

# מה לומדים על היפרטוניה פירמידלית מ MAS ומ TSRT?

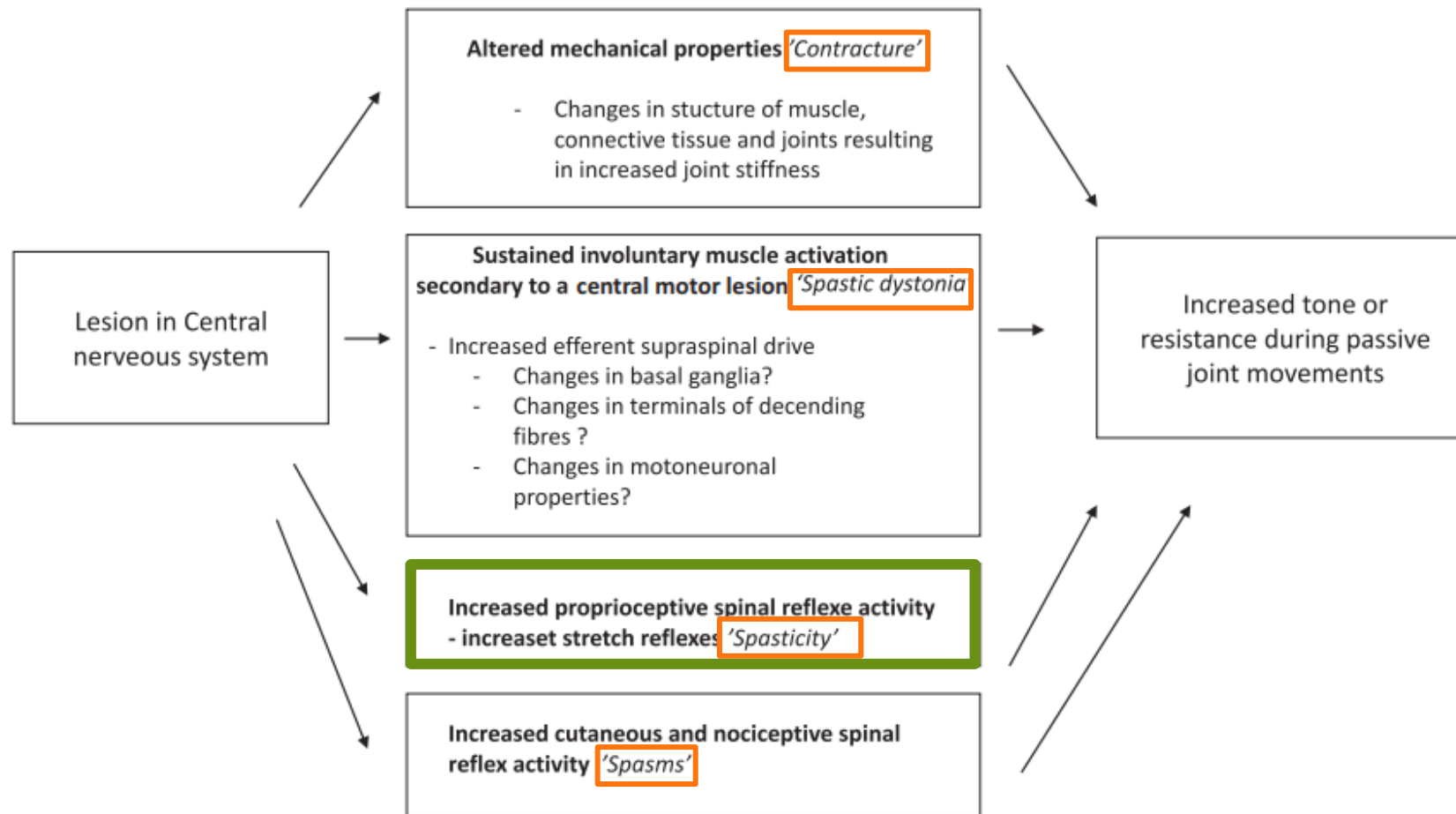
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# Proposed contributing components to hypertonia (increased muscle tone)



