UNIVERSITY OF GOTHENBURG

MOTOR REHABILITATION AFTER STROKE: EUROPEAN STROKE ORGANISATION (ESO) CONSENSUS-BASED DEFINITION AND GUIDING FRAMEWORK

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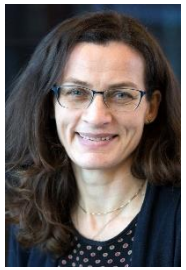

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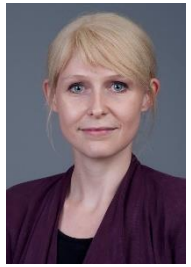

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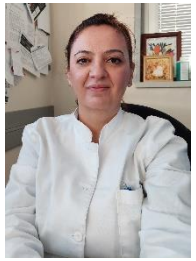

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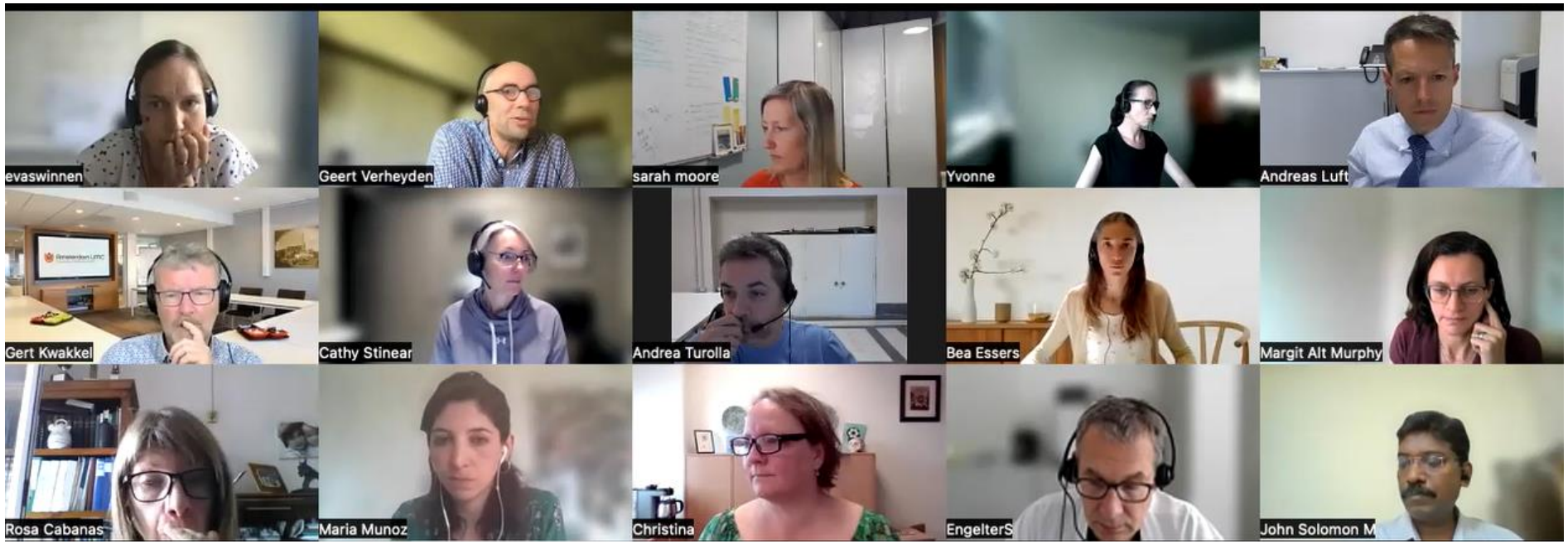

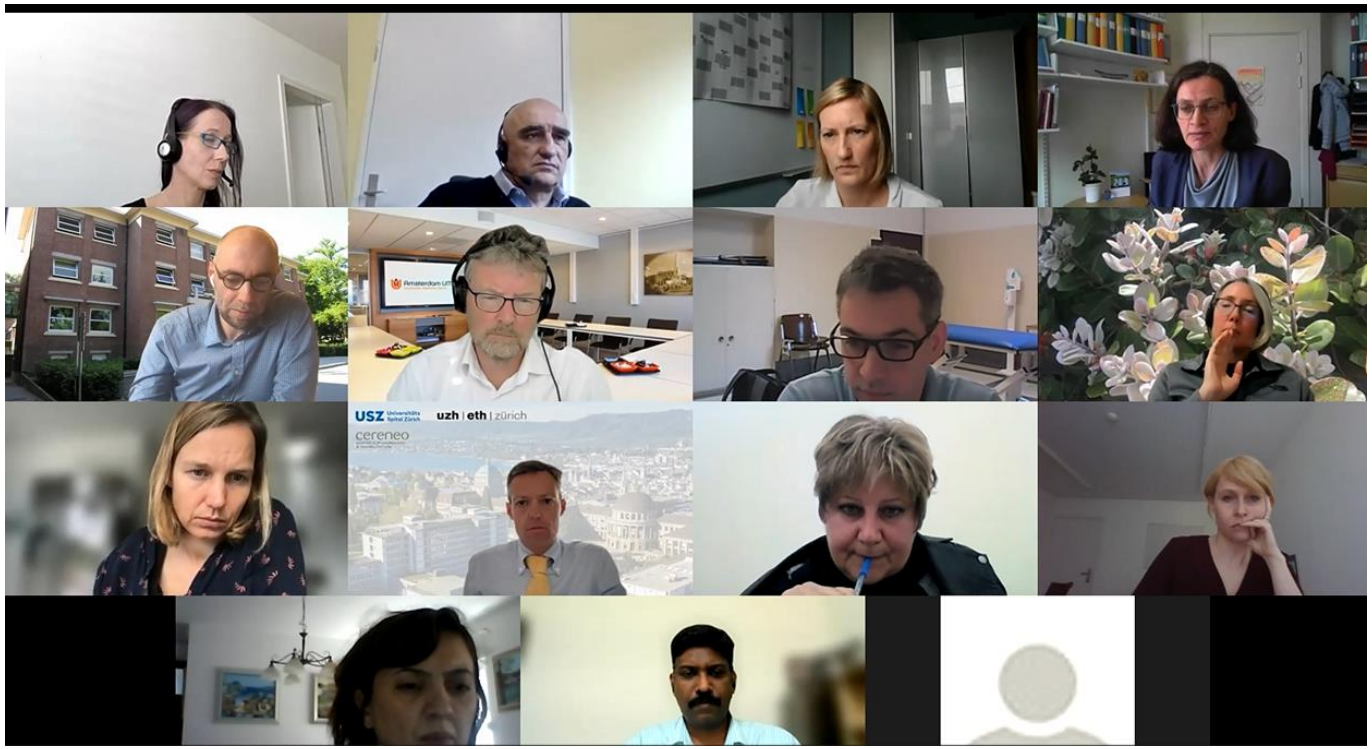

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ESO Stroke Action Plan for Europe 2018-2030

- 30 targets and 72 research priorities within 7 domains
- One domain targets stroke rehabilitation improving management, outcome and quality of life

- Rehabilitation defined as «a set of measures that assist individuals, who experience or are likely to experience disability, to achieve and maintain optimal functioning in interaction with their environment»

- Specific principles of motor rehabilitation not addressed

Norrving et al. Eur Stroke J 2018; WHO 2011

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First task decided by the group ….

