The Unrelenting Misperceptions of Spasticity and Hypertonicity: Background & Research
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Disclosure
The speaker cannot identify any potential conflict of interest and has no relationships that should be disclosed.

Outline for this Presentation
• Statement of the problem
• The research evidence
• Clinical management: a movement re-education perspective versus a spasticity/tone perspective
What is the problem?

- Spasticity and hypertonicity erroneously linked to voluntary movement capability
- Spasticity and hypertonicity used synonymously
- The issues remain in the forefront of our clinical conversations

Definitions

**SPASTICITY**: The most well-known and referenced description of spasticity is the physiological definition proposed by Lance in 1980

- Spasticity is a motor disorder characterized by a velocity-dependent increase in tonic stretch reflexes with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex, as one component of the upper motor neuron syndrome.


**TONE**: The tension attained at any moment between the origin and the insertion of a muscle. The tension is determined partly by mechanical factors (connective tissue and viscoelastic properties of muscle) and the degree of motor unit activity (Duncan & Badke, 1967)

**HYPERTONICITY**: The sensation of [increased] resistance felt as one manipulates a joint through a range of motion, with the subject attempting to relax. (Katz & Rymer, 1989)
KEY POINTS:

1) HAVING SPASTICITY DOES NOT PREDICT A PATIENT’S MOVEMENT ABILITY OR DISABILITY
2) WHEN TOLD A PATIENT HAS SPASTICITY IN THE BICEPS, WE HAVE NO IDEA WHAT THE PATIENT CAN DO WITH THEIR ARM
3) WHEN WE HEAR THAT THE PATIENT HAS HYPERTONICITY, WE START TO MAKE ASSUMPTIONS ABOUT THEIR MOVEMENT; WHAT KIND OF GAIT PATTERN THEY HAVE, FOR EXAMPLE.
How big is the problem?
Impact on all three pillars of EBP

Patient Perspective

IT’S TIME TO FIGHT
UPPER LIMB SPASTICITY

Impact on all three pillars of EBP
Clinical Expertise

Title: Physical Therapy for Spasticity

“So with her upper extremity we are doing things like weight bearing and trying to get her to activate the muscles she now has access to because her spasticity is not overpowering them” (2011)

https://www.youtube.com/watch?v=V2_306MMm70

Clinical Expertise – impact on DPT and Continuing Education

“Spasticity obstructs the yielding quality of eccentric muscle action during stance and swing.”

“The persistent knee flexion that follows hamstring spasticity limits the effectiveness of terminal swing and restricts thigh advancement in stance.”

pgs. 172-173
Impact on all three pillars of EBP

What is the problem?

• Spasticity and hypertonicity erroneously linked to voluntary movement capability
• Spasticity and hypertonicity used synonymously
• The issue remains in the forefront of our clinical conversations

Internet obtained definitions

• **Spasticity** is a feature of altered skeletal muscle performance with a combination of paralysis, increased tendon reflex activity and hypertonia (Wikipedia)
• **Hypertonia** is a term sometimes used synonymously with **spasticity** in the literature surrounding damage to the central nervous system, namely upper motor brain lesions (Wikipedia)
• **Spasticity** is a muscle control disorder that is characterized by tight or stiff muscles and an inability to control those muscles (WebMD)
Literature obtained definitions

<table>
<thead>
<tr>
<th>Measures used:</th>
<th>Definitions used:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lancet</td>
</tr>
<tr>
<td>Clinical trials</td>
<td>59</td>
</tr>
<tr>
<td>Literature reviews</td>
<td>16</td>
</tr>
<tr>
<td>Case reports</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>78 (31%)</td>
</tr>
</tbody>
</table>

This table demonstrates that the most common definition for spasticity equates the phenomenon with ‘muscle tone’ and that a significant number of articles have not provided an explicit definition for the phenomenon.

What is the problem?

- Erroneously linked to voluntary movement capability
- Spasticity and Hypertonicity used synonymously
- The issue remains in the forefront of our clinical conversations
These findings correspond to the clinical and experimental observations that reducing or abolishing hyperactive stretch reflexes in patients with spasticity does not result in an improvement of functional movements such as gait.\textsuperscript{*}

Sahrmann & Norton (1977)

**Historical Perspective**

- Research in decerebrate cats launching research associated with spasticity
- When in physical therapy history did the tone or reflexive state of a muscle become connected to movement?
## Upper Motor Neuron Syndrome

<table>
<thead>
<tr>
<th>Characterization</th>
<th>Positive Symptoms</th>
<th>Negative Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples</strong></td>
<td>Muscle Overactivity</td>
<td>Muscle Underactivity</td>
</tr>
<tr>
<td>Spasticity, clonus, flexor/extensor spasm, hyper-reflexia, dystonia, and rigidity</td>
<td>Decreased dexterity, weakness, paralysis, fatigability, and slowness of movement</td>
<td></td>
</tr>
</tbody>
</table>