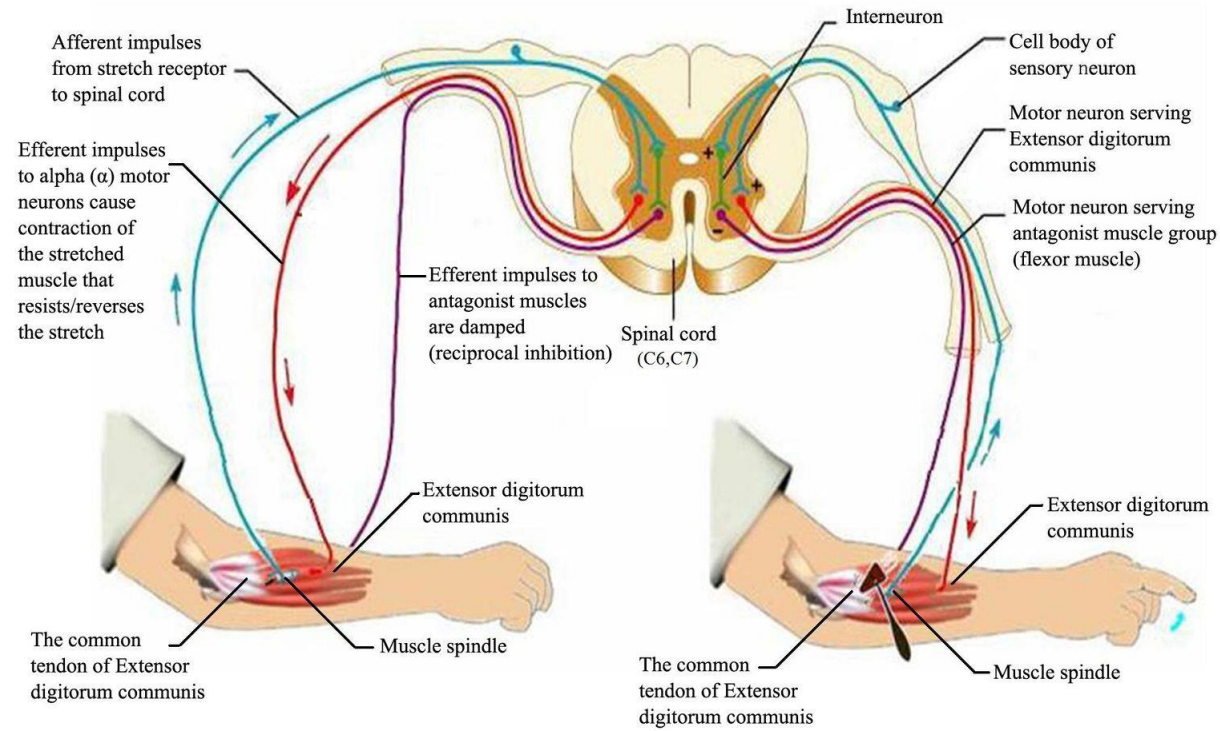
(Lorentzen et al., 2018)

# Spasticity

- Spasticity is often described as a motor disorder characterized by a velocity-dependent increase in stretch reflexes with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex arc, as one component of the upper motor neuron syndrome (Lance, 1980).
- Spasticity was reported in 4–43% of people in different phases post-stroke (Wissel et al., 2013), leading to difficulty in accomplishing daily activities and to a reduced quality of life (Zorowitz et al., 2013).

