well established.	IIb	B
The effectiveness of levodopa to enhance motor recovery is not well established.	IIb	B
The use of dextroamphetamine or methylphenidate to facilitate motor recovery is not recommended.	III	B

Recommendations: Upper Extremity Activity, Including ADLs, IADLs, Touch, and Proprioception (Continued)	Class	Level of Evidence
Somatosensory retraining to improve sensory discrimination may be considered for stroke survivors with somatosensory loss.	IIb	B
Bilateral training paradigms may be useful for upper limb therapy.	IIb	A
Acupuncture is not recommended for the improvement of ADLs and upper extremity activity.	III	A

AHA guidelines 2016: Upper limb training

Recommendations: Upper Extremity Activity, Including ADLs, IADLs, Touch, and Proprioception	Class	Level of Evidence
Functional tasks should be practiced; that is, task-specific training, in which the tasks are graded to challenge individual capabilities, practiced repeatedly, and progressed in difficulty on a frequent basis.	I	A
All individuals with stroke should receive ADL training tailored to individual needs and eventual discharge setting.	I	A
All individuals with stroke should receive IADL training tailored to individual needs and eventual discharge setting.	I	B
CIMT or its modified version is reasonable to consider for eligible stroke survivors.	IIa	A
Robotic therapy is reasonable to consider to deliver more intensive practice for individuals with moderate to severe upper limb paresis.	IIa	A
NMES is reasonable to consider for individuals with minimal volitional movement within the first few months after stroke or for individuals with shoulder subluxation.	IIa	A
Mental practice is reasonable to consider as an adjunct to upper extremity rehabilitation services.	IIa	A
Strengthening exercises are reasonable to consider as an adjunct to functional task practice.	IIa	B
Virtual reality is reasonable to consider as a method for delivering upper extremity movement practice.	IIa	B

AHA reccomendations 2016: assistive devices

Recommendations: Adaptive Equipment, Durable Medical Devices, Orthotics, and Wheelchairs	Class	Level of Evidence
Ambulatory assistive devices (eg, cane, walker) should be used to help with gait and balance impairments, as well as mobility efficiency and safety, when needed.	I	B
AFOs should be used for ankle instability or dorsiflexor weakness.	I	B
Wheelchairs should be used for nonambulatory individuals or those with limited walking ability.	I	C
Adaptive and assistive devices should be used for safety and function if other methods of performing the task/activity are not available or cannot be learned or if the patient's safety is a concern.	I	C

AHA guidelines 2016: Continuity of care

Recommendations: Chronic Care Management: Home- and Community-Based Participation	Class	Level of Evidence
After successful screening, an individually tailored exercise program is indicated to enhance cardiorespiratory fitness and to reduce the risk of stroke recurrence.	I	A (for improved fitness); B (for reduction of stroke risk)
After completion of formal stroke rehabilitation, participation in a program of exercise or physical activity at home or in the community is recommended.	I	A

Recommendation: Ensuring Medical and Rehabilitation Continuity Through the Rehabilitation Process and Into the Community	Class	Level of Evidence
It is reasonable to consider individualized discharge planning in the transition from hospital to home.	IIa	B
It is reasonable to consider alternative methods of communication and support (eg, telephone visits, telehealth, or Web-based support), particularly for patients in rural settings.	IIa	B

Recommendations: Social and Family Caregiver Support	Class	Level of Evidence
It may be useful for the family/caregiver to be an integral component of stroke rehabilitation.	IIb	A
It may be reasonable that family/caregiver support include some or all of the following on a regular basis:	IIb	A
Education		
Training		
Counseling		
Development of a support structure		
Financial assistance		
It may be useful to have the family/caregiver involved in decision making and treatment planning as early as possible and throughout the duration of the rehabilitation process.	IIb	B

The rehab pathways

Phase	Admission	Length of Stay (Mean±SD)
Hospital-based care		
Acute intensive care	Onset to hours	Subarachnoid hemorrhage: 9.2 ±12.3 h Intracerebral hemorrhage: 5.1 ±9.2 h Ischemic stroke: 1.8 ±12.3 h
Acute care	2–3 d	Subarachnoid hemorrhage: 11.3 ±11.6 d Intracerebral hemorrhage: 8. 0 ±9.2 d Ischemic stroke: 6.3 ±6.8 d
Inpatient rehabilitation care	5–7 d	Mean of 8–30 d; median of 15 d
Skilled nursing facility care		
Inpatient SNF rehabilitation	5–7 d after stroke	Dependent on individual stroke severity (with maximum of 100 d)
Long-term care	Dependent on stroke severity, individual resources, multiple comorbidities	Variable depending on care needs (eg, long-term care vs palliative/end-of-life)
Community-based rehabilitation, including home health care		
Early supported discharge services	20–30 d	1–44 mo
Chronic outpatient rehabilitation	>4–6 mo Variable onset based on individual resources and functional needs	Variable termination based on individual resources and functional needs

and in Italy?