## STAGES OF MOTOR RECOVERY (BRUNSTROMM)

<table>
<thead>
<tr>
<th>Spasticity</th>
<th>Marked spasticity</th>
<th>Out of synergy less spasticity</th>
<th>Subjective control of movement</th>
<th>Isolated/coordinate movement</th>
</tr>
</thead>
</table>

**Motor control**

## NET EFFECT OF THE PHYSICAL THERAPY PERSPECTIVE

- TREATMENT OF SPASTICITY AND TONE WOULD LEAD TO IMPROVED VOLITIONAL MOVEMENT CAPABILITY
The True Clinical Importance of Spasticity and Hypertonicity

- Differential Diagnosis
- Awareness of impending problems
- Development of Contracture

Differential Diagnosis

The True Clinical Importance of Spasticity and Hypertonicity

- Differential Diagnosis
- Awareness of impending problems
- Development of Contracture
Common Triggers that Increase Spasticity in SCI

• Pressure sores.
• A urinary tract infection
• Full bladder
• Tight clothing

http://www.msktc.org/sci/factsheets/spasticity#sthash.h8a5K0v2.dpuff

The True Clinical Importance of Spasticity and Hypertonicity

• Differential Diagnosis
• Awareness of impending problems
• Development of Contracture
SPASTICITY DETERMINED TO BE THE SOURCE OF WORLD HUNGER

Lorem ipsum

In libris graecis appetere mea.

At vim odio lorem omnes, pri id iuvaret partiendo. Vivendo menandri et sed. Lorem volumus blandit cu has. Sit cu alia porro fuisset.

Ea pro natum invidunt repudiandae, his et facilisis vituperatoribus. Mei eu ubique altera senserit, consul eripuit accusata has ne. Ignota verterem te nam, eu cibo causae menandri vim. Sit rebum erant dolorem et, sed odio error ad. Vel molestie corrumpit deterruisset ad, mollis ceteros ad sea.

THE FICKLE NEWS

SPASTICITY CONFUSION EXPOSED AT MEETING

Berta Bobath

Signe Brunstrom

THE STEADFAST LEGEND

NEUROFACILITATION APPROACHES CITE HYPERTONICITY/SPASTICITY AS KEY SOURCE OF MOVEMENT DYSFUNCTION (Chicago, 1964)

THE WORLD’S FAVOURITE NEWSPAPER

- Since 1879

SPASTICITY CONFUSION EXPOSED AT MEETING

Berlin 1998 - For too long, too many clinicians have treated spasticity as if the patient’s reflex abnormality were the cardinal mechanism underlying the motor disturbances. This workshop places the emphasis on the true disability, an inability to generate or to control appropriate movements, which may be causally independent of the abnormalities of muscle tone.

THE FICKLE NEWS

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LANDAU LASHES OUT AT SPASTICITY OBSESSION

To the Editor (2004):

“...the perseverative preoccupation of professional neurologists and therapists with the purpose of overpowering the spasticity ogre seems to be an endemic, intractably-taught delusion that afflicts both academic scholars and clinicians.

THE BEATEN HORSE
SPASTICITY AFTER STROKE: WHY BOTHER?

THE RECOMMENCE

AHA 2036 Seminar: Cassandra Sanders-Holly, Joann Benjamin TO DISCUSS
MISPERCEPTIONS OF TONE & SPASTICITY

The Evidence

There is no convincing evidence that hypertonia or spasticity interfere with volitional movement.
The Agenda

1. State of the Evidence
2. The Big Picture
3. Tying it all Together
4. A Problem with the Evidence and Moving Forward

State of the Evidence

• What is being measured?
  • “Spasticity, an impairment that is poorly measured and poorly defined”
• Who is being studied?

Malhotra & Pandya, Clin Rehabil 2009
The Big Picture

Resting tone or spasticity cannot explain volitional movement capability

1) Active and Passive Assessments are Different: The Elbow
2) Active and Passive Assessments are Different: The Ankle
3) Does Reducing “Tone” Improve Movement?

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Active and Passive Assessments are Different: The Elbow

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Active and Passive Assessments are Different: The Ankle

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Does Reducing “Tone” Improve Movement?