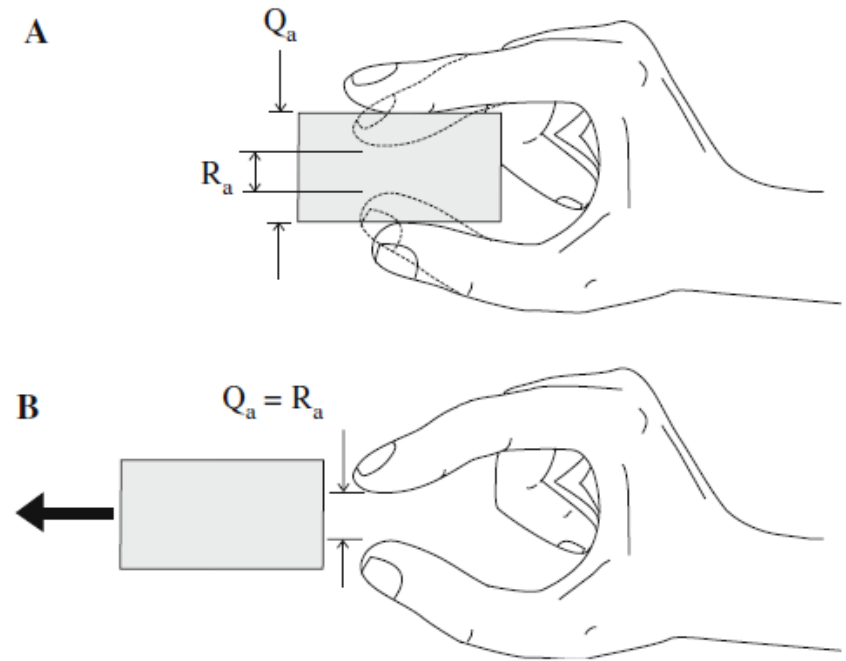


# Spasticity - Stretch reflex



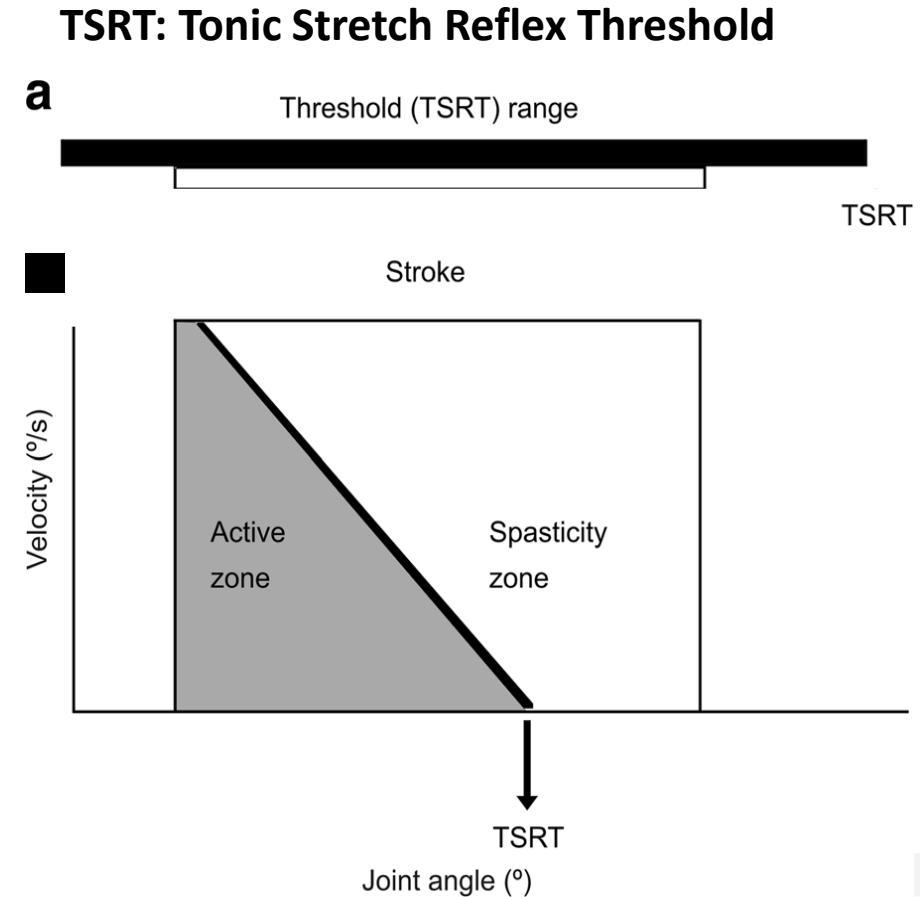
# Threshold position control theory

- Levin and Feldman (1994) described a measure of spasticity based on the concept of threshold position control.
- The intact nervous system controls movement by specifying where in the biomechanical range of a joint (muscle length/joint angle), muscle activation, the stretch reflex and other proprioceptive reflexes begin to act. This angle is expressed as a “spatial threshold” and is called the **Tonic Stretch Reflex Threshold (TSRT)**.