- To deliver an agreed definition of motor rehabilitation after stroke
- Supported by a framework synthesizing key literature to provide a state-of-the-art overview of the stroke motor rehabilitation domain
- To guide educators, to update clinicians and to enable researchers to identify gaps in the evidence base

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Development of the definition

- Panel of experts convend by ESO Guideline Board
- Three-round process
  - Online discussion, first draft and online survey (April-June 2022)
  - Online discussion, revision and second round survey (July-Aug), requiring 75% agreement
  - Online presentation of results, further discussion and fine-tuning (Sept)
- Feedback on the agreed definition was received from
  - clinicians (8 MD, 33 PT and 9 OT)
  - Research partners with lived experience of stroke
- Feedback was collated into the final definition

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Guiding framework

- Presenting the ICF as the central concept and contextualising it to motor rehabilitation
- Summary of biology of recovery, distinguishing between early versus later recovery
- Widely recommended motor assessments and prediction tools
- Summary of strongly recommended evidence-based interventions from recent motor rehabilitation guidelines

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ICF (the overreaching concept)

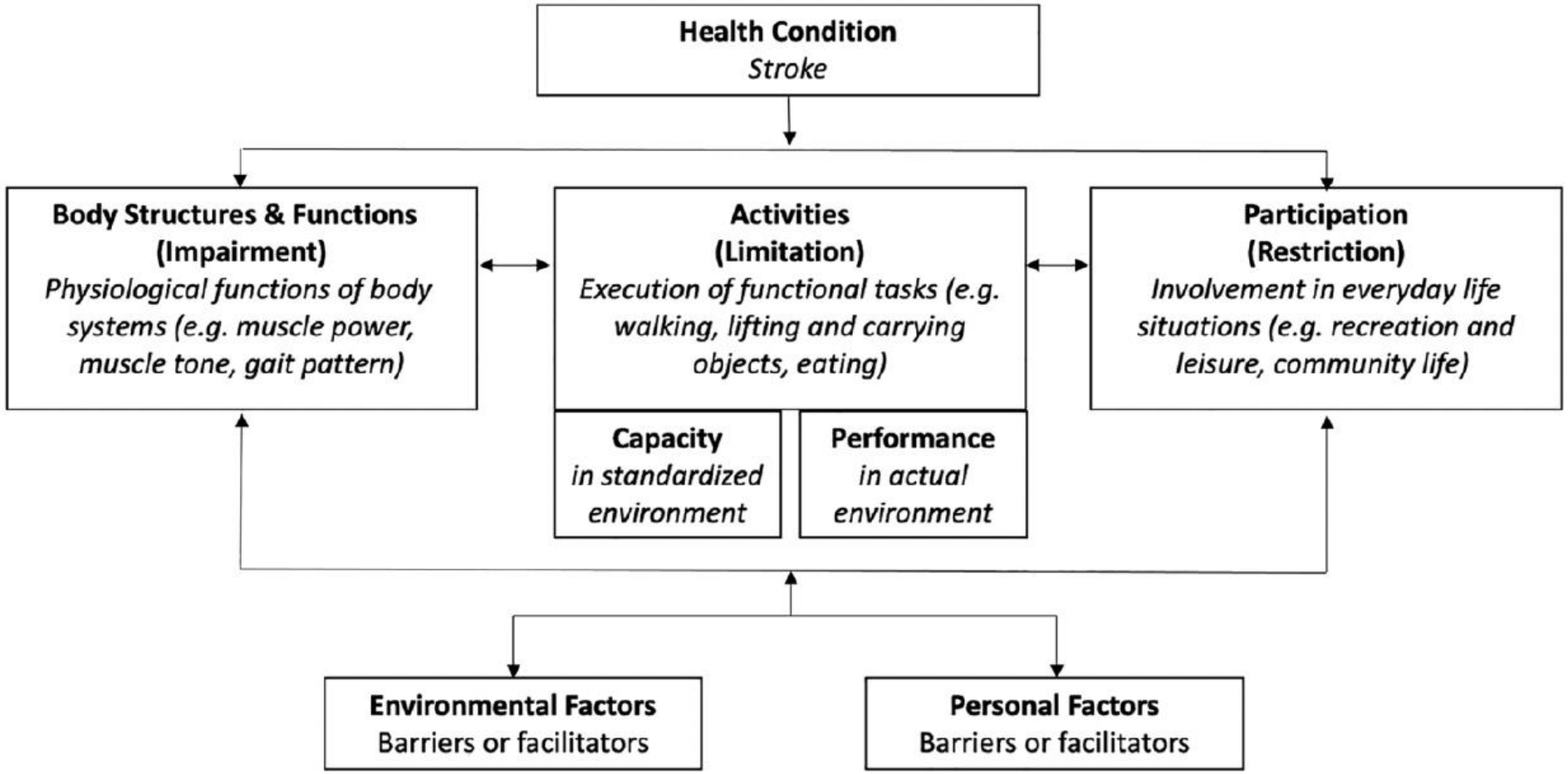

Figure 1. The international classification of functioning, disability and health.[8]

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Box 1. Glossary and definitions.

Behavioral adaptation: occurs when the movement or task is executed with the impaired body pattern is used. Behavioral adaptation results in deviating quality of movement compared to non-c

Behavioral compensation: occurs as adaptation, in which the impaired body part is used in an motor task; or as substitution, in which different atypical body part(s) or body segment(s) are use

Behavioral restitution: a return toward more normal patterns of motor control with the impaired

International Classification of Functioning, Disability and Health (ICF) terminology[c]

- Body functions: the physiological functions of body systems.
- Body structures: anatomical parts of the body such as organs, limbs and their components.
- Impairments: problems (the negative term) in body functions and structures.
- Activities: the execution of a task(s) or action(s).
- Activity limitations: difficulties (the negative term) in executing tasks and activities.
- Activity capacity: relates to what an individual can do in a "standardized" environment.
- Activity performance: what the person actually does in his or her "current" (usual) enviror
- Participation: involvement in a life situation.
- Participation restriction: problems (the negative term) an individual may experience in invo
- Functioning: an umbrella term for body function, body structures, activities and participatic interaction between a person's health condition(s) and that individual's contextual factors
- Disability: an umbrella term for impairments, activity limitations and participation restrictic interaction between a person's health condition(s) and that individual's contextual factors

Motor control: the process whereby the central nervous system produces purposeful coordinat body and the environment.[d]