AHA for primary care 2021

AHA/ASA SCIENTIFIC STATEMENT

Primary Care of Adult Patients After Stroke: A Scientific Statement From the American Heart Association/American Stroke Association

Kernan et al 2021
StrokeVolume 52, Issue 9, September 2021; Pages e558-e571

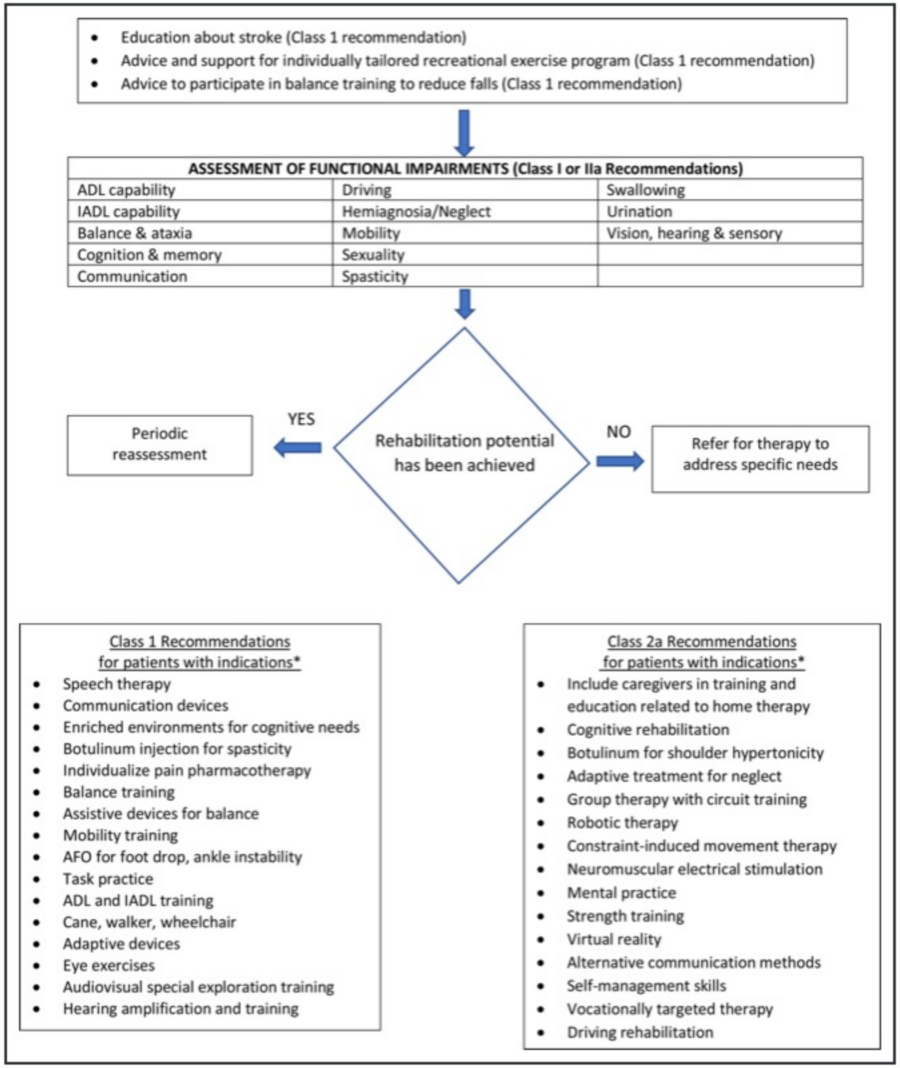

Figure 2. An algorithm for screening and management of poststroke physical rehabilitation needs in primary care. Class or recommendations from the 2016 AHA poststroke rehabilitation guidelines.[92] ADL indicates activities of daily living; AFO, ankle-foot orthosis; and IADL, instrumental activities of daily living.