INCOMPLETE SPINAL CORD INJURY & SPINAL CORD PLASTICITY

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OBJECTIVES

- Summarize research evidence of neuroplasticity following spinal cord injury
- Describe expectations for ambulation and functional independence based on ASIA impairment scale classification and neurological level (level of injury).
- Discuss major factors affecting outcome in patients with incomplete SCI.
- Describe standardized assessments for monitoring and documenting progress in patients with incomplete SCI.
- Given a description of a patient's MMT results, provide appropriate recommendations for lower extremity bracing.
- Describe intervention strategies for facilitating neuroplasticity and behavioral recovery following spinal cord injury, including treadmill locomotion with and without partial body weight support.
- Given a written description of a patient with incomplete SCI, identify impairments and functional limitations, determine short-term and long-term physical therapy goals, discuss functional progressions which may aid in regaining independent movement, and make recommendations for assistive device(s) and adaptive equipment.

WHAT IS IT?

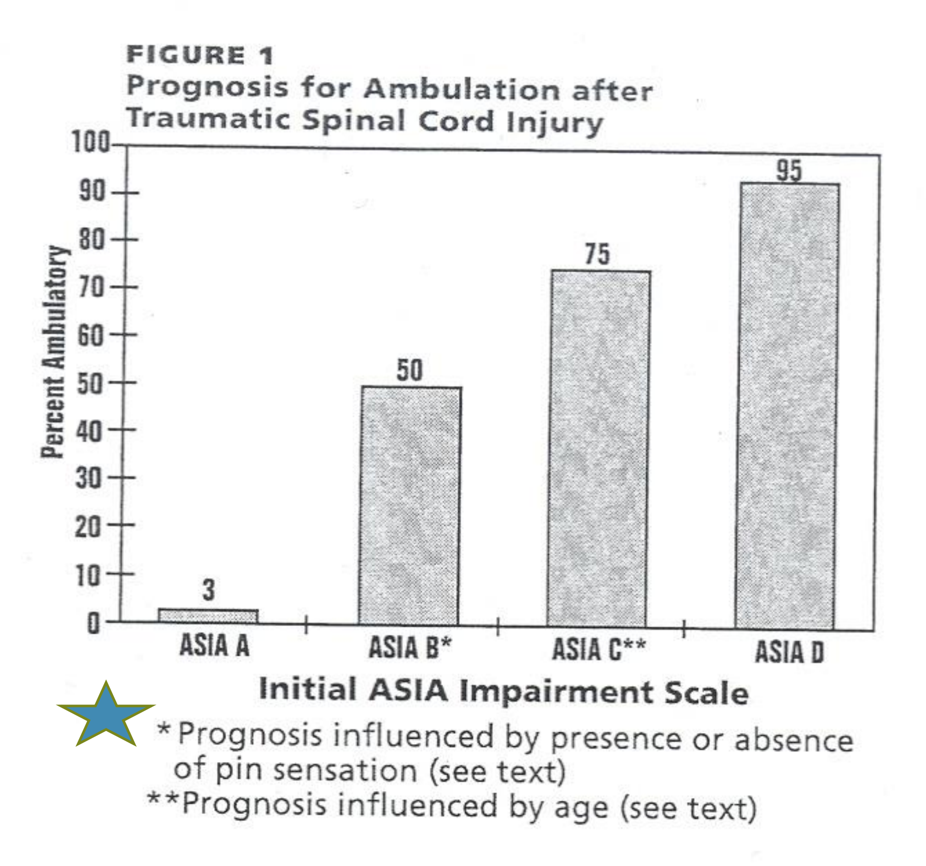
- Incomplete SCI occurs when the spinal cord is compressed or injured, but there is preservation of motor or sensory function below the level of the lesion.
- Incomplete quadriplegia – 34.5%
- Incomplete paraplegia – 17.5%

NEUROPLASTICITY

- Nervous system has capability for change in response to activity, injury
- Evidence for both anatomical and functional changes
- Novel technology may have a place in rehabilitation of people with SCI

OUTCOME PREDICTION

OUTCOME PREDICTION
AMBULATION POST SCI



Graphs from Clinical Practice Guidelines for SCI[1]

OUTCOME PREDICTION
PINPRICK SENSATION[2]