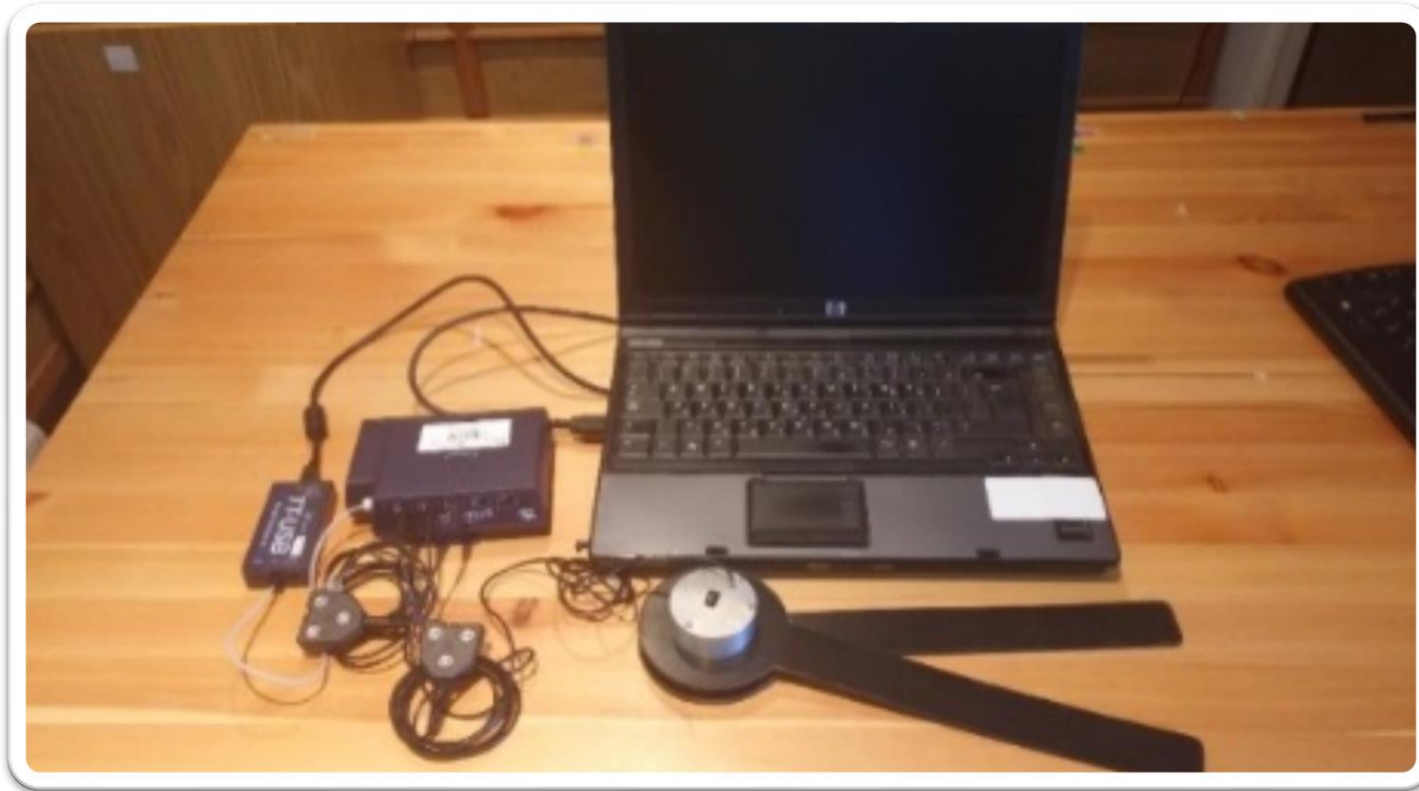
# Threshold position control theory -TSRT

- After stroke, the ability to regulate TSRTs in a task-specific manner is impaired.
- In patients with spastic hemiparesis this impairment may lead to the inability to shift the TSRT outside of the biomechanical range in order to voluntarily relax muscles. Consequently, attempts to passively or actively move the limb beyond the pathologically set TSRT evoke increased resistance, or spasticity.



(Levin et al., 2018)

# Montreal Spasticity Measure (MSM) for determination of the TSRT



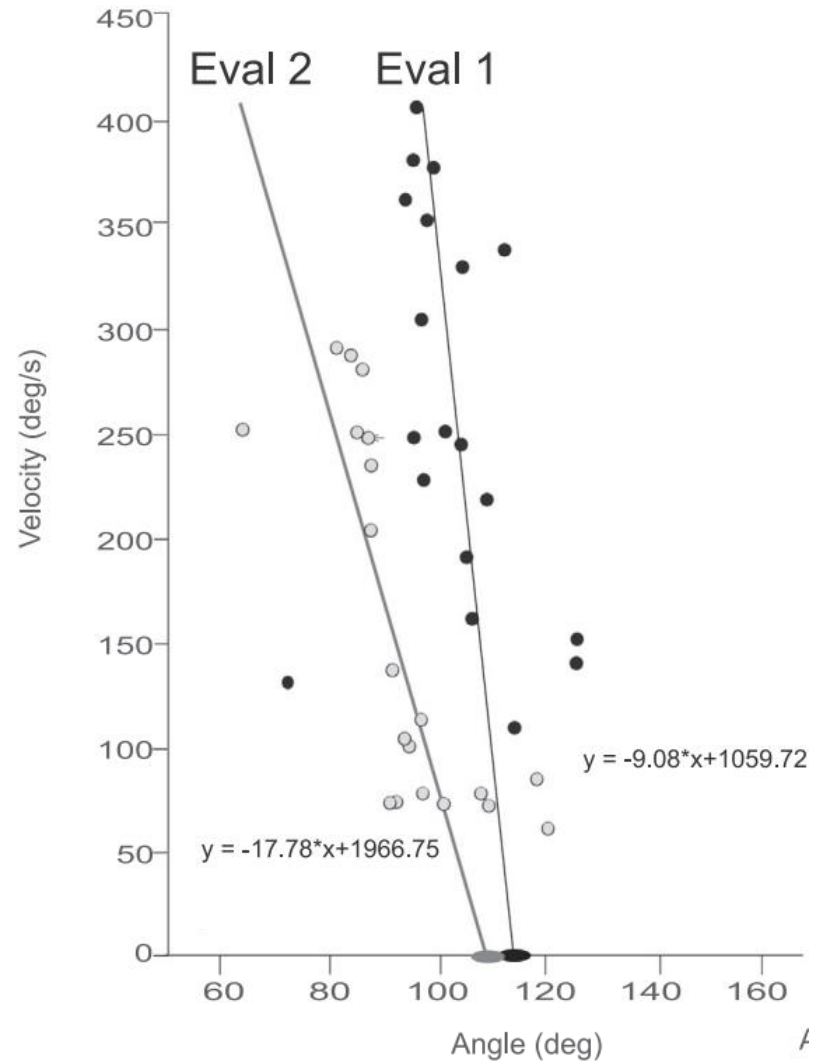
The device includes:

- EMG - For each muscle stretch, the MSM identifies the angle and velocity at which the evoked stretch response is elicited (this is the point where the EMG signal of the stretched muscle increases and remains 3SDs above the background EMG level for 25 ms).
- Goniometer - measures the angle.

Spasticity - Tonic Stretch Reflex Threshold (TSRT)



 TSRT



**Examples of tonic stretch reflex threshold (TSRT) estimations in a representative patient.** Stretch reflex thresholds in elbow flexors (biceps brachii) at different velocities in evaluation 1, (test) and 2 (retest) are shown. Regression line equations,, and TSRTs (the angle of spasticity onset at rest (velocity = 0/s) are shown. Eval = evaluation (Frenkel-Toledo et al., Clin Neurophysiol. 2021)



## Spasticity - Psychometric properties of TSRT

- Moderate-to-high inter-rater and/or intra-rater reliability were found for TSRT assessment of elbow flexor spasticity in the paretic arm in patients with chronic stroke (Calota et al., 2008), plantar flexor spasticity in patients with sub-acute or chronic stroke (Blanchette et al., 2016), and elbow flexor spasticity in children with cerebral palsy (Jobin and Levin, 2000).

# Spasticity - Psychometric properties of TSRT

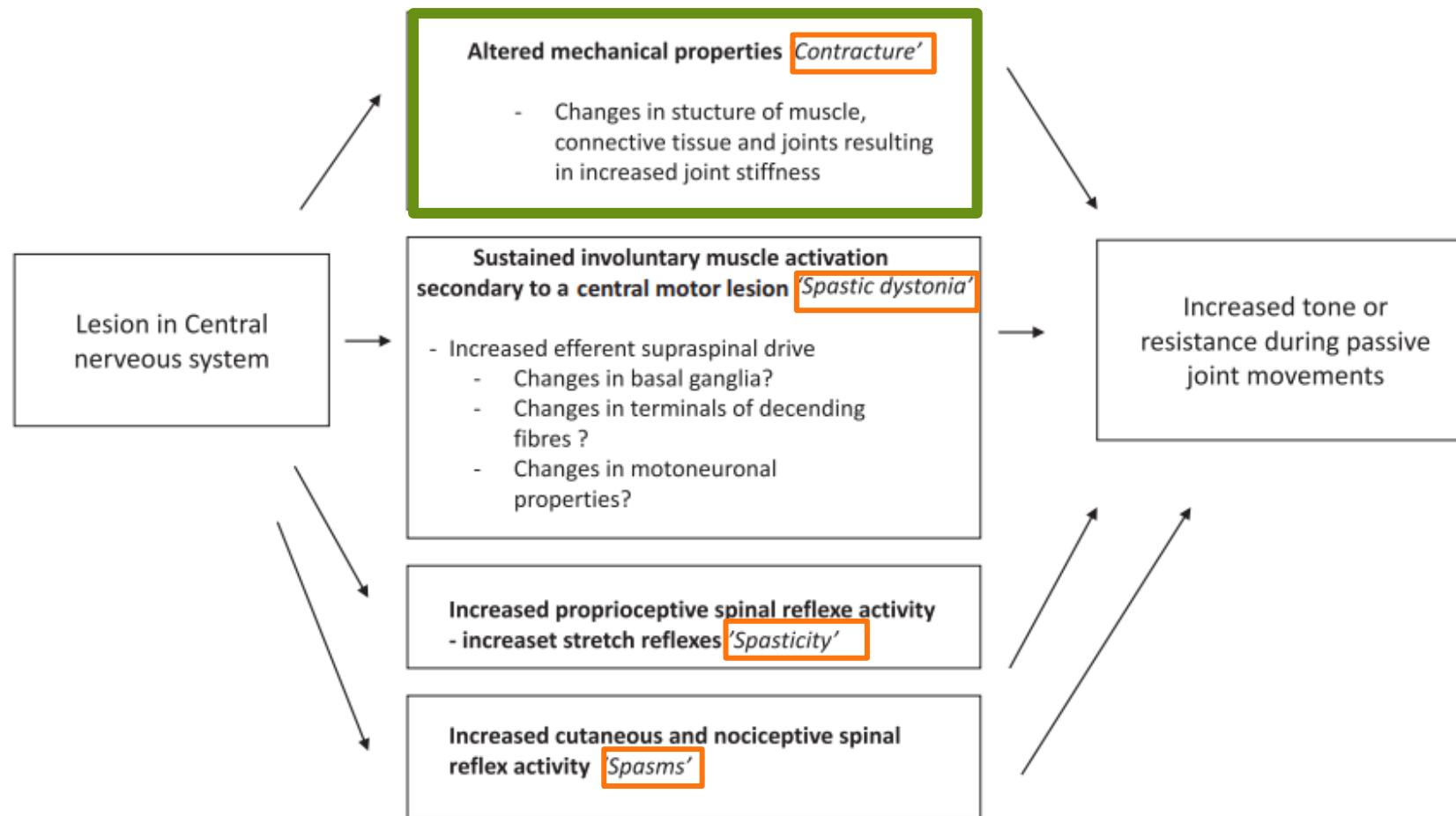
## Inter-rater reliability of TSRT measurement in the biceps brachii of subacute stroke patients