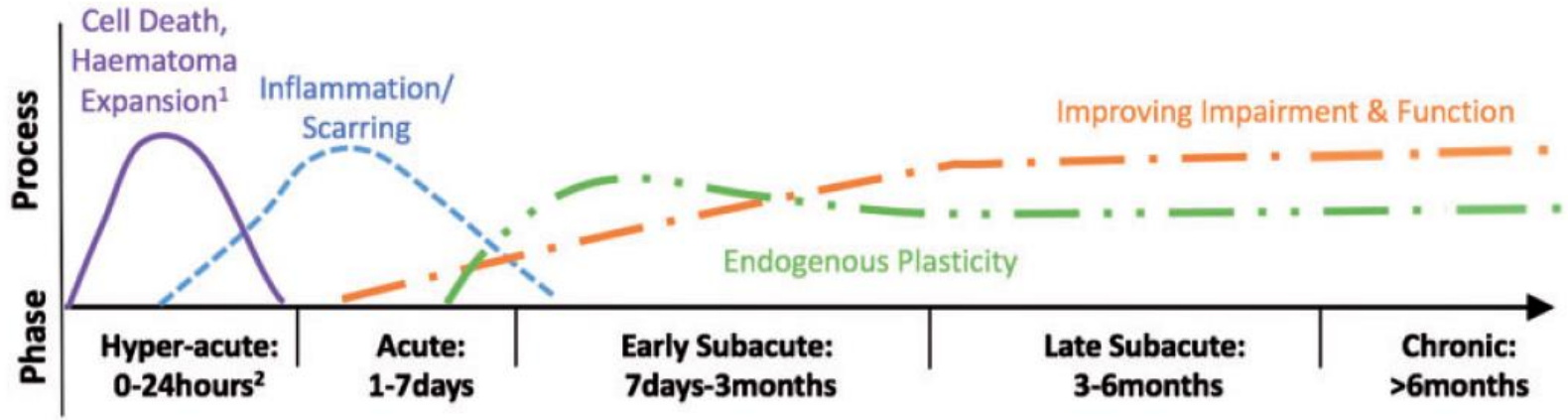
Motor function: body functions related to muscle force and endurance, control over and coordi patterns associated with walking, running or other whole body movements.[c]

Motor learning: the changes, associated with practice or experience, in internal processes, that motor skill.[e]

Motor recovery: the extent to which motor functions and activities have returned to their pre-

Recovery

Figure 1. Framework that encapsulates definitions of critical timepoints post stroke that link to the currently known biology of recovery.



[1] Haemorrhagic stroke specific. [2] Treatments extend to 24 hours to accommodate options for anterior and posterior circulation, as well as basilar occlusion.

Consensus

International Journal of Stroke WSO

Agreed definitions and a shared vision for new standards in stroke recovery research: The Stroke Recovery and Rehabilitation Roundtable taskforce

Julie Bernhardt[1,2], Kathryn S Hayward[1,2,3], Gert Kwakkel[4,5], Nick S Ward[6,7], Steven L Wolf[8,9], Karen Borschmann[1,2], John W Krakauer[10], Lara A Boyd[3,11], S Thomas Carmichael[12], Dale Corbett[13,14] and Steven C Cramer[15]

International Journal of Stroke
2017, Vol. 12(5) 444–450

DOI: 10.1177/1747493017711816
journals.sagepub.com/home/wso
SAGE

Motor recovery (biology of recovery)

A combination of **spontaneous biological recovery processes** and **use- and learning dependent processes**

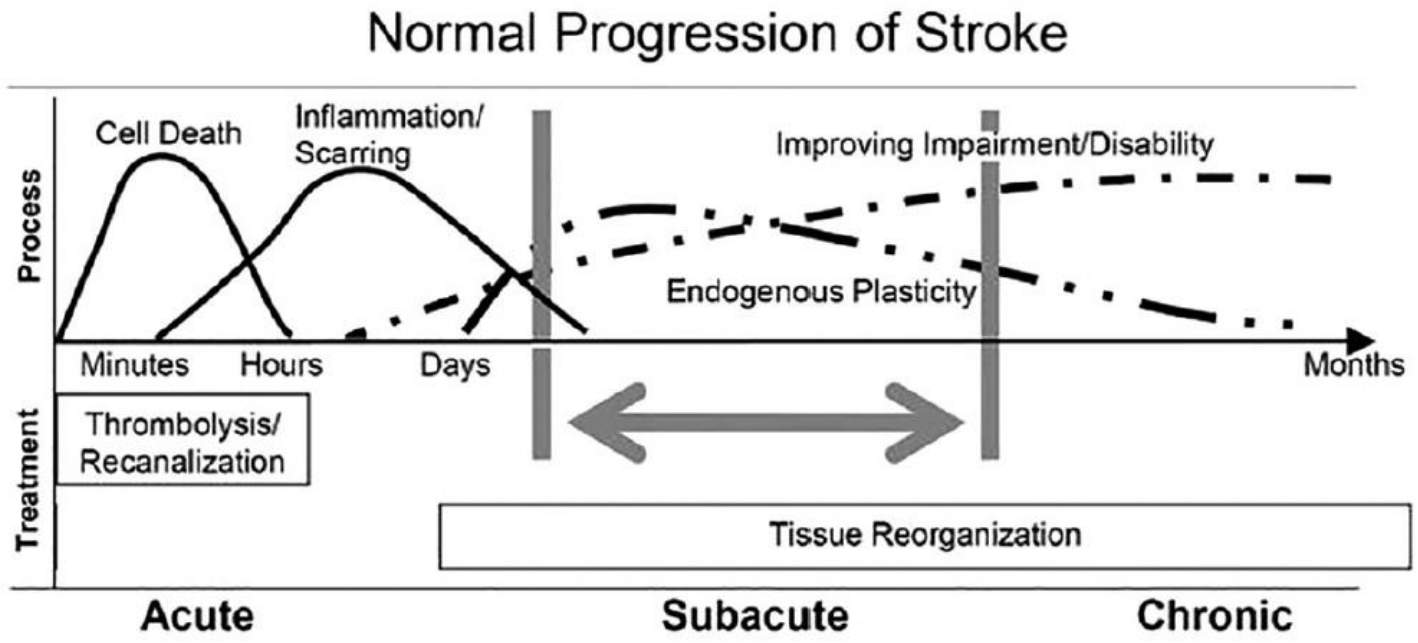


Figure 2. Patterns, processes and treatment opportunities post-stroke (adapted from Dobkin and Carmichael,[28] used with permission).