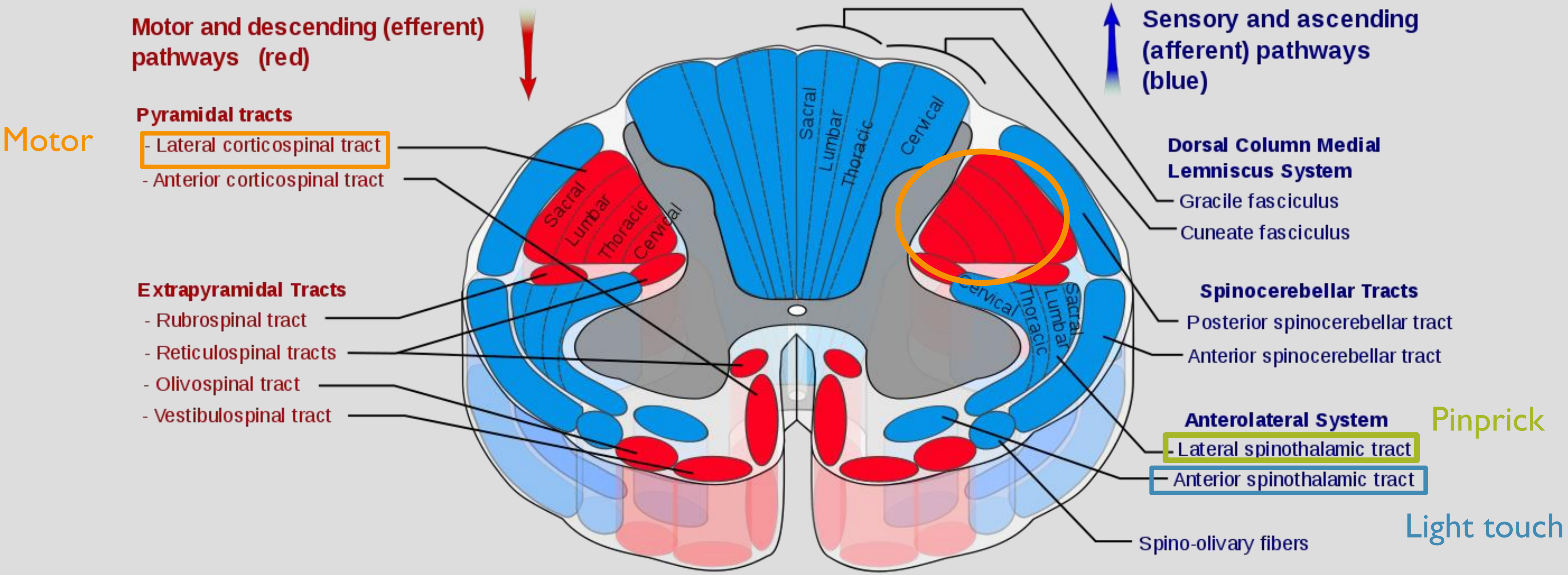
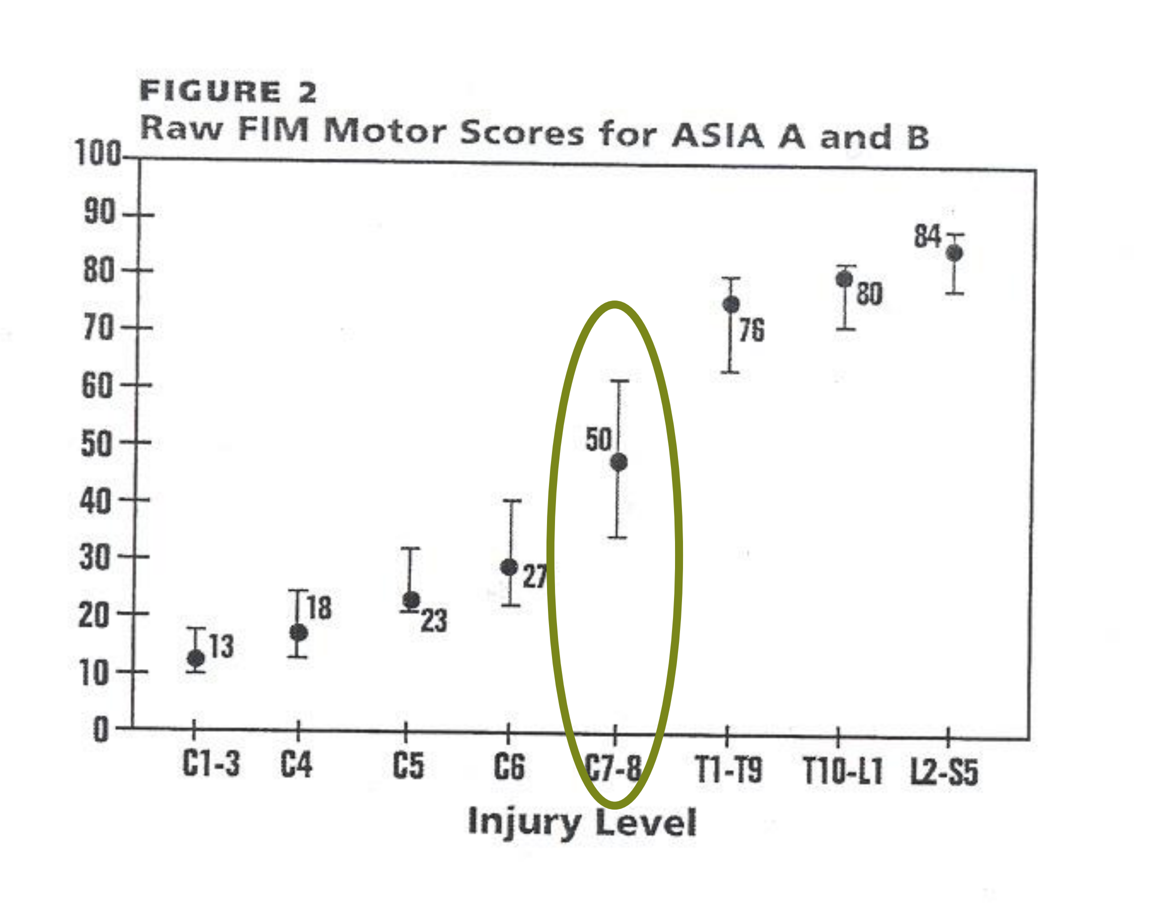