- 18 month study period
- 4 young adults with cerebral palsy
- Goal of reducing EMG while attempting to relax

**Does Reducing “Tone” Improve Movement?**

- EMG
- Elbow Angle

**Does Reducing “Tone” Improve Movement?**

- Elbow Angle
- Biceps EMG

- 7 Months of Training
- 1 Year of Training
The Agenda

1. State of the Evidence
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3. Tying it All Together
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Tying it all Together

Resting tone or spasticity cannot explain volitional movement capability
There is no convincing evidence that antagonist hypertonia or spasticity resist voluntary movement

1) Example of a Misperception
2) Research Example 1: Rapid elbow movement
3) Research Example 2: The calf during swing phase of gait

Antagonist Hypertonia or Spasticity

“They can’t reach because of their biceps tone.”

https://www.youtube.com/watch?v=V23lXMKT7Q

Antagonist Hypertonia or Spasticity Do Not Impact Volitional Movement

Sahrmann & Norton Ann Neurol 1977
“Thus, only in the normal subject was there any phasic exaggeration of antagonist EMG activity to which the impairment of voluntary elbow flexion might be attributed.”

“Excess Ankle Plantarflexion During Swing: Unlikely to be Caused by Calf Spasticity or Hypertonia”

Hypertonia and spasticity are measured at rest; walking is a volitional activity.

There is no convincing evidence that excess calf activity causes toe drag during swing.

“ Their calf spasticity is causing them to drag their toe.”

“Antagonist Hypertonia or Spasticity Do Not Impact Volitional Movement”

Unimpaired

Tying it all Together

There is no convincing evidence that agonist hypertension or spasticity interfere with voluntary movement. Limited Ankle Dorsiflexion During Stance

Antagonist
Agonist
Contracture
Hypertonia as an Asset

Agonist Hypertonia or Spasticity Do Not Impact Volitional Movement

“Their calf spasticity is causing them to toe walk.”

Hypertonia and spasticity are separate considerations. Despite this, there is no convincing evidence that calf overactivity causes toe walking.

Bilateral Hypertonia and Spasticity

PF
DF

Walking on Their Toes

Tying it all Together

Resting tone or spasticity cannot explain volitional movement capability

Contracture and Hypertonia

“They need botulinum injections because their tone is so bad.”

Botulinum treatment of spasticity: why is it so difficult to show a functional benefit?

Sheean, Curr Opin Neurol, 2001

The Unrelenting Problem of Contracture

• What causes increased stiffness?
  • Tonic neural activity?
    • This happens later (e.g. Lieber 2004; Gracies 2005; Burne et al. 2005; Chang et al. 2013)
  • Is the muscle “on” all the time when hypertonia is present?
    • Not in all people (Burne et al. 2005; Chang et al. 2013)
• Contracture: An impairment
  • Can we do a better job of preventing it?

Contracture = Immobilization + Tonic neural activity later

Tying it all Together

Abnormal Muscle Contraction During Movement

Movement patterns often thought to be caused by hypertonia or spasticity, are often reflective of task demands and learned movement strategies.

"I can see the muscle contracing. I see hypertonia all the time when my patients are walking."

"I have EMG evidence that this muscle is on. How can you tell me hypertonia is not a factor?"
Hypertonia as an Asset

“They need their tone to transfer.”

“I don’t want to reduce their tone, because they need it to stand.”

Can Hypertonia Or Spasticity be Something Good?

“Abnormal” activity
• These are un 1991; Sinkjaer

Yetz, et al.

Dietz, et al.


Don’t confuse hypertonia with spasticity, since the former is an involuntary reflex...

EMG (% of maximal contraction)

‘S’-shaped curve?

‘A’-shaped curve?

Sahrmann & Norton Ann Neurol 1977


“Pain and contracture are disabling.”

“Tone is an asset in transferring.”

Neilson & McCaughey J Neurol Neurosurg Psychiatry 1982

70
80
90
100
Yes
No

SPAS %

A
B
C
D
E
F
G

Months
Tying it all Together

Time to get out of this stupid forest

Resting tone or spasticity cannot explain volitional movement capability

The Agenda

1. State of the Evidence
2. The Big Picture
3. Tying it All Together
4. A Problem with the Evidence and Moving Forward
Stretch Reflexes are Correlated with, but are Unlikely to Cause, Gait Deviations

“These data demonstrate that an imposed hip extension movement contributes to heightened, long-lasting quadriceps muscle activity in individuals with stroke.”
What about children with cerebral palsy?

“There is in fact little evidence available regarding the role of stretch reflex activity during gait in children with CP.”

(Willerslev-Olsen et al., 2014, J Neurophysiol)

“Selective dorsal rhizotomy appears to reduce spasticity and increase joint range of motion. Abnormal movement patterns, however, persist after the spasticity is reduced. Well-coordinated movement patterns are acquired slowly and appear to be related to an intense period of physical therapy. I argue that these results provide evidence that the presence of spasticity alone is an insufficient explanation for abnormal movement patterns.”

(Giuliani C, 1991, Physical Therapy)

Time To Move Forward

“So, I ignore hypertonia and spasticity and maintain joint mobility... That’s it?”

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References


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