Mechanisms contributing to behavioral recovery:

- **Autoregulation of vascular collaterals supports the survival of penumbra** – larger number is associated with smaller brain damage and better recovery **(first week)**
- **Neuronal plasticity in perilesional areas** is enhanced by a cascade of post-ischemic inflammation processes (first days/weeks) and by use-dependent processes enhancing plasticity **(first months)**
- **Gradual peripheral changes**, such as, spasticity, mechanical effects and changes in soft tissues can influence and constrain the recovery **(subacute and chronic stages of stroke)**

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Assessment of motor function and activity

Recent consensus-based recommendations for motor assessments in stroke rehabilitation

Source	Aim	Focus	Time post stroke	Recommended assessments
CAULIN 2021	Clinical practice	UL	Within 1st week, 3-, 6- and 12-months; prior to discharge or transfer; before, during and after a rehabilitation program	**FMA-UE, ARAT** Extended: Kinematics, BBT, CAHAI, WMFT, NHPT, ABILHAND Supplementary: MI, CMSA, STREAM, FAT, MAS, sensor-based use of the upper limb
Core set 2020		Motor	Day 2±1 and 7, week 2 and 4, month 3, 6 and 12, and every following 6 months	**FMA, ARAT**, **10MWT, TUG, BBS, SIS**
SRRR-2 2019	Research	UL QoM	Within 1st week, 3-, 6- and 12-months, 4 and 8 weeks recommended	2D reaching, finger individuation, grip/pinch strength and 3D functional drinking task
SRRR-1 2017		Recovery	Within 1st week, 3-months, 6- and 12-months recommended	NIHSS, **FMA-UE and FMA-LE, ARAT, ability to walk, 10MWT,** mRS and EQ-5D

CAULIN: Clinical Assessment of Upper Limb in Neurorehabilitation
SRRR: Stroke Recovery and Rehabilitation Roundtable
QoM: Quality of Movement

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Prediction tools can be used to guide rehabilitation goal setting and tailor therapy, and doing so may improve rehabilitation efficiency

Validated tools that predict outcomes at specific time points for individual patients

	Prediction tool	Outcome	Prediction time	Outcome time	Type of tool	Predictor variables
	PUPPI	NIHSS arm < 2 of 4 points	24 hours	3 months	Scoring system	Age, NIHSS
UL	PREP2	Upper limb activity capacity: Excellent, Good, Limited, Poor	3 – 10 days	3 months	Decision tree	SAFE, Age MEP status, NIHSS
	EPOS-UL	>10 out of 57 points on ARAT	2 – 10 days	3 months	Multi-variable equation	FMA-UE, finger extension, MI, shoulder abduction
	EPOS-LL	Independent walking	3-10 days	3 months	Multi-variable equation	Trunk Control Test, MI leg
LL	TWIST	Independent walking	7 days	1-3 months	Scoring system	Age, knee extension, BBS
	Kwah	Independent walking	Within 7 days	6 months	Multi-variable equation	Age, NIHSS

PUPPI: Persistent Upper Extremity Impairment
EPOS: Early Prediction of Functional Outcome after Stroke
TWIST: Time to Walking Independently After Stroke

Motor assessment results should be discussed with patients and their caregivers, together with assessments of other domains, such as cognition and communication, to establish a shared understanding of the patient's current status.

Assessment results can also be used to estimate the patient's likely outcomes, and these expectations can be combined with the patient's personal goals to agree on the rehabilitation plan.

Motor rehabilitation interventions

Strongly recommended evidence-based interventions

- Summary of national clinical practice guidelines, included if
  - Guidelines written in English or Dutch
  - Containing a section ‘rehabilitation after stroke’
  - Received ‘strong’ recommendation ‘in favour’ in at least three guidelines (2 reviewers)

- 5 high-quality guidelines included
  - Australian and New Zealand Guidelines
  - Canadian Guidelines
  - American Guidelines
  - UK National Clinical Guidelines
  - Guidelines from the Netherlands

Strongly recommended evidence-based interventions

More is better

Principles

Intensity (amount of rehabilitation)

Rehab is structured to provide as much scheduled therapy (OT and PT) as possible.	AU/NZ, CA, NL	**AU/NZ**: therapist should maximize the amount of active task practice during therapy sessions. Use of objective measurement of activity should be considered. **CA**: once deemed to be medically and neurologically stable, more therapy results in better outcomes. **NL** (in all phases): intensifying exercise therapy (more hours) compared to fewer hours leads to faster recovery of the dissociated movement, comfortable walking speed, maximum walking speed, walking distance, muscle tone, sitting and standing balance, the performance of basic activities of daily living, quality of life and degree of depression and feelings of anxiety.

2023 UK National Clinical Guidelines:

- *at least 3 hours of multidisciplinary therapy per day focused on exercise, motor retraining and/or functional practice*
- *people should be supported to remain active for 6 hours a day, including the hours of therapy (open gyms, self-practice, carer-assisted practice, engaging in activities of daily living, and activities promoting cardiovascular fitness)*

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Strongly recommended evidence-based interventions

Repetitive, intense, task- and context specific, progressive

General considerations		
Patients should participate in training that is meaningful, engaging, progressively adaptive, intensive, task-specific and goal-oriented in an effort to improve transfer skills and mobility.	CA, UK, US	**CA**: Therapy should include repetitive and intense use of patient-valued tasks that challenge the patient to acquire the necessary skills needed to perform functional tasks and activities. **UK**: People with loss of movement should be taught task-specific, repetitive, intensive exercises or activities that will increase strength. **US**: Intensive, repetitive, mobility-task training if gait limitations.

UK 2023: repetitive task practice should be provided as the principal rehabilitation approach, in preference to other therapy approaches including Bobath

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Progressive strength and functional balance training should be provided for those with reduced strength or balance

Specific therapies		
Weakness		
Progressive resistance training to improve strength	AU/NZ	**AU/NZ**: For stroke survivors with reduced strength in their arms or legs, progressive resistance training should be provided to improve strength.
Balance		
Balance training	NL, UK, US	**NL** (examined in ER, LR and RC): balance training during different activities improves *sit- and standing balance* and *basic ADL activities*. **UK**: People with significant impairment of their balance and walking ability after stroke should receive progressive balance training. **US**: 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.

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Strongly recommended evidence-based interventions

Walking in different forms

Individualized, repetitive, task and context specific, high variability combined with high number of repetitions

Circuit class therapy with focus on overground walking and mobility

Treadmill training with or without BWS

Robot-assisted for those who would otherwise not practice walking, but robotics should not used in place of conventional gait therapy

Ankle foot orthosis (AFO) should be offered when needed

Functional electric stimulation (FES) for drop-foot

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Strongly recommended evidence-based interventions

Arm training – specific therapies

Original or modified CIMT – active repetitive task-practice is the key element, no evidence for restraint alone, only relevant for those with minor cognitive deficits, and some finger/wrist function

Mental practice as adjunct therapy – for suitable candidates

Robot-assisted therapy only as an adjunct therapy, can increase repetition in those with moderate to severe impairment, shoulder and elbow movements

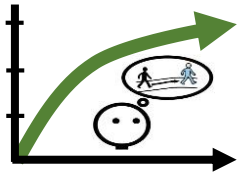
NMES as adjunct therapy for wrist/finger extensors can be offered for those with minimal active function, during the first months of stroke

ESO consensus-based definition on motor rehabilitation after stroke

European Stroke Journal 2023

MOTOR REHABILITATION AFTER STROKE . . .