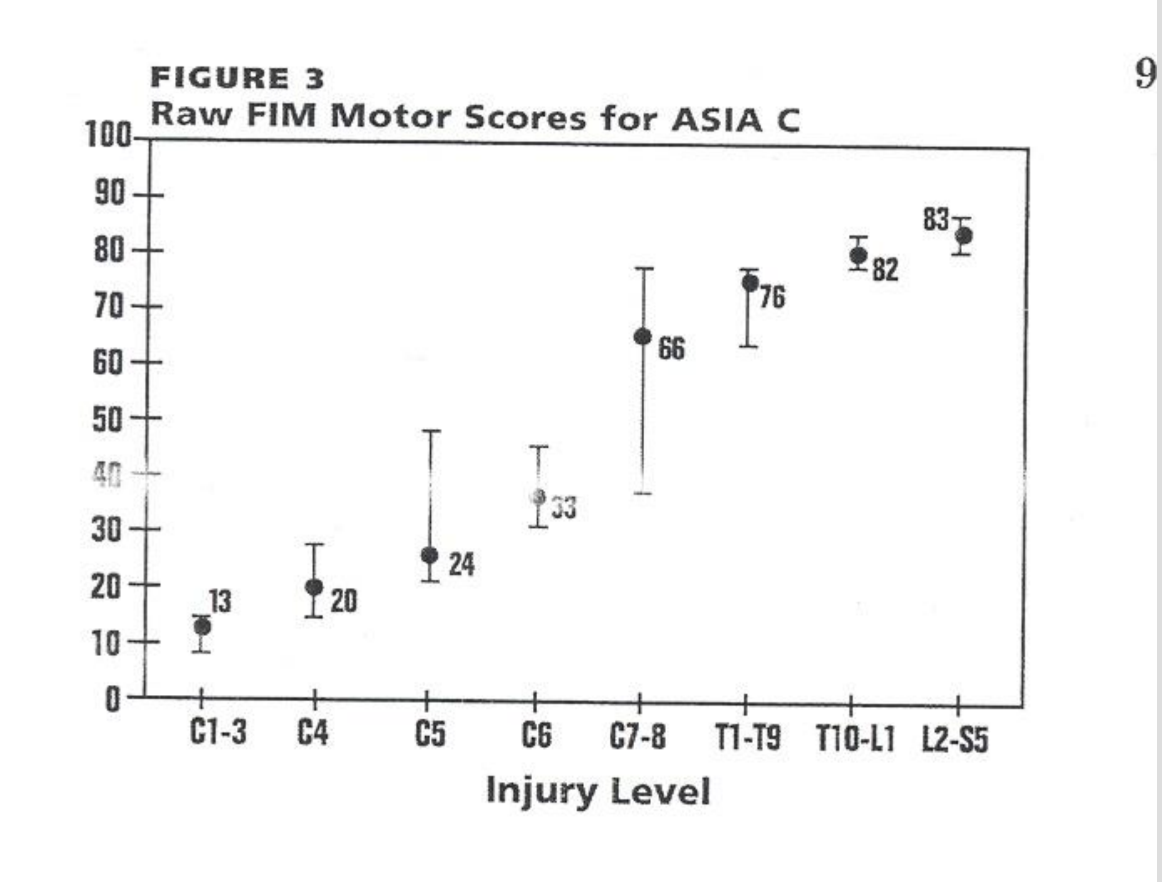
Image: https://www.physio-pedia.com/Spinothalamic_tract

