Spasticity (non-live)

Course Description
"Spasticity" is an online recorded video of a previously presented live CE webinar for athletic trainers. This course includes a review of current