A PROCESS THAT ENGAGES AND IS NECESSARY for all people with residual disability whose goal is to enhance their functioning, independence and participation.



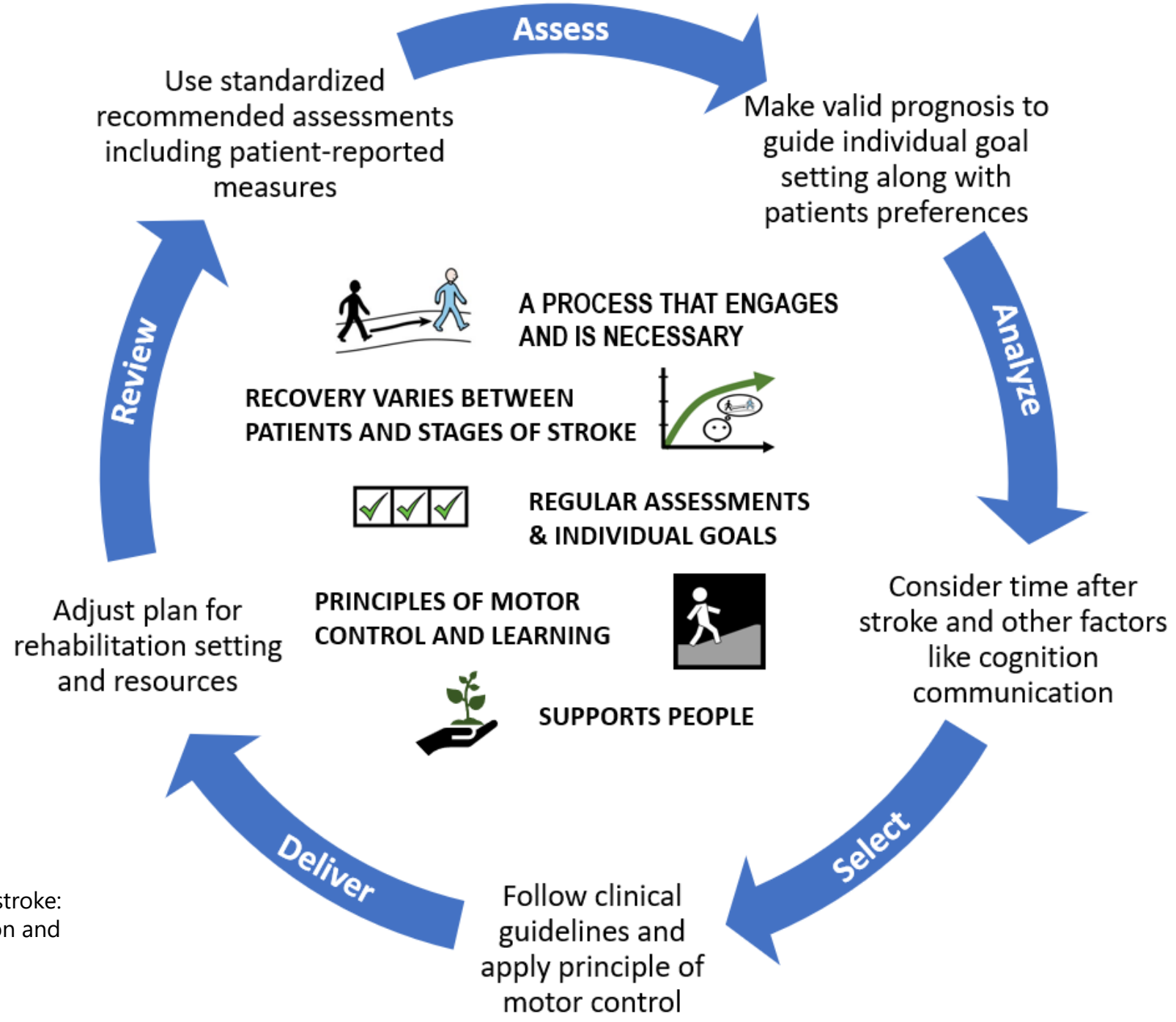
Strives to **REDUCE MOTOR IMPAIRMENTS AND IMPROVE FUNCTIONING IN ACTIVITIES** through learning- and use-dependent mechanisms while acknowledging variability between patients and stages of recovery.

Is **GUIDED BY REGULAR ASSESSMENTS**, discussed with the patient and carers to set personal goals.

INCORPORATES PRINCIPLES OF MOTOR CONTROL AND LEARNING to optimise functioning through appropriately dosed, repetitive, goal-oriented, progressive, task- and context-specific training.

SUPPORTS PEOPLE with stroke to maximise health, well-being and quality of life.

VISUAL DEFINITION on MOTOR REHABILITATION



Kwakkel G, Stinear C, Essers B, et al. Motor rehabilitation after stroke: European Stroke Organisation (ESO) consensus-based definition and guiding framework. *Eur Stroke J.* 2023

Review Article

EUROPEAN STROKE JOURNAL

European Stroke Journal
1–15

DOI: 10.1177/23969873231191304
journals.sagepub.com/home/eso

Sage

Motor rehabilitation after stroke: European Stroke Organisation (ESO) consensus-based definition and guiding framework

Gert Kwakkel[1,2,3*], Cathy Stinear[4*], Bea Essers[5], Maria Munoz-Novoa[6], Meret Branscheidt[7], Rosa Cabanas-Valdés[8], Sandra Lakičević[9], Sofia Lampropoulou[10], Andreas R Luft[7], Philippe Marque[11], Sarah A Moore[12,13], John M Solomon[14,15], Eva Swinnen[16], Andrea Turolla[17,18], Margit Alt Murphy[6,19#] and Geert Verheyden[5#]