OUTCOME PREDICTION
FIM SCORE - ASIA A & B



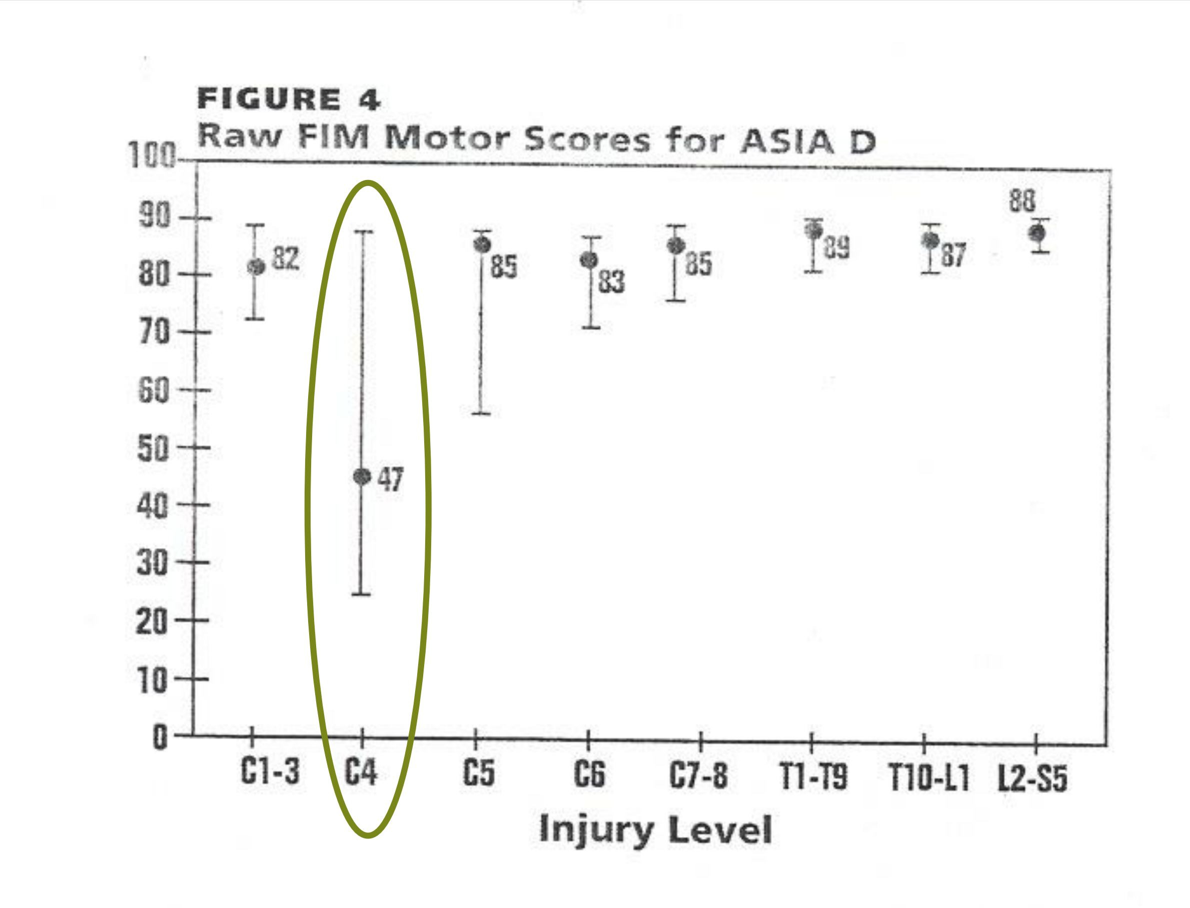
Graphs from Clinical Practice Guidelines for SCI[1]

OUTCOME PREDICTION
FIM SCORE - ASIA C



Graphs from Clinical Practice Guidelines for SCI[1]

OUTCOME PREDICTION
FIM SCORE – ASIA D



Graphs from Clinical Practice Guidelines for SCI[1]

OUTCOME PREDICTION
OTHER FACTORS

- Abnormal muscle tone
  - Incomplete lesions tend to result in more spasticity and hypertonia
- Sensory sparing and return
  - Pinprick as greatest indicator for motor return
- Age
- Concurrent brain injury
- Pressure ulcers, pain, limited ROM
- Obesity, body proportions, motivation, etc.

NEUROPLASTICITY

NEUROPLASTICITY[3,4,5,6]

- Damage to the spinal cord is thought to progress over time
  - i.e., neurologic lesions and their effects are dynamic
- Methylprednisolone?[4,5,6]
  - Controversial
  - Suggested only for patients within 8-hours of injury
- Evidence shows most individuals with SCI have sparing of white matter[3]

NEUROPLASTICITY
ANIMAL MODELS[3,7,8]