Position	Test Mean, SD (°)	Re-test Mean, SD (°)	ICC (CI 95%)
Supine & Sitting (n = 55)	100.6 (20.3)	107.7 (24.9)	0.65 (0.40-0.80)
Supine (n = 11)	104.6 (11.6)	98.7 (10.9)	0.79 (0.26-0.94)
Sitting (n = 44)	99.6 (21.9)	109.9 (26.9)	0.64 (0.35-0.81)

Test: evaluation 1; Re-test: evaluation 2; ICC = intraclass correlation coefficient; CI = confidence interval

(Frenkel-Toledo et al., Clin Neurophysiol. 2021)

# Proposed contributing components to hypertonia



(Lorentzen et al., Clin Neurophysiol. 2018)



## Hypertonia – mechanical properties

- An increase in passive stiffness of a muscle to stretch due to changes in collagen tissue and tendons, an enhancement of intrinsic stiffness of muscle fibers, and a loss of sarcomeres      subclinical contractures.
- Morphometric and histochemical investigations show changes in mechanical muscle-fiber properties that might contribute to spastic muscle tone.
- Clinical muscle hypertonia in patients with stroke seems to be associated with subclinical muscle contracture rather than with reflex hyperexcitability.

# Hypertonia – Modified Ashworth Scale (MAS)

- **MAS** is based on the examiner's subjective impression of the amount of resistance felt when the limb is passively stretched, usually at a non-specified velocity
- Validity of MAS has been questioned
- Values for MAS inter-rater and intra-rater reliability are variable (inter-class correlation coefficients [ICCs range = 0.54–0.85])

**MAS does not reflect the neurophysiological origin of hypertonia.**

Modified ashworth scale	Description
0	No increase in muscle tone
1	Slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end range of motion when the affected parties moved in flexion or extension
1+	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the range of motion
2	More marked increase in muscle tone through most of the range of motion, but the affect part is easily moved
3	Considerable increase in muscle tone, passive movement is difficult
4	Affected part is rigid in flexion or extension

# Links between TSRT and MAS

TSRT values did not correlate with the MAS scores

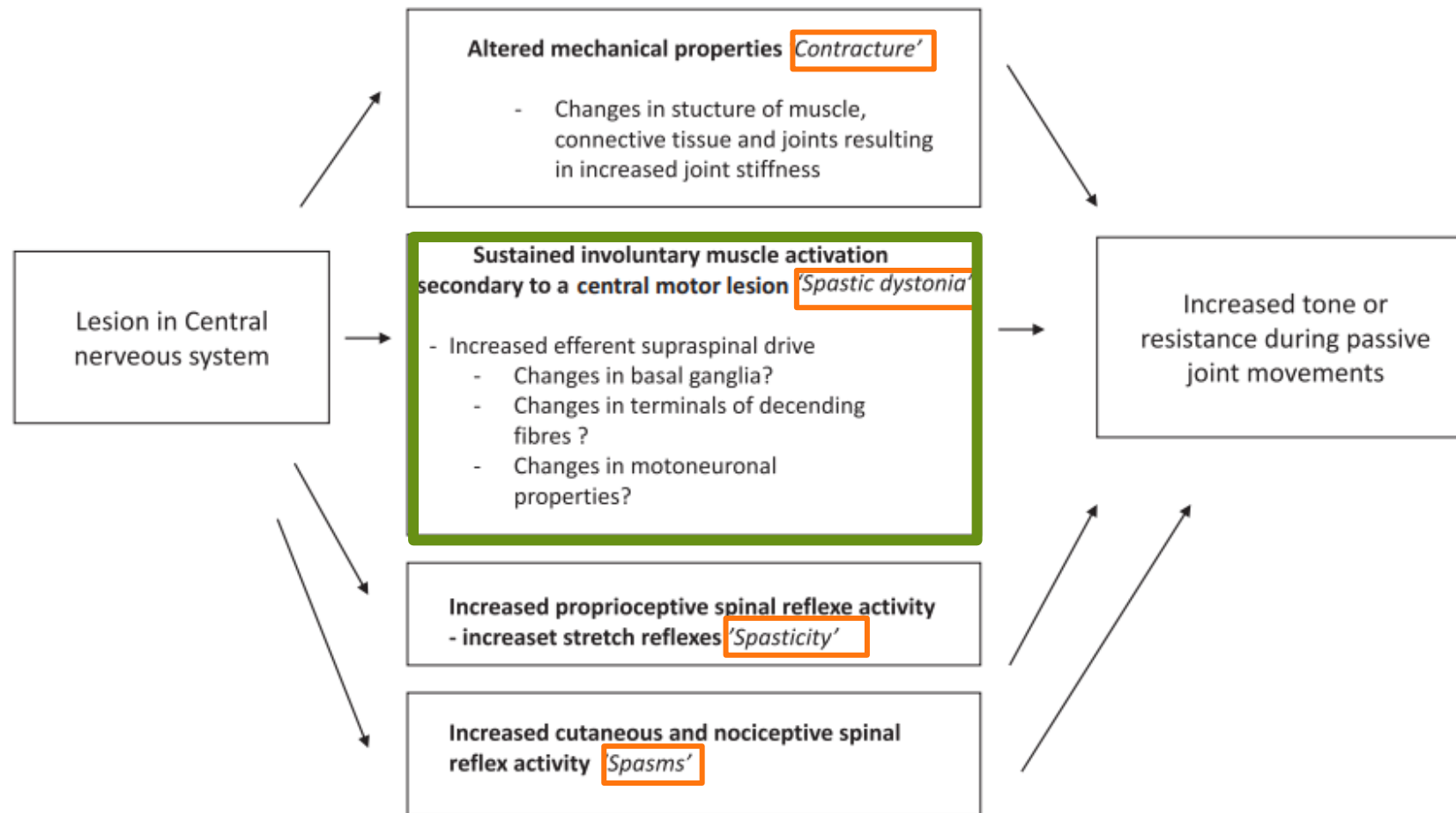
## Measures of internal responsiveness of the TSRT and MAS measure following two-week intervention (n = 44)

Measure	TSRT change mean (SD) (°)	TSRT change 95% CI	p-value	ES	SRM
TSRT	8.79 (24.96)	1.20-16.38	0.024	0.40	0.35

SD = standard deviation; CI = confidence interval; ES = effect size; SRM = standardized response mean

MAS did not change over time across groups (p = 0.354)

# Proposed contributing components to hypertonia



(Lorentzen et al., Clin Neurophysiol. 2018)



## Spastic dystonia

- Overactivity causing unwanted muscle activity when the patient attempts to remain at rest.
- The term was coined by Derek Denny-Brown to denote a consequence of experimental brain damage in monkeys, where muscles are activated in a sustained manner affecting the animal's posture in a typical way.
- Denny-Brown reported that this phenomenon is not abolished by dorsal rhizotomy (section of neural transmission from muscle spindles which acts on spinal motor neurons and interneurons).

(Denny-Brown. Bull. N. Y. Acad. Med. 1965).