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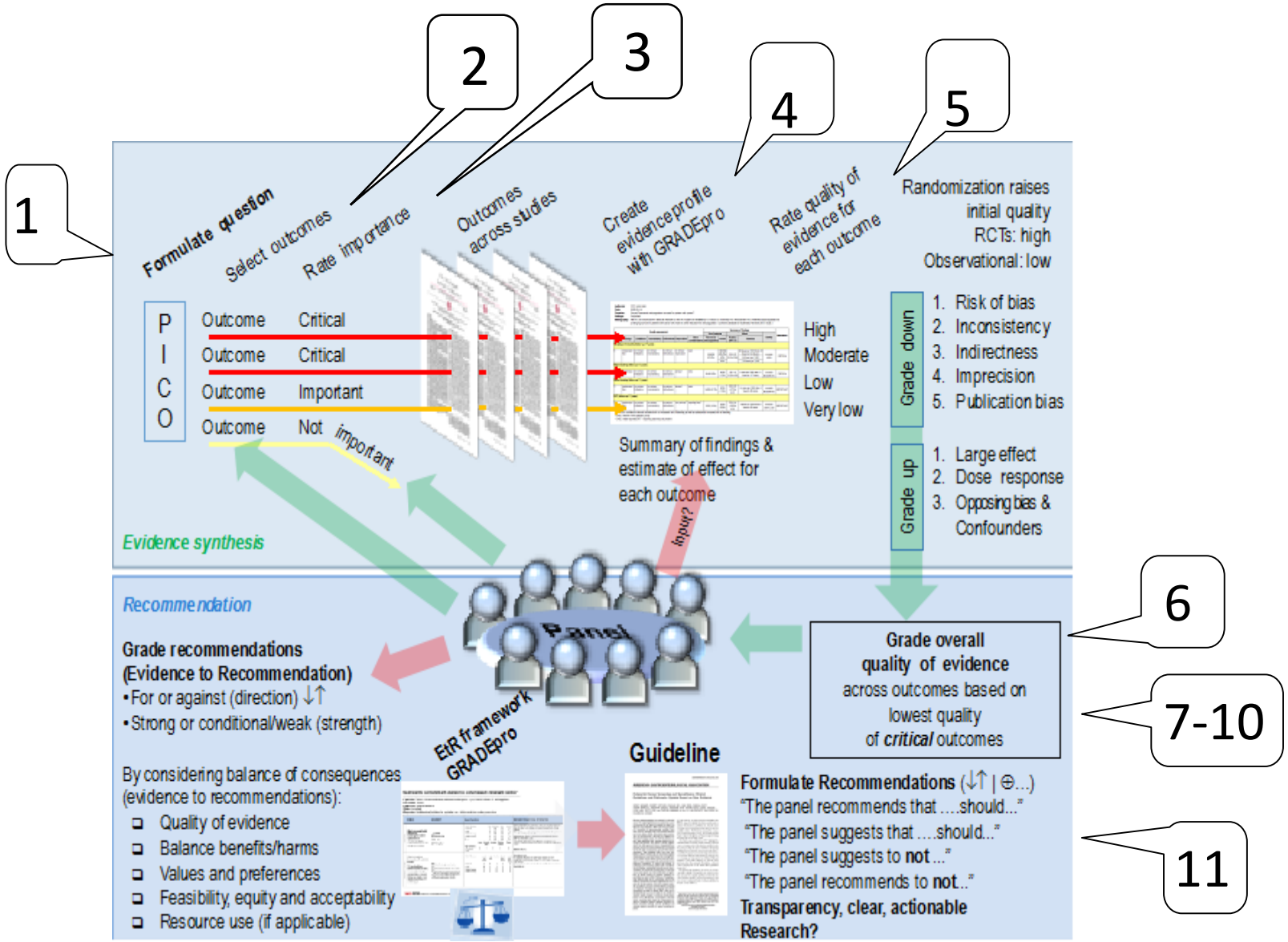
GRADE-Steps for ESO Guidelines



Identify GAPS in guidelines
PICO long list
Agreed final 6 PICOs
Outcomes long list
Agreed critical outcomes

Systematic literature search
Synthesize of evidence

Rate the quality of evidence GRADE

Evidence based recommendation

Expert consensus statement

https://gdt.gradepro.org/app/handbook/handbook.html

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European Stroke Organisation (ESO) Guideline on Motor Rehabilitation

PICO 1: does a **higher dose of upper limb** **active repetitive training compared to a lower dose of the same type of training** improve upper limb?

PICO 2: does a **higher dose walking training** **compared to a lower dose gait training** improve walking?

PICO 3: does **a high-intensity walking training** **compared to dose-matched walking training at a lower intensity** improve walking?

- PICO 4: does **repetitive upper limb task-specific training with a behavioural transfer package compared to the same type of duration-matched training without a behavioural transfer package** improve upper limb?
- PICO 5: does the provision of **task-specific training in group compared to the same type of time-matched one-to-one training** have the same effect on motor functioning?
- PICO 6: does the provision of usual care plus **additional sit-to-stand training compared to usual care alone** improve balance, independence in ADL and time taken in sit-to-stand?

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What do the systematic reviews and meta-analyses say of DOSE?

Cochrane Library

Cochrane Database of Systematic Reviews

The effect of time spent in rehabilitation on activity limitation and impairment after stroke (Review)

Clark B, Whitall J, Kwakkel G, Mehrholz J, Ewings S, Burridge J

Cochrane Library

Cochrane Database of Systematic Reviews

Repetitive task training for improving functional ability after stroke (Review)

French B, Thomas LH, Coupe J, McMahon NE, Connell L, Harrison J, Sutton CJ, Tishkovskaya S, Watkins CL

Research

Increasing the amount of usual rehabilitation improves activity after stroke: a systematic review

Emma J Schneider [a,b], Natasha A Lannin [a,b,c], Louise Ada [d], Julia Schmidt [a,e]

Is More Better? Using Metadata to Explore Dose–Response Relationships in Stroke Rehabilitation

Keith R. Lohse, PhD; Catherine E. Lang, PT, PhD; Lara A. Boyd, PT, PhD

OPEN ACCESS Freely available online

PLOS | ONE

What Is the Evidence for Physical Therapy Poststroke? A Systematic Review and Meta-Analysis

Janne Marieke Veerbeek[1], Erwin van Wegen[1], Roland van Peppen[2], Philip Jan van der Wees[3], Erik Hendriks[4], Marc Rietberg[1], Gert Kwakkel[1,5]*

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What do the systematic reviews and meta-analyses say?

Higher dose of practice time (same type of control)

Clark et al 2021 21 RCT (n=1412), 13 studies in upper extremity, 5 studies in walking/mobility

- the effect of time in same type of therapy aiming to improve activity
- positive effect was show for UE motor function and walking capacity, but not for ADL
- Authors concluded that more time spent in rehabilitation may be beneficial, provided the increased amount reaches a threshold of total time of approximately 1000 minutes (16 hours and 40 minutes).

Schneider et al. 2016 14 RCT (n=954)

- the effect of time in same type of therapy aiming to improve activity
- positive effect was show for UE activity capacity
- ROC curve analysis indicated that an increase of 240% in therapy time was necessary to have a significant effect on activity outcomes

What do the systematic reviews and meta-analyses say?

Higher dose of practice time (any control)

Weerbeek et al 2014

- control groups with lower dose usual care of any other therapy or no therapy
- Higher dose had significant effect on leg muscle strength
- The contrast between groups was approximately 17 hours delivered over 10 weeks

French et al. 2016

- control groups with any usual care including attention control and no therapy
- Repetitive task training improved activity capacity when compared between more or less of 20 h practice

Lohse et al. 2014

- Control groups with any dose and type of therapy
- Significant effect of more therapy time, independent of the stage of stroke recovery

What do the systematic reviews and meta-analyses say?