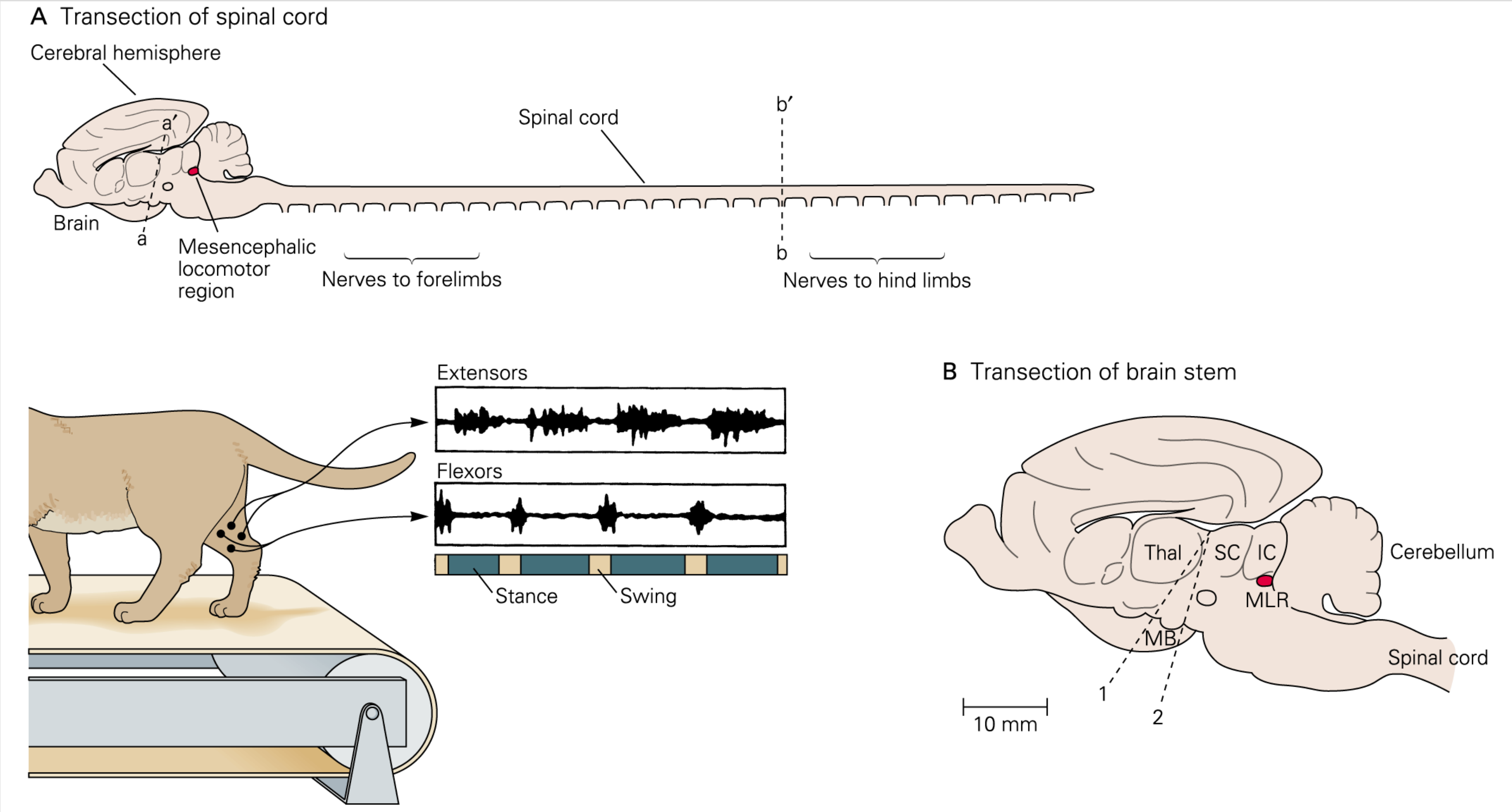
- More spared axons = better functional outcome!
  - Maximal locomotor recovery requires this
- However, even with minimal sparing, there is spinal cord reorganization below the level of the lesion
- Rubrospinal, vestibulospinal, and reticulospinal systems may induce plasticity of segmental systems
  - Particularly with task-specific rehabilitation

NEUROPLASTICITY
COMPENSATION VS. RESTORATION[9]