## Spastic dystonia

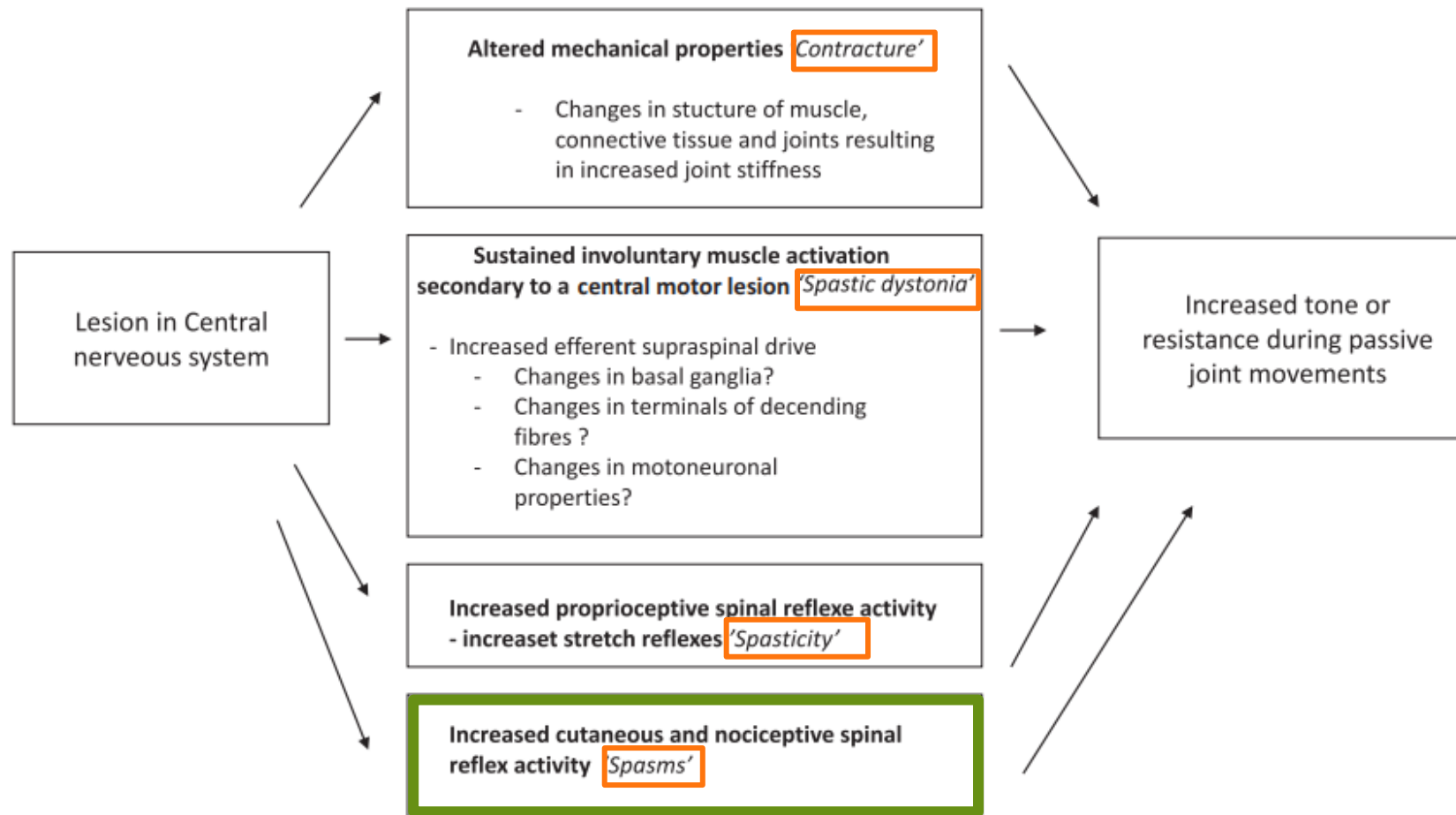
- Thus, contrary to ‘spasticity’ as defined by Lance, ‘spastic dystonia’ cannot be attributed to the effect of increased afferent stimulation of spinal motor neurons by hyperactive muscle-spindles.
- It should rather be conceived as a sequence of damage to motor control mechanisms within the central nervous system (an efferent phenomenon), impairing the regulation of spinal motor neurons’ excitability.



# Differentiating between neural and mechanical causes of hypertonia

- Mechanical properties ('passive' stiffness) may be distinguished from other (neural) causes of increased muscle resistance by the absence of any muscle activity during testing (Lorentzen et al., 2010; Malhotra et al., 2009).
- In spastic dystonia - sustained EMG activity is demonstrated despite intended relaxation.

# Proposed contributing components to hypertonia



(Lorentzen et al., 2018)



## Discussion & Conclusions

- Components underlying hypertonia in neurological patients consist of mechanical properties of the muscle tendon complex, and exaggerated reflexes (neurological aspect measured by TSRT).
- **TSRT** is a measure derived from a specific line of motor control theorizing, where the severity of impairment in regulation of stretch reflex activity is represented by the spatial threshold (angle) in the joint range of motion at which the hyperactive stretch reflex begins to act. The **MAS**, in contrast, measures the amount of supra-threshold resistance produced by the stretched muscle, without considering the joint angle at which pathological resistance begins.



## Discussion & Conclusions

- MAS does not distinguish between spasticity and soft tissue stiffness.
- TSRT can complement the clinical measure MAS.
- The psychometric properties of these measures should be taken into consideration.

Thanks for listening