High intensity walking practice

Mah et al 2023

- 3 out of 4 RCT showed significant improvement in walking distance and walking speed
- 3 studies reported sustained effect 3-6 months post intervention

Moncion et al 2024

- High intensity interval training (HIIT) improved VO2max and walking speed and was superior compared to low and moderate intensity ant to high intensity continuous training

European Stroke Organisation (ESO) Guideline on Motor Rehabilitation

- PICO 1: **higher dose of upper limb active repetitive training compared to a lower dose of the same type of training** improve upper limb?
- PICO 2: does a **higher dose walking training compared to a lower dose gait training** improve walking?
- PICO 3: does **a high-intensity walking training compared to dose-matched walking training at a lower intensity** improve walking?

Contrast between groups needed to be at least 20h total practice time

High-intensity: >60% heart rate reserve OR 77% heart rate maximum OR 14-16 perceived exertion (Borgs scale)

Many studies did not make it to the inclusion:

- Too small groups
- Dose is not described sufficiently for both groups (most commonly the control group)
- Content of the therapy is not clearly described (not possible to know what was actually done)
- Too low contrast between groups, less than 20 hours
- Both dose and content were different between groups

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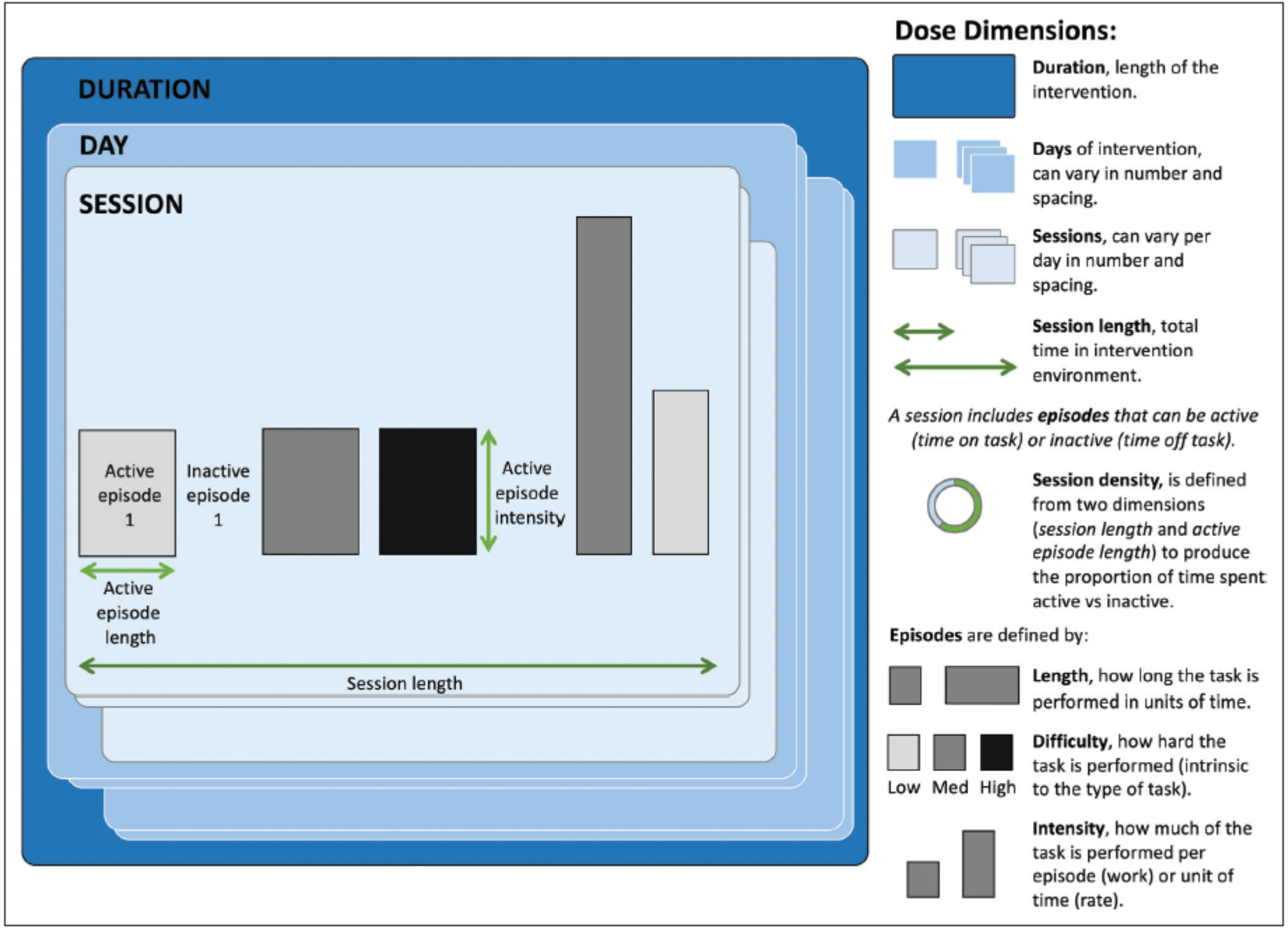

Advancing Stroke Recovery Through Improved Articulation of Nonpharmacological Intervention Dose. Hayward et al. *Stroke.* 2021;52:761–769