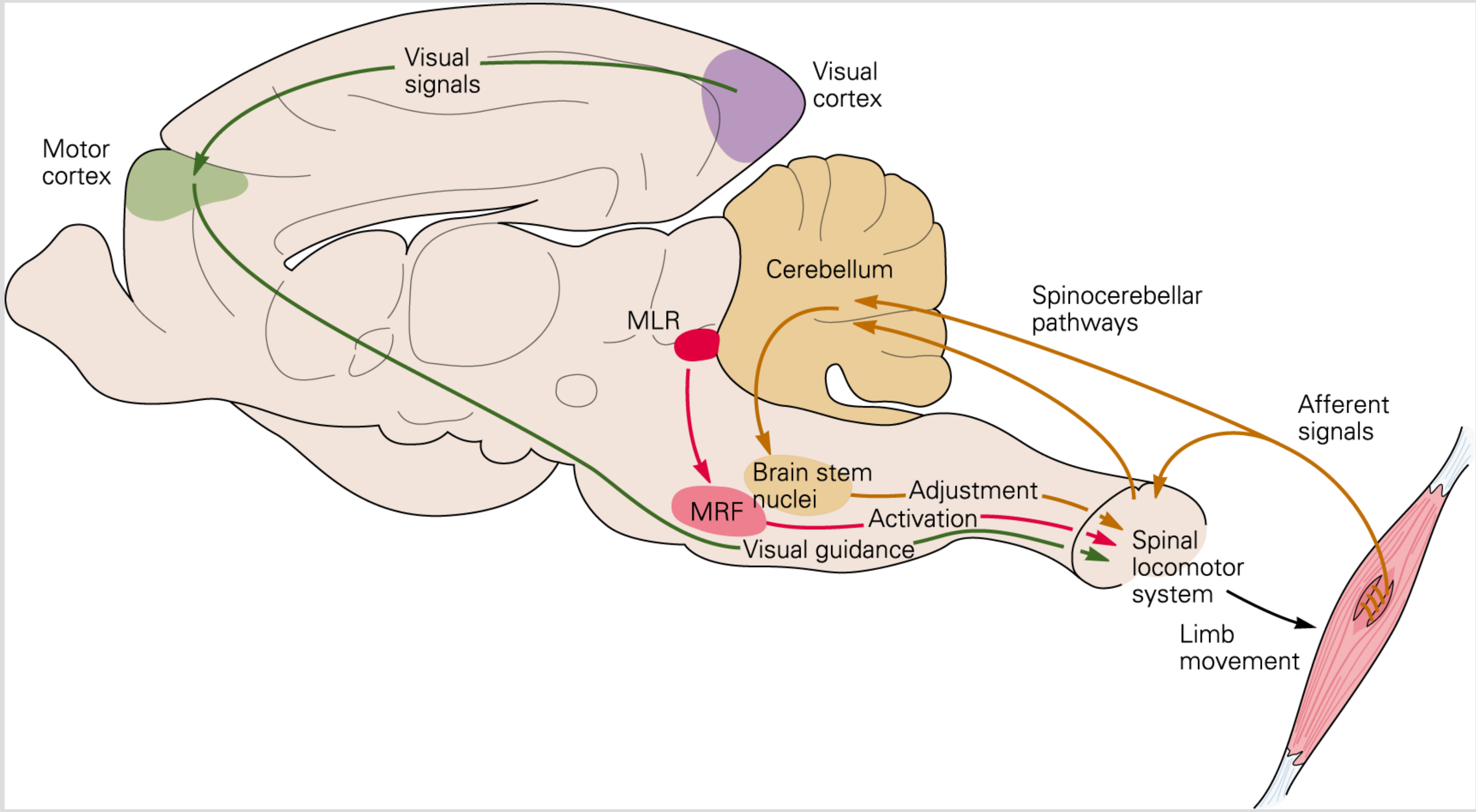
- Patients with incomplete SCI often experience return for ≥ 1 year after injury; most improvement early
- Capability for restoration of function depends on extent and pattern of neurological damage
- Recovery of motor function relies on compensation and adaptation, and not solely on neuroplasticity

LOCOMOTION TRAINING AFTER SCI

LOCOMOTION TRAINING
CPGS OFFER HOPE!



LOCOMOTION TRAINING
FUNCTIONAL AMBULATION REQUIRES MORE THAN JUST CPGS…



LOCOMOTION TRAINING IN ANIMALS[3]

- Locomotor training after SCI in animals
  - Body weight supported locomotor training improved stepping.
  - Those trained to stand could stand for 30 minutes, unsupported.
  - Untrained group could not stand, and while they could step some, it was 3x slower than trained group.
- Isolated lumbar spinal cord can “learn”, but only in a context specific manner with extensive, task specific training.

LOCOMOTION TRAINING DEPENDS ON PROPRIOCEPTION[9]

- Sensory information, including proprioception, is important for inducing plasticity

LOCOMOTION TRAINING DEPENDS ON PROPRIOCEPTION[10]

