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Walking Forward: Evolving Strategies for Mobility Rehabilitation Following Stroke

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Objectives

1. Review evidence supporting early mobilization and verticalization following stroke and brain injury.

2. Identify clinical tools used to predict motor recovery and guide rehabilitation planning after stroke.

3. Explain the role of high-intensity, task-specific training in promoting neuroplasticity and locomotor recovery.

4. Provide practical strategies and tools to translate current rehabilitation research into everyday clinical practice

Early Mobilization

- Very early mobilization (<24 hours) must be cautious
- Short, frequent, low-intensity sessions are best
- Avoid high-dose, prolonged early mobilization in first 24 hours

- Research shows first 14 days after a stroke represent a critical period of heightened neuroplasticity, during which the brain is especially responsive to rehabilitation and reorganization efforts.

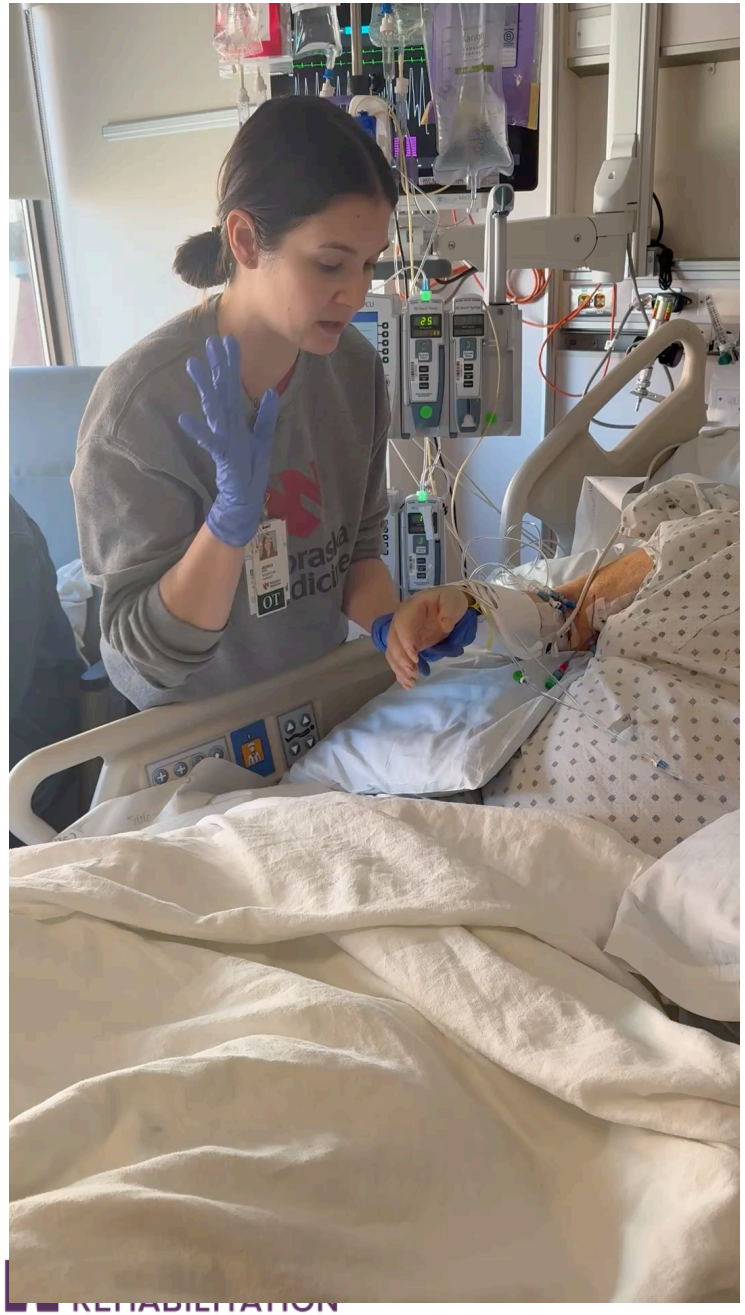
Predicting Upper Limb Recovery after Stroke

- Predicts function over 3 months Post-Stroke
- Helps Clinicians:
  - Early Goal-Setting
  - Therapy Focus (remediation vs compensation)
  - Communicating prognosis to patients and families

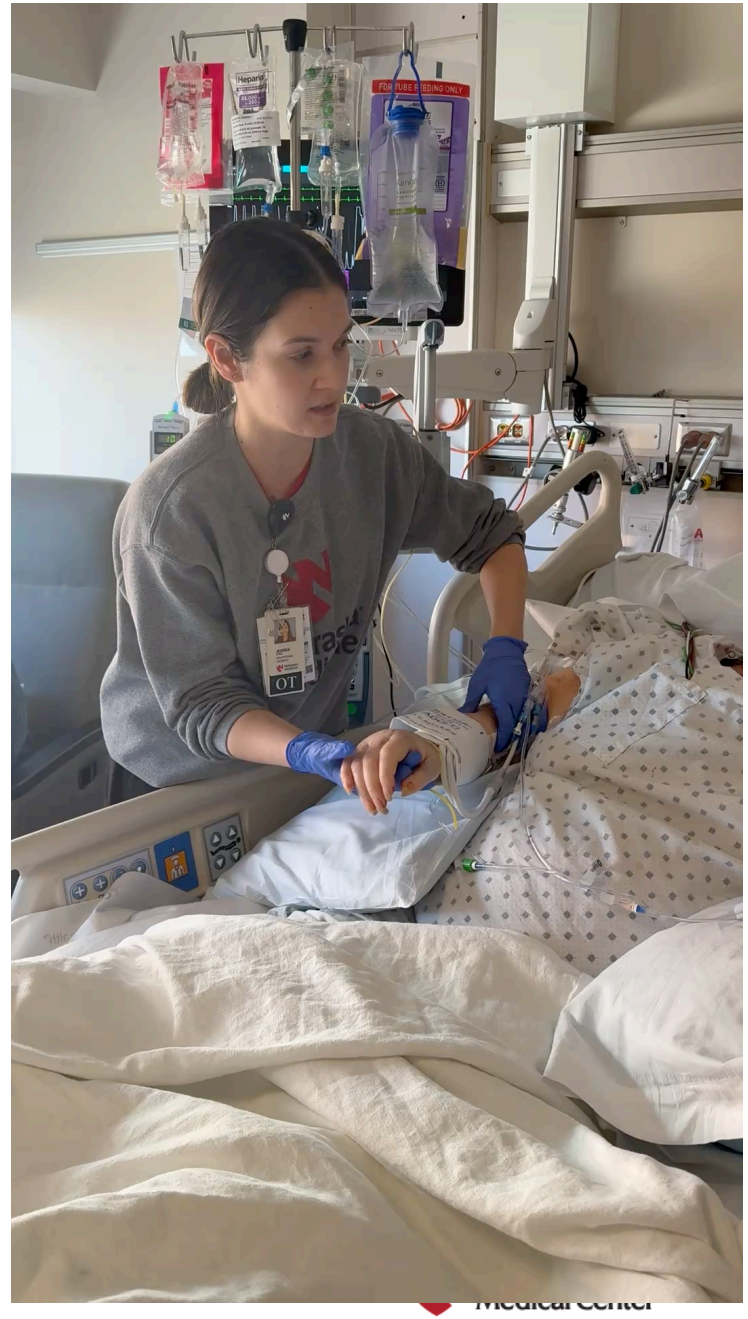
APRAHL: Alternative Prognosis of Recovery Assessment for the Hemiparetic limb