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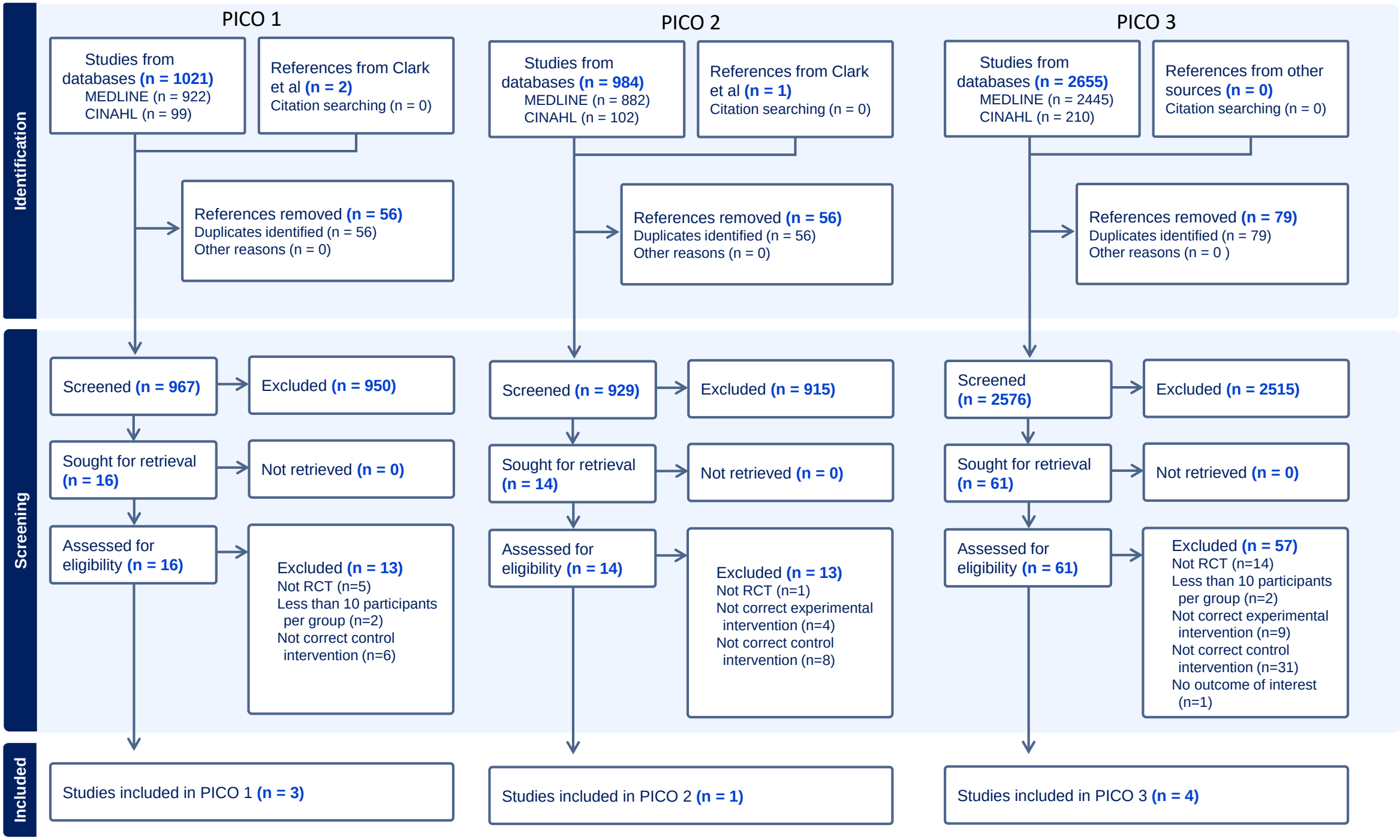
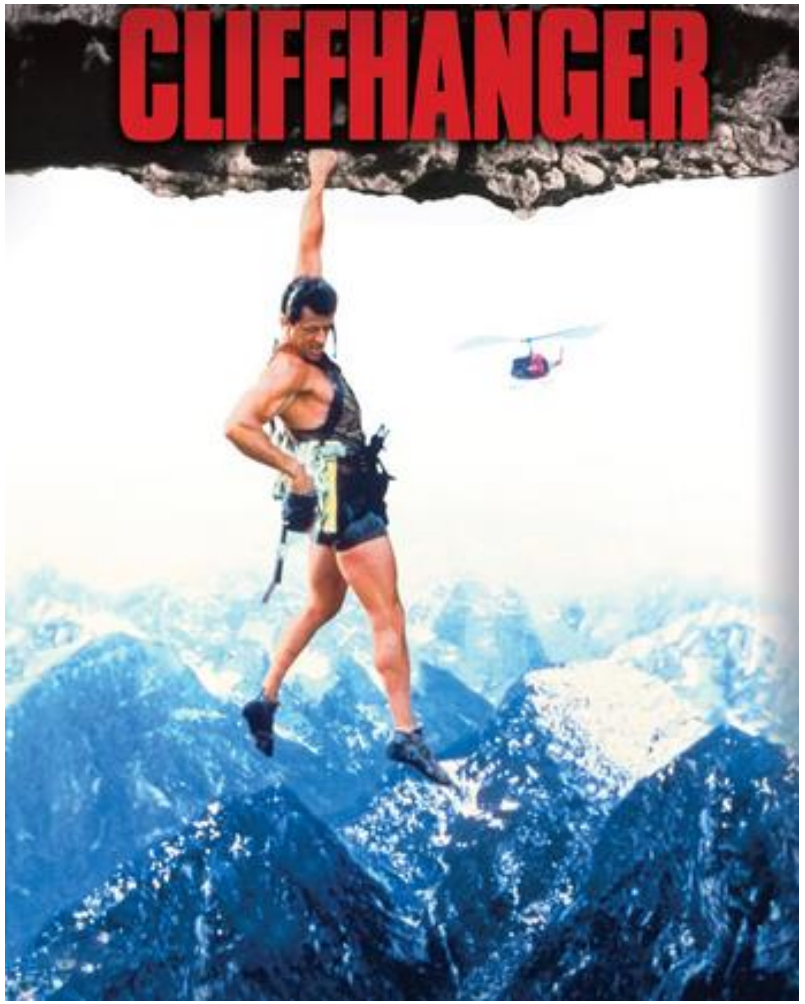

Identification
Screening
Included
PICO 1
Studies from databases (n = 1021)
MEDLINE (n = 922)
CINAHL (n = 99)
References from Clark et al (n = 2)
Citation searching (n = 0)
References removed (n = 56)
Duplicates identified (n = 56)
Other reasons (n = 0)
Screened (n = 967)
Excluded (n = 950)
Sought for retrieval (n = 16)
Not retrieved (n = 0)
Assessed for eligibility (n = 16)
Excluded (n = 13)
Not RCT (n=5)
Less than 10 participants per group (n=2)
Not correct control intervention (n=6)
Studies included in PICO 1 (n = 3)
PICO 2
Studies from databases (n = 984)
MEDLINE (n = 882)
CINAHL (n = 102)
References from Clark et al (n = 1)
Citation searching (n = 0)
References removed (n = 56)
Duplicates identified (n = 56)
Other reasons (n = 0)
Screened (n = 929)
Excluded (n = 915)
Sought for retrieval (n = 14)
Not retrieved (n = 0)
Assessed for eligibility (n = 14)
Excluded (n = 13)
Not RCT (n=1)
Not correct experimental intervention (n=4)
Not correct control intervention (n=8)
Studies included in PICO 2 (n = 1)
PICO 3
Studies from databases (n = 2655)
MEDLINE (n = 2445)
CINAHL (n = 210)
References from other sources (n = 0)
Citation searching (n = 0)
References removed (n = 79)
Duplicates identified (n = 79)
Other reasons (n = 0)
Screened (n = 2576)
Excluded (n = 2515)
Sought for retrieval (n = 61)
Not retrieved (n = 0)
Assessed for eligibility (n = 61)
Excluded (n = 57)
Not RCT (n=14)
Less than 10 participants per group (n=2)
Not correct experimental intervention (n=9)
Not correct control intervention (n=31)
No outcome of interest (n=1)
Studies included in PICO 3 (n = 4)



ESOC 2025

11th European Stroke Organisation Conference – ESOC 2025

21–23 May 2025, Helsinki, Finland

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Thank you!

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