SPINAL CORD PLASTICITY AFTER INJURY

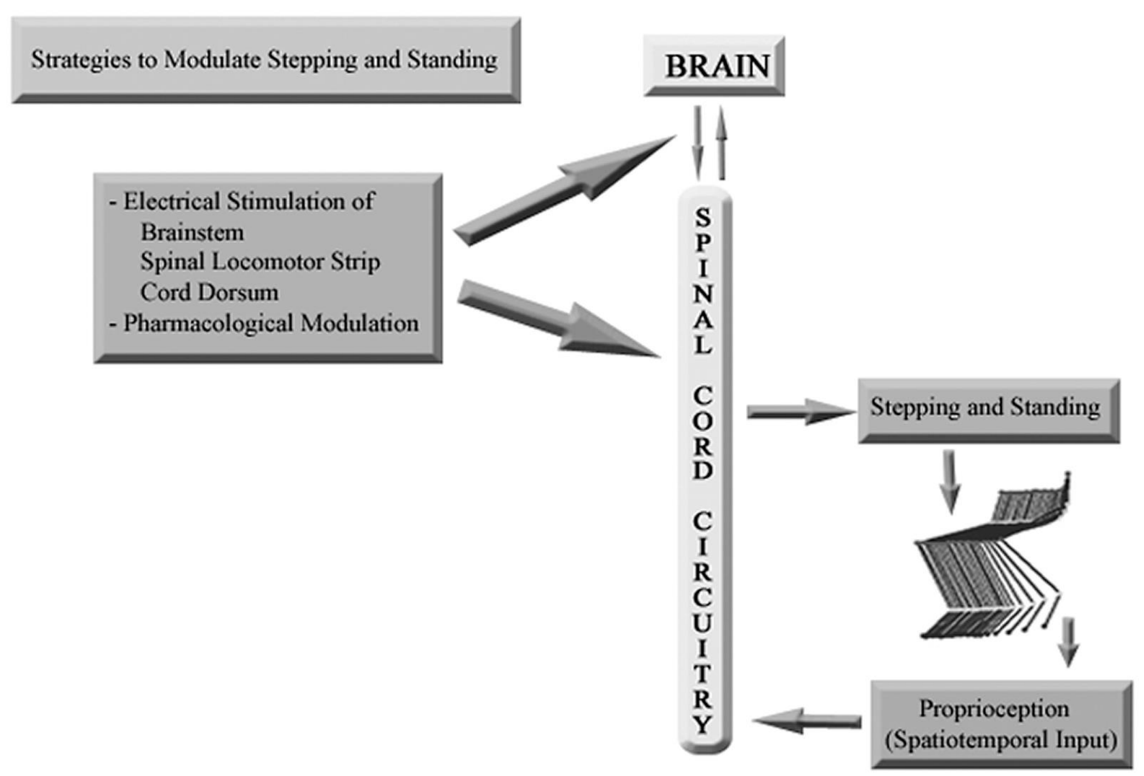


FIG. 1. This illustration emphasizes four points: (1) stepping and standing are normally controlled by both the brain and the peripheral afferent input to the spinal cord; (2) when there is a complete spinal cord injury (SCI), the only remaining control is from the peripheral afferents; (3) the spinal circuitry has the capability to utilize specific patterns of proprioceptive information to generate stepping and standing; and (4) there are a variety of strategies that can be used to take advantage of the ability of the spinal circuitry to organize this input and generate stepping and standing.

Edgerton and coworkers, Journal of Neurotrauma, 2006[10]

LOCOMOTION TRAINING
BODY WEIGHT SUPPORTED TREADMILL TRAINING[11]