- Offers biomarker- free pathway when Predict Recovery Potential (PREP2) cannot be completed due to unavailability of Transcranial Magnetic Stimulation (TMS)

- Still early in research journey


OT


OT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National Institutes of Health Stroke Scale (NIHSS)

- a 15-item checklist assessing stroke severity
- Scores from 0 (no stroke) to 42 (severe stroke)
- Evaluating alertness, language, vision, motor skills, sensation, and coordination.
- Scores correlate to severity: 0-4 (minor), 5-15 (moderate), 16-20 (moderate-severe), and 21-42 (severe), helping predict outcomes and track changes in neurological function.

APRAHL Algorithm

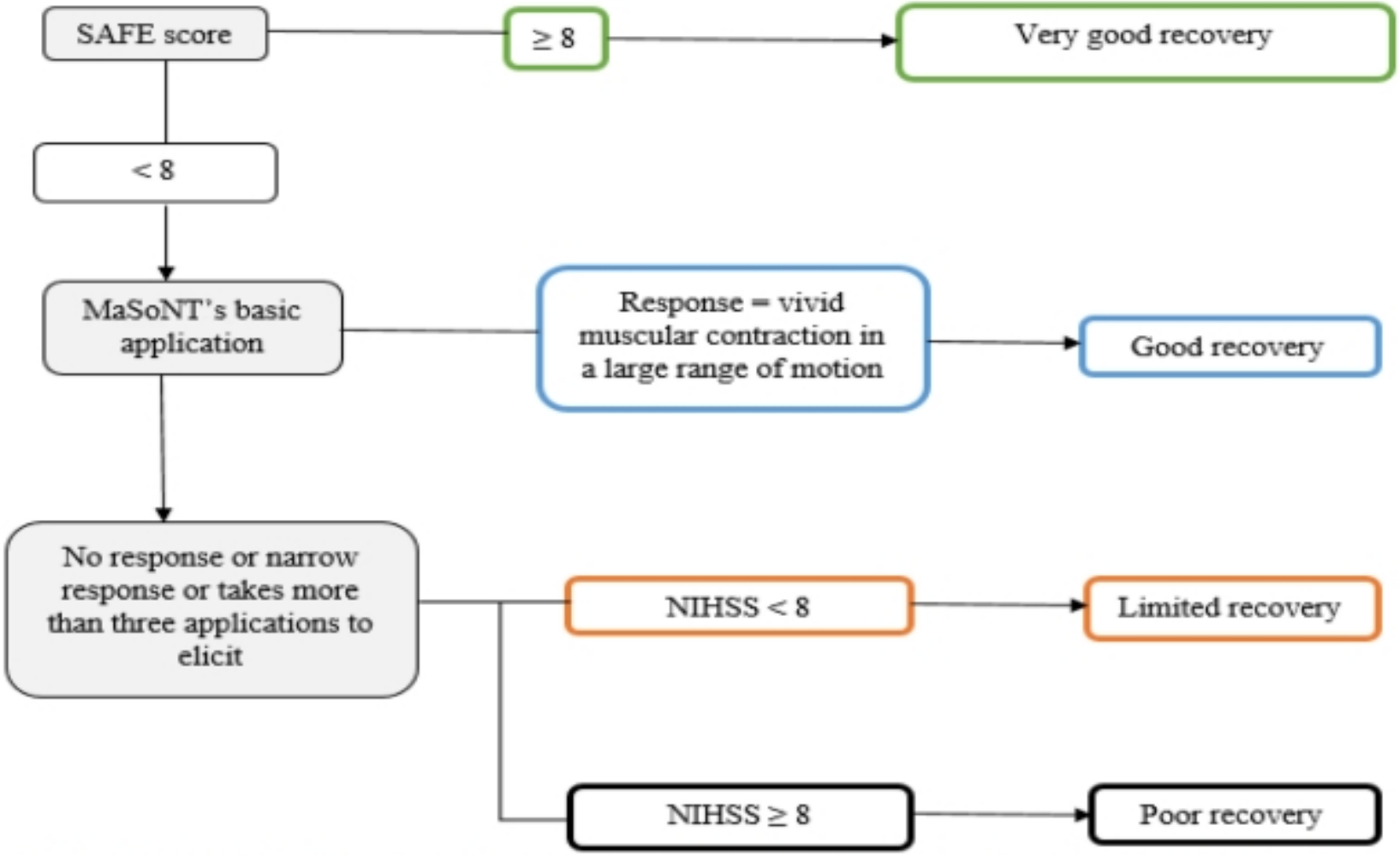
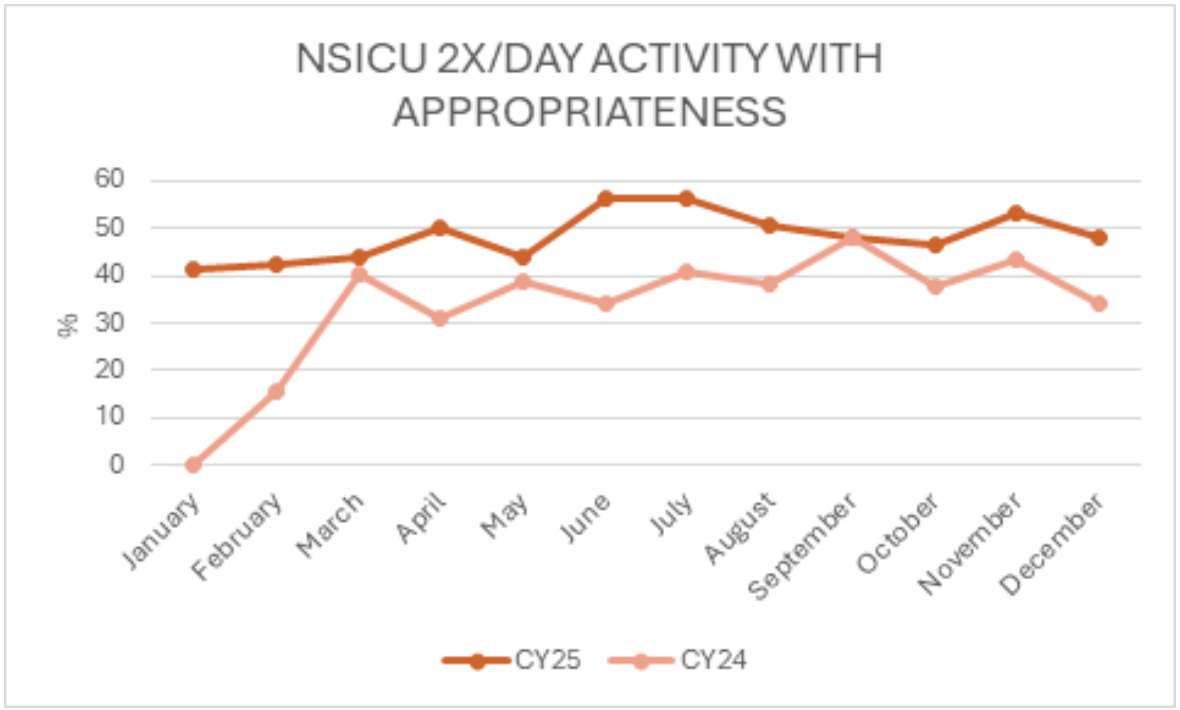
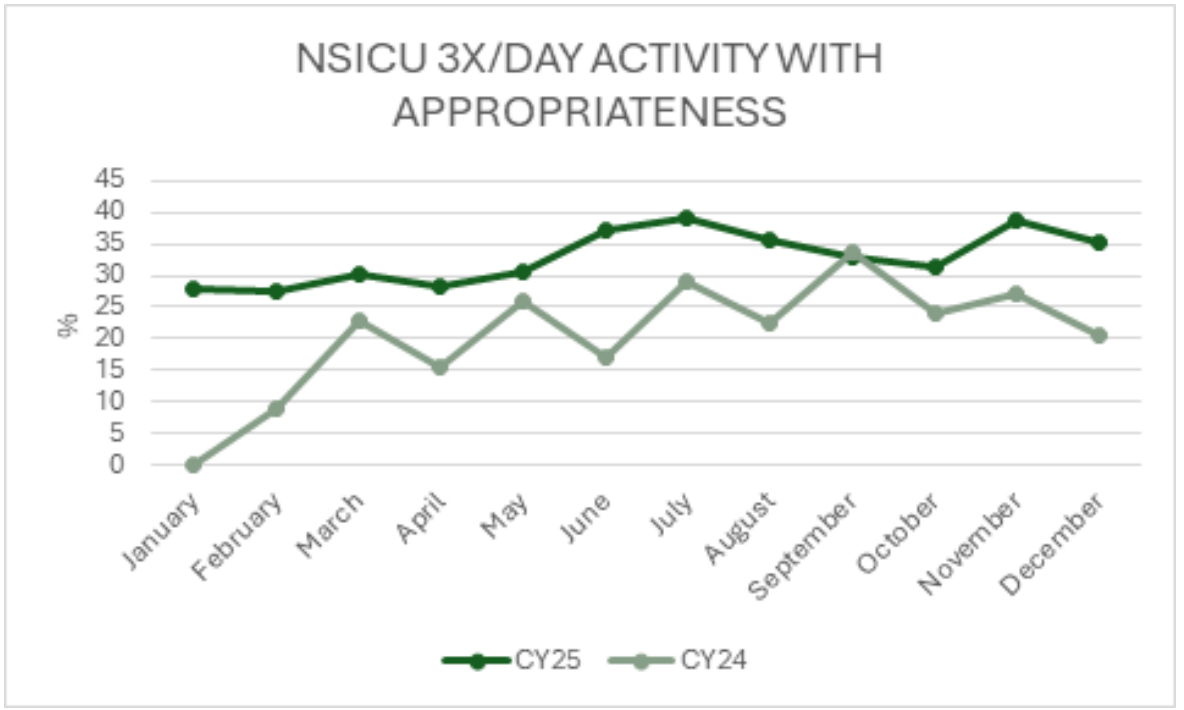


Fig. 5 The APRAHL algorithm for the hemiplegic upper-limb prognosis. SAFE, sum of the shoulder abduction and finger extension Medical Rating Council muscle grades at day 3 after stroke; MaSoNT, Mobilization and Stimulation of Neuromuscular Tissue; NIHSS, National Institutes of Health Stroke Scale. The test starts at day 3 after stroke. The patient is categorized according to the SAFE score to very good recovery if the score is above or equal to 8. If the SAFE score is lower than 8, the basic technique of MaSoNT is applied on the extensors' muscle group of the upper limb at day 3. The therapist, then, assesses the elicited brisk muscular contraction which is triggered as a response to that stimulation. If the response is a vivid muscular contraction in a large range of motion, the prognosis is good. If there is no response or if the response is narrow or subtle or takes more than three applications to elicit, the prognosis is limited if the NIHSS is under 8 and poor if the NIHSS is over 8

Nebraska Medicine and The Best ICU Study





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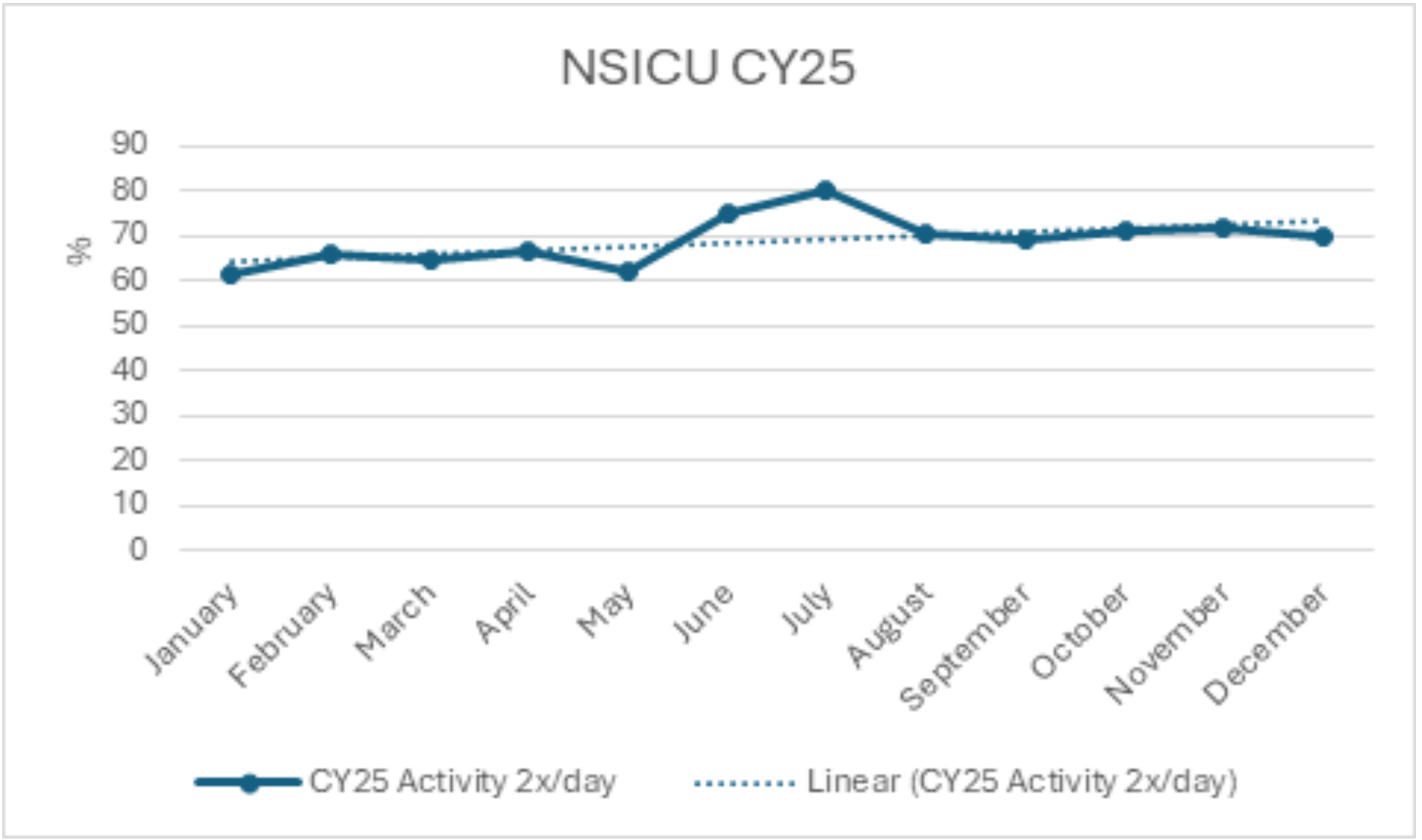
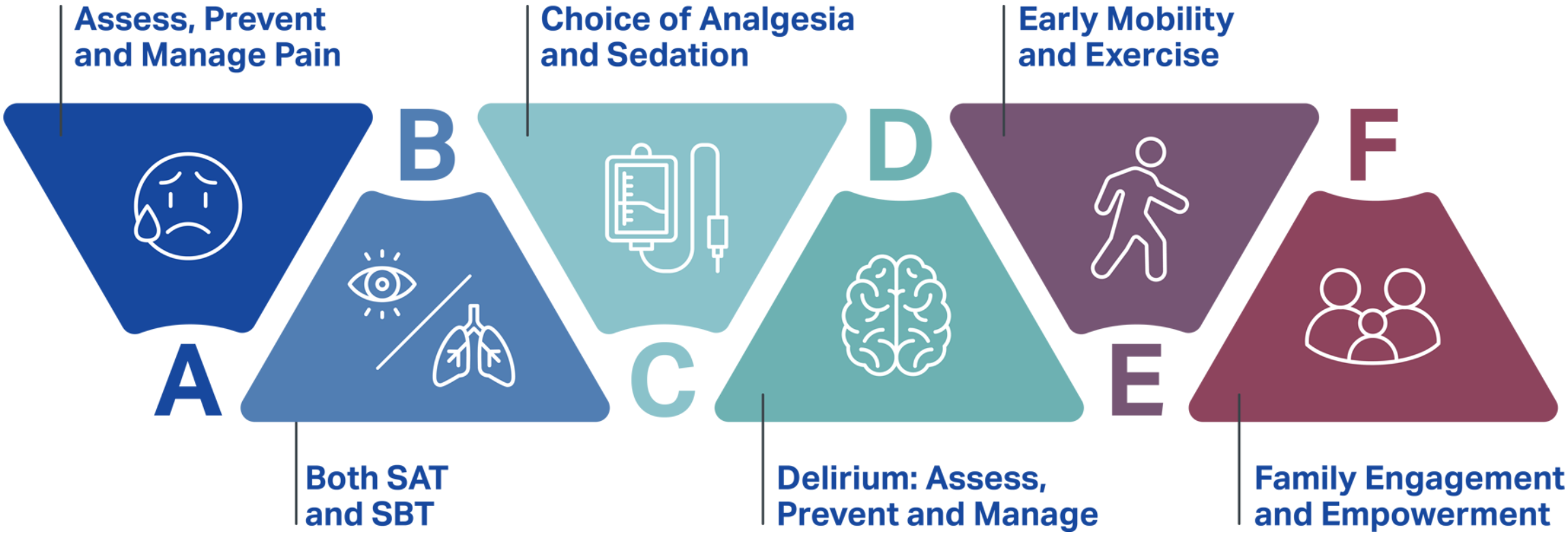
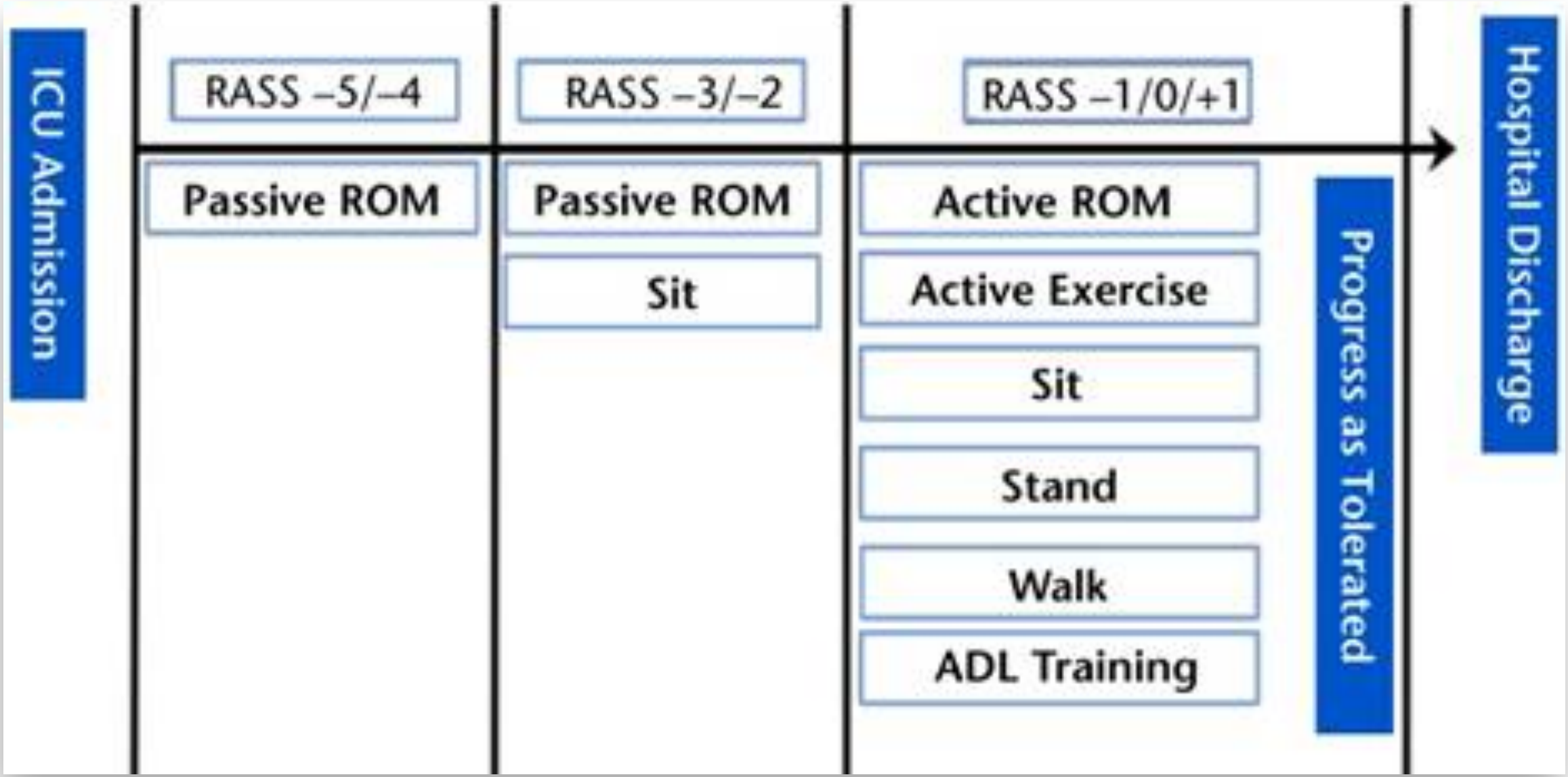