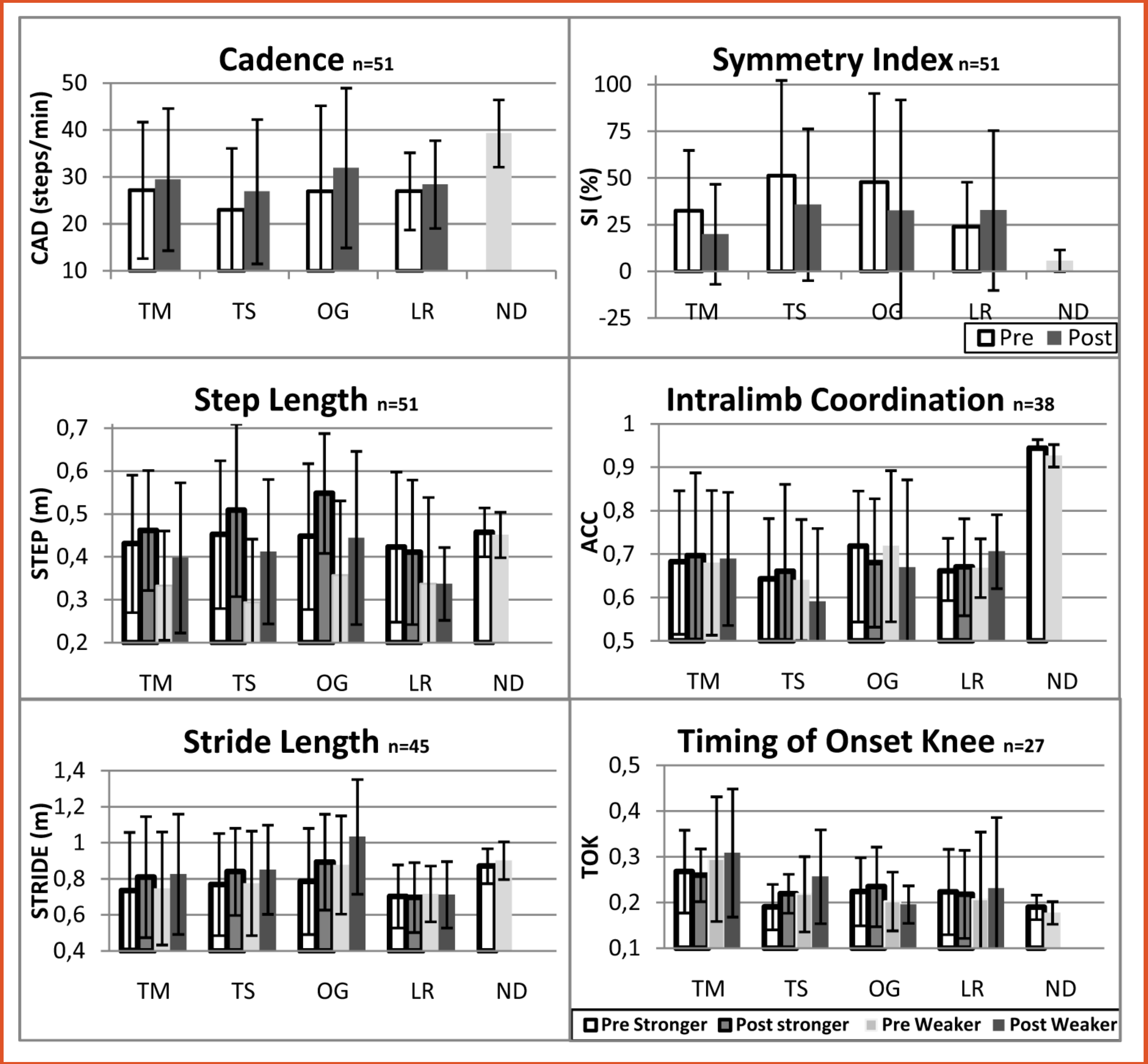
- Mehrholz 2017 systematic review –
  - BWSTT, robot-assisted gait training, and over ground training had similar training effects on walking speed and walking distance
    - Small treatment effect of 0.13m/s (BWSTT vs. OG)
  - Choosing one intervention depends on time, cost, inconvenience and potential for harm in contrast to functional benefits.
    - i.e. it depends on the patient!

https://www.aretechllc.com/products/zerog-lite-bwstt/

www.biomedcentral.com

LOCOMOTION TRAINING
WHAT ABOUT GAIT QUALITY?
NOOIJEN, 2009[12]

- Purpose: to compare outcomes associated with different approaches for body weight supported locomotor training
- Tested 51 subjects with motor-incomplete SCI – randomly assigned to 4 groups
- 1. BWS treadmill training with manual assist. (TM)
- 2. BWS treadmill training with peroneal nerve stim (TS).
- 3. BWS overground training with peroneal nerve stim (OG)
- 4. BWS treadmill training with robotic (Locomat) assist (LR)



Nooijen, 2009[12]

WHAT ELSE?

ADJUNCT THERAPIES

- Aquatic therapy[13]
- Functional Electrical Stimulation[14] – bike or walking
- Adaptive Sports
- Standing Programs

https://www.livewellmedical.com/live-well-blog/88-exploring-the-benefits-of-standing-frames

http://iongreenville.net/facebook-event/adaptive-cycling-ride-2

OUTCOME MEASURES

GENERAL

- 10MWT (HR)
- 6MWT (HR)
- Berg Balance Scale (R)
- Hand Held Myometry (HR)
- TUG (HR)
- FIM (R)
- WHO QOL BREF – World Health Organization Quality of Life (HR)

SPECIFIC TO SCI

- SCIM – Spinal cord independence measure (R)
- SCI-FAI – Spinal Cord Injury Functional Ambulation Inventory (R)
- WISC – Walking Index for SCI (R – HR)

* HR = Highly Recommended by SCI Edge Task Force
* R = Recommended by SCI Edge Task Force

BRACING

- Patients with cervical injuries may not have adequate hand function for use of some types of assistive devices for ambulation
- Amount and type of bracing will depend on muscles innervated and their strength – for example:
  - Hip flexors – L2
  - Quadriceps – L3
    - ≥4/5 then AFO over KAFO
  - Dorsiflexors – L4
    - AFO +/- DF and PF stop for control
  - Plantar flexors – S1
    - If weak, AFO +/- PF stop

CONCLUSIONS

- Potential exists for substantial functional changes for long periods of time after spinal cord injury.
- Functional status is related to severity of injury, amount of sparing.
- Use of various forms of BWS locomotor training may improve outcomes in people with incomplete spinal cord injury.
- Saliency matters in training – task specificity, repetition, intensity and time matter!

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