NSICU CY25
%
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
CY25 Activity 2x/day
Linear (CY25 Activity 2x/day)

ABCDEF Bundle



Richmond Agitation and Sedation Scale (RASS)		
+4	Combative	violent, immediate danger to staff
+3	Very Agitated	Pulls or removes tube(s) or catheter(s); aggressive
+2	Agitated	Frequent non-purposeful movement, fights ventilator
+1	Restless	Anxious, apprehensive but movements not aggressive or vigorous
0	Alert & calm	
-1	Drowsy	Not fully alert, but has sustained awakening to *voice* (eye opening & contact ≥ 10 sec)
-2	Light sedation	Briefly awakens to *voice* (eye opening & contact < 10 sec)
-3	Moderate sedation	Movement or eye-opening to *voice* (but no eye contact)
-4	Deep sedation	No response to voice, but movement or eye opening to *physical* stimulation
-5	Unarousable	No response to *voice or physical* stimulation


ICU Admission
RASS –5/–4
RASS –3/–2
RASS –1/0/+1
Hospital Discharge
Passive ROM
Passive ROM
Sit
Active ROM
Active Exercise
Sit
Stand
Walk
ADL Training
Progress as Tolerated

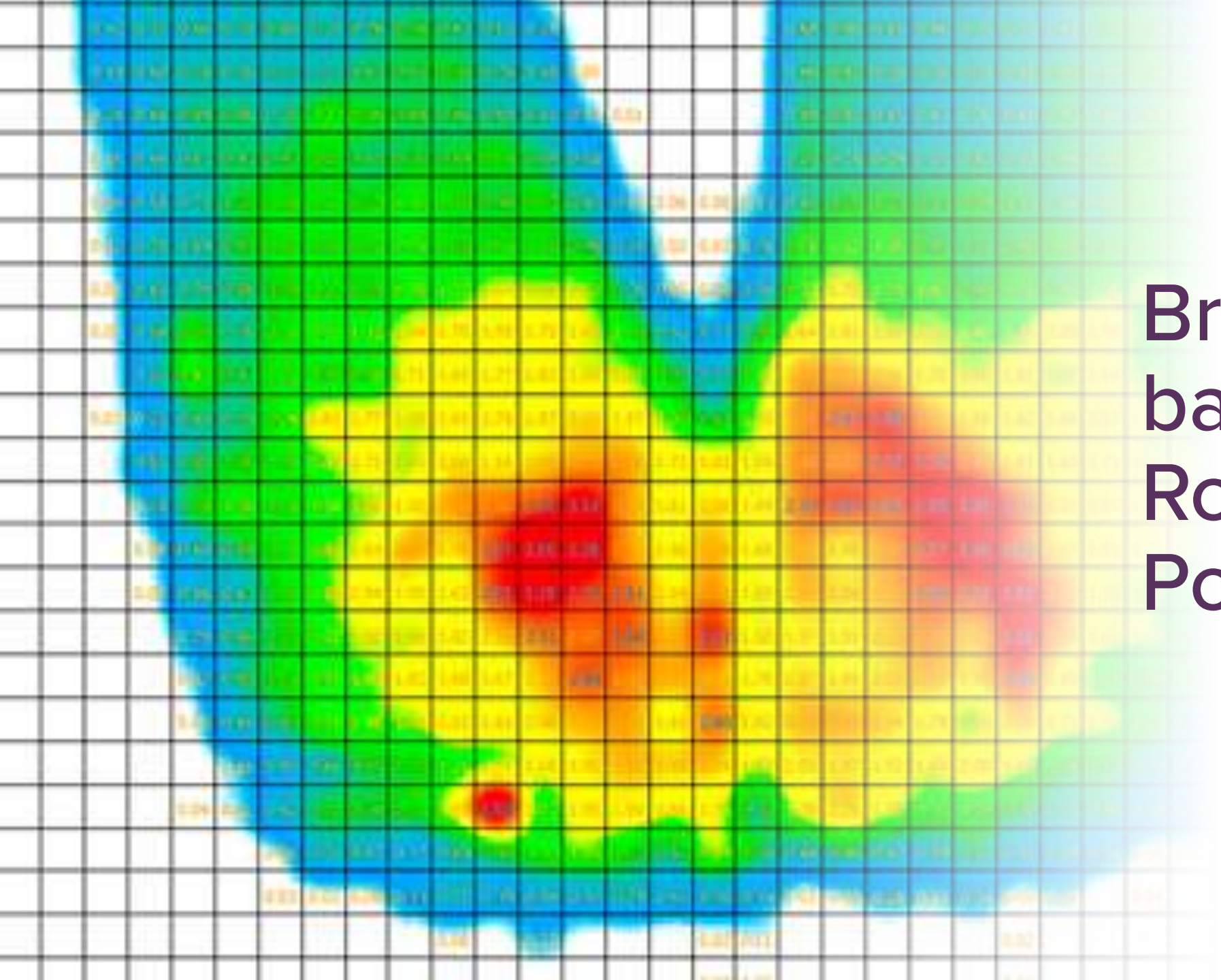
What do we do with patients on vent, at RASS -3, -4, -5?

Passive range of motion?

How do we move them safely?

What are the benefits?

Bed Chair?



Bringing it back to OT's Role in Positioning

Let's get vertical!

Ideal Population for Verticalization Therapy

- Stroke
- TBI/Concussion
- Disorders of consciousness (minimally conscious, vegetative states)
- SCI (incomplete/complete)
- ICU or prolonged bedrest
- Orthostatic intolerance or dysautonomia
- Severe weakness/deconditioning

Indications for Verticalization Therapy

- Airway issues (e.g., intubated, trach, Opti-flow/high flow)
- Delirium
- Patient needs increased stimulus
- Orthostatic Hypotension
- Does not OR intermittently following commands
- Craniectomy without helmet
- Spinal Cord
- RASS –2 to +1
- Femoral Line

Contraindications for Verticalization Therapy

- Worsening Neuro exam, pupillary changes
- Intercranial pressure greater than 20
- Transcranial doppler greater than 3.0 (at risk for vasospasm)
- Bolt
- Medically paralyzed
- Trach, must be older than 24 hours
- Uncontrolled blood pressure
- Pulmonary Embolism w/o therapeutic intervention
- PEEP < 10, Fi02 60 or below

Benefits of Verticalization

- Early Mobilization and Neuro Recovery
  - Enhances arousal and attention
  - Promotes Neuroplasticity
  - Reduces Spasticity
- Cardiovascular and Autonomic System Benefits
  - Improves orthostatic tolerance
  - Supports hemodynamic stability
- Pulmonary Advantages
  - Better ventilation & oxygenation
  - Helps secretion clearance

Benefits continued..

- Musculoskeletal health
  - Prevents contractures
  - Maintain bone density
  - Stimulates postural muscles
- GI, Renal, and Bowel Benefits
  - Improves digestion and bowel motility
  - Enhances bladder emptying
- Pressure Injury Prevention
  - Relieves prolonged pressure
  - Promotes skin perfusion

Benefits continued..

- Psychological & Cognitive Improvements
  - Improves mood and engagement
  - Supports cognitive participation
  - Delirium
- Functional gains
  - Prepares for transfers, standing, gait
  - Increases tolerance for therapy

Vital Monitoring

Vitals

- Oxygen, increased needs, Fi02, PEEP
- Intercranial pressure >20
- Blood pressure MAP <65, sudden BP drops or escalating vasopressors
- Pupil response and difference
- Heart rate
- Respiratory Rate

How do I get patients vertical without a vertical bed?

- Air pal
- Vertical Table

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BRIEF REPORT

The Effect of Positioning on the Level of Arousal and Awareness in Patients in the Vegetative State or the Minimally Conscious State: A Replication and Extension of a Previous Finding

Barbara A. Wilson ,[1,2,4] Samira Dhamapurkar,[1] Catherine Tunnard,[3] Peter Watson,[4] and Gerhard Florschutz[1]

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In 2005 Elliott et al. published a paper entitled 'Effect of posture on levels of arousal and awareness in vegetative and minimally conscious patients: a preliminary investigation'. Twelve patients, of whom 5 were in the vegetative state (VS) and 7 in the minimally conscious state (MCS), were assessed with the Wessex Head Injury Matrix (WHIM) when supine and when upright on a tilt table. The present study replicated and extended these findings by including a third position, sitting, in addition to supine and standing. We assessed 16 patients (8 in the VS and 8 in the MCS) with mixed aetiologies and compared the observed behaviours in three different positions (supine, sitting and standing) using the WHIM. Most patients (75%) showed more behaviours when in the upright position, compared to lying down ($p < .003$). Our findings are similar to those seen in the study reported by Elliott et al. With regard to sitting, 62.5% of patients were more responsive when assessed sitting in a wheelchair ($p < .05$) than in a supine position, and almost 69% were more responsive if assessed in an upright position compared to sitting. This was particularly true for patients in the MCS, where 87.5% did better if assessed on a tilt table or standing frame compared to sitting, suggesting that positional changes can have an effect on the level of arousal and awareness among patients in the VS and MCS.

Keywords: consciousness, head injury, persistent vegetative state, rehabilitation

- "75% of patients scored higher on the WHIM when assessed in standing position compared to the supine position."

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DOI 10.3233/RNN-140475
IOS Press

Do post-stroke patients benefit from robotic verticalization? A pilot-study focusing on a novel neurophysiological approach

Rocco Salvatore Calabrò*,[1], Antonino Naro[1], Margherita Russo, Antonino Leo, Tina Balletta, Ileana Saccà, Rosaria De Luca and Placido Bramanti
IRCCS Centro Neurolesi "Bonino-Pulejo", Messina, Italy

Abstract.
Background: Tilt-table equipped with the dynamic foot-support (ERIGO) and the functional electric stimulation could be a safe and suitable device for stabilization of vital signs, increasing patient's motivation for further recovery, decreasing the duration of hospitalization, and accelerating the adaptation to vertical posture in bedridden patients with brain-injury. Moreover, it is conceivable that verticalization may improve cognitive functions, and induce plastic changes at sensory motor and vestibular system level that may in turn facilitate motor functional recovery.
Objective: To test the safety and effectiveness of ERIGO treatment on motor and cognitive functions, cortical plasticity within vestibular and sensory-motor systems in a bedridden post-stroke sample.
Methods: 20 patients were randomly divided in two groups that performed ERIGO training (30 sessions) (G1) or physiotherapist-assisted verticalization training (same duration) (G2), beyond conventional neurorehabilitation treatment. Motor and cognitive functions as well as sensory-motor and vestibular system plasticity were investigated either before (T_0) or after (T_1) the rehabilitative protocols.
Results: Both the verticalization treatments were well-tolerated. Notably, the G1 patients had a significant improvement in cognitive function ($p = 0.03$), global motor function ($p = 0.006$), sensory-motor ($p < 0.001$) and vestibular system plasticity ($p = 0.02$) as compared to G2.
Conclusions: ERIGO training could be a valuable tool for the adaptation to the vertical position with a better global function improvement, as also suggested by the sensory-motor and vestibular system plasticity induction.

Keywords: ERIGO, verticalization, stroke, vestibular system, sensory-motor plasticity, bedridden condition

- "Our pilot-study supports the safety and effectiveness of ERIGO verticalization in bedridden post-stroke patients, even in the sub-acute phase.. We found greater improvement in nearly all clinical and safety outcomes after rVT to FM (lower limb motor function), PASS (postural control) and RCPM (cognitive abilities)"

Neurocrit Care (2022) 36:
https://doi.org/1
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NEUROCRITICAL CARE SOCIETY

ORIGIN

Verticalization for Refractory Intracranial Hypertension: A Case Series

Brittany Bolduc Lachance[1*], WanTsu Chang[1,2], Melissa Motta[1], Gunjan Parikh[1], Jamie Podell[1], Neeraj Badjatia[1], J. Marc Simard[3], Gary T. Schwartzbauer[3] and Nicholas A. Morris[1]

Abstract

Background: Severe intracranial hypertension is strongly associated with mortality. Guidelines recommend medical management involving sedation, hyperosmotic agents, barbiturates, hypothermia, and surgical intervention. When these interventions are maximized or are contraindicated, refractory intracranial hypertension poses risk for herniation and death. We describe a novel intervention of verticalization for treating intracranial hypertension refractory to aggressive medical treatment.

Methods: This study was a single-center retrospective review of six cases of refractory intracranial hypertension in a tertiary care center. All patients were treated with a standard-of-care algorithm for lowering intracranial pressure (ICP) yet maintained an ICP greater than 20 mmHg. They were then treated with verticalization for at least 24 h. We compared the median ICP, the number of ICP spikes greater than 20 mmHg, and the percentage of ICP values greater than 20 mmHg in the 24 h before verticalization vs. after verticalization. We assessed the use of hyperosmotic therapies and any changes in the mean arterial pressure and cerebral perfusion pressure related with the intervention.

Results: Five patients were admitted with subarachnoid hemorrhage and one with intracerebral hemorrhage. All patients had ICP monitoring by external ventricular drain. The median opening pressure was 30 mmHg (25th–75th interquartile range 22.5–30 mmHg). All patients demonstrated a reduction in ICP after verticalization, with a significant decrease in the median ICP (12 vs. 8 mmHg; $p < 0.001$), the number of ICP spikes (12 vs. 2; $p < 0.01$), and the percentage of ICP values greater than 20 mmHg (50% vs. 8.3%; $p < 0.01$). There was a decrease in total medical interventions after verticalization (79 vs. 41; $p = 0.05$) and a lower total therapy intensity level score after verticalization. The most common adverse effects included asymptomatic bradycardia ($n = 3$) and pressure wounds ($n = 4$).

Conclusions: Verticalization is an effective noninvasive intervention for lowering ICP in intracranial hypertension that is refractory to aggressive standard management and warrants further study.

Keywords: Brain edema, Intracranial hypertension, Intracranial pressure

Total number of acute interventions for ICP elevation was significantly lower after verticalization (79 interventions vs 41interventions; p=0.04)"

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Other tools for Early Mobility

- Mechanical sit to stand lifts
- Walking devices
- Hoyer lift
- Vent Walks

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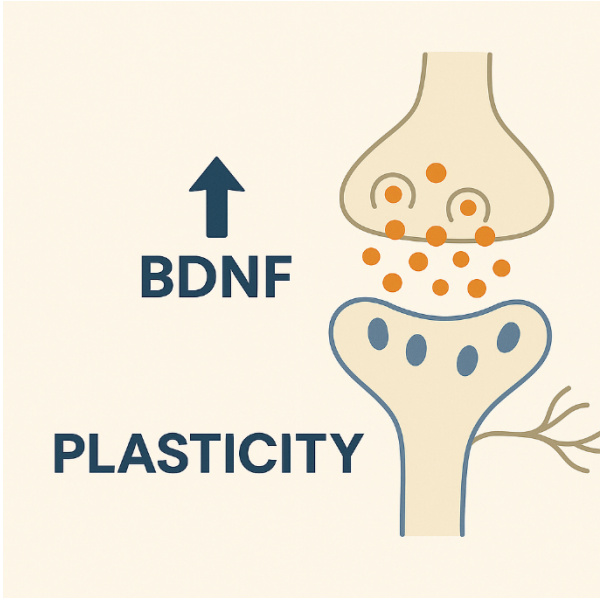
EXIT
MED SLED


PTA

Specificity, Intensity, Repetition

- Neuroplasticity Principles
  - High-intensity, **task-specific** practice drives stronger neural adaptation and strengthens synaptic connections, and increase dendritic growth
  - BDNF (Brain-Derived Neurotrophic Factor) increases with **high intensity** training, enhancing synaptic plasticity (no increase with low/moderate intensity training)
  - Clinically: **higher reps**, focused effort, and active participation improve recovery



INTENSITY MATTERS!

Clinical Practice Guideline to Improve Locomotor Function

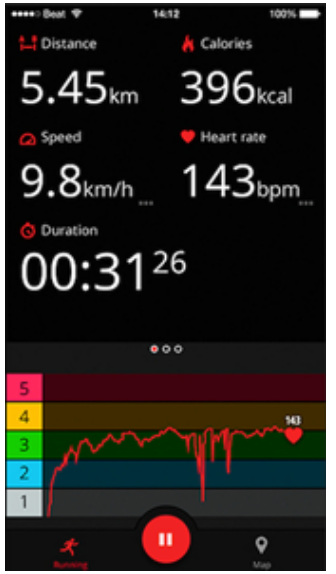
- Goal of the guideline was to look at the efficacy of a variety of interventions to improve walking speed and duration
- Chronic (>6 months) Stroke, Incomplete SCI, and Brain Injury
- Patient has goal to improve walking function
- **DO** these things:
  - Perform walking training at aerobic intensities
  - Performs walking training with augmented visual feedback

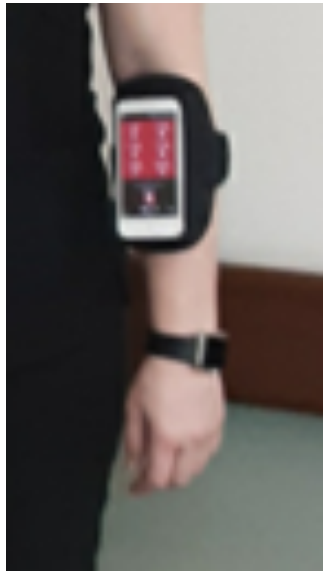
Clinical Practice Guideline to Improve Locomotor Function

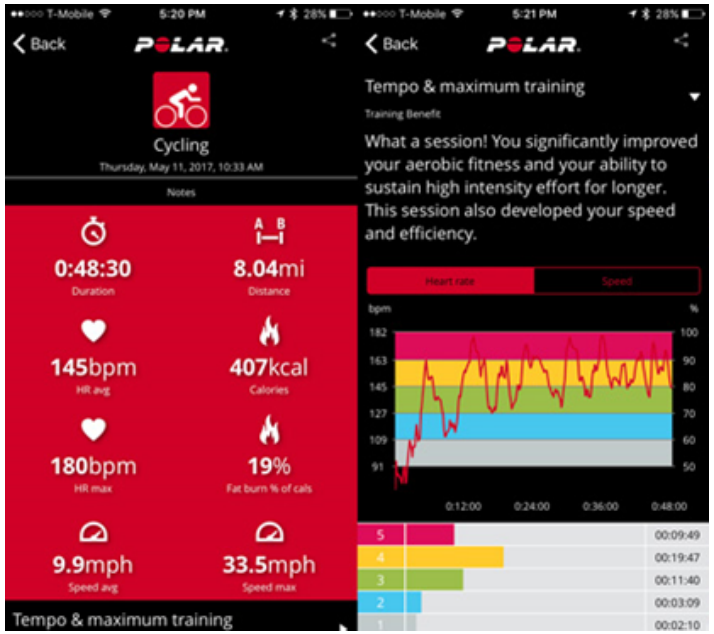
- **MAYBE** do these things:
  - Strength training at > 70% 1 RM
  - Circuit training at 60-80% HRR
  - Balance training with augmented visual feedback
  - Perform aerobic cycling/stepping
- **STOP** these things:
  - Perform balance/pre-gait activities without feedback or with vibration
  - Performs body weight support treadmill training with assistance for kinematics
  - Perform robotic assisted walking training

What is moderate to high intensity?

- Moderate to high intensity levels = 75-85% of HR max and/or RPE ≥ 15
- Calculate appropriate HR max, considering effect of beta blockers
- Requires constant monitoring
  - Polar HR monitors, spot check in 5 minute increments, RPE chart
  - ANPT: Clinician Tools and Resources
- Can't substitute duration for intensity
- May need to clear with physician if concerns with exercise at this intensity
  - ANPT: Physician Resources



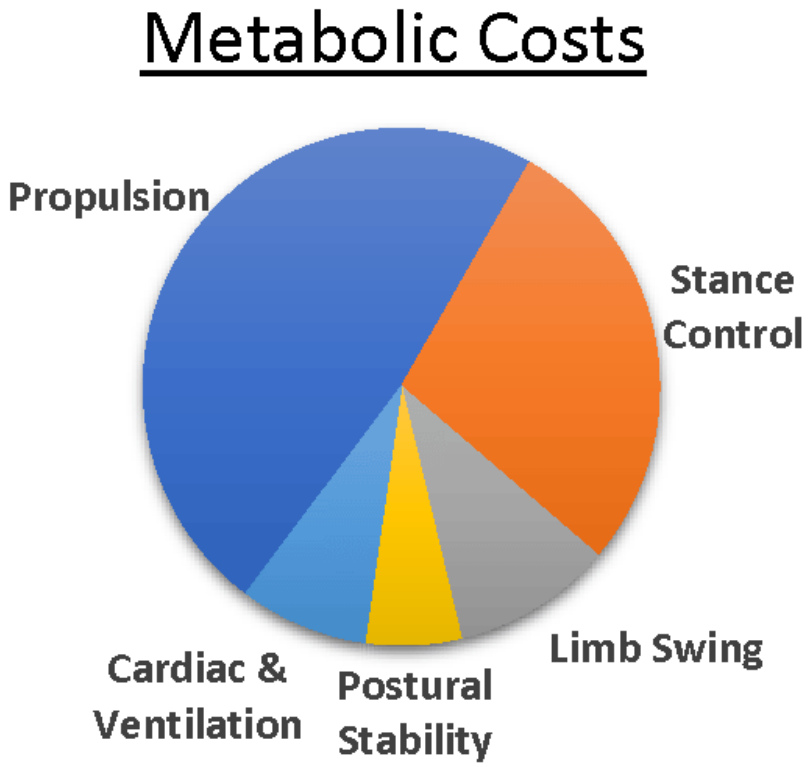




Metabolic Cost of Walking

- Propulsion (50-75%)
- Limb Swing (5-10%)
- Postural Stability (25%)
- Stance Control (5-10%)

- All patients can work on propulsion!



Academy of Neurologic PT Resources

ANPT CLINICAL PRACTICE GUIDELINES

Clinical Practice Guideline to Improve Locomotor Function following Chronic Stroke, Incomplete Spinal Cord Injury and Brain Injury

The scope of this Clinical Practice Guideline (CPG) is to evaluate available evidence of the efficacy of various physical interventions to improve walking function of patients with a history of a stroke, motor incomplete SCI, or TBI of > 6 months duration. **Click on this link for the full article is accessible in the Journal of Neurologic Physical Therapy**.

Clinical Tools for Implementation of Recommended Action Statements

The ANPT Knowledge Translation Task Force has put together a toolbox of resources to help physical therapists implement the Guidelines. **CLICK ON THE LINKS** on the right to obtain these resources:

In This Section

- CPG Resources
- Clinician Resources
- Physician Resources
- Podcasts
- Patient Resources

NATIONAL CAMPAIGN: INTENSITY MATTERS

Intensity Matters: Clinician Tools & Resources

These are tools and resources to help clinicians implement high intensity gait training with patients as well as provide educational materials for patients, physicians, and other stakeholders

Tools

In This Section

- Heart Rate Tool Tutorial Video
- Heart Rate Reserve Calculator
- Heart Rate Max Calculator
- Heart Rate Guide
- Continuous Heart Rate Monitoring Device Choices
- Walking Function Stoplight
- Borg Rating Scale

Resources

- APTA The Pulse: *Don't Be Afraid to Sweat*
- Safety - Intensity Matters
- Vital Signs Parameters
- A Framework for Implementing High Intensity Gait Training
- ANPT Spinal Cord Injury Special Interest Group Podcast: Interview with Carey Holleran and George Hornby about the Locomotion - chronic CVA, SCI, TBI CPG
- ANPT Stroke Special Interest Group Locomotion Podcast Part 1- Chronic CVA, SCI, TBI CPG
- ANPT Stroke Special Interest Group Locomotion Podcast Part 2- Chronic CVA, SCI, TBI CPG

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Locomotor Training Equipment

- **Robotics**
  - Body weight support treadmill training with robotic legs
  - Exoskeleton

Locomotor Training Equipment

- **Ellipticals**
  - With or without motor assistance
  - Optional body weight support
  - Enables mass practice of simulated gait activity
  - Affordable alternative used in small rehabs and community settings

Locomotor Training Equipment

- **Body weight support utilizing a floor lift**
  - Walking Harness
  - Ambulation shorts
  - Static BWS
  - Ensure harness used is approved by manufacturer to be used with floor lift
  - OT can use for standing activities and/or gait in functional settings (ie. kitchen)

Locomotor Training Equipment

- **Body weight support locomotor training**
  - Provides postural and body weight support during gait training
  - Can use over treadmill or overground
  - Not just for locomotor training
  - Sitting balance, tall kneeling, quadruped
  - Used by PT and OT

Locomotor Training Equipment

- **Ceiling track systems**
  - Used for safety as a passive catch
  - Provides little to no body weight support
  - Quick and easy set up
  - Can customize the track (over treadmill and/or steps)
  - PT and OT can use for gait and/or balance activities

Vagus Nerve Stimulator

- Implanted device that stimulates the left vagus nerve
- Delivers mild electrical impulses during therapy
- For chronic Ischemic strokes with moderate upper extremity weakness

- Purpose
  - Enhances neuroplasticity
  - Improves upper extremity motor recovery
  - Used along task-specific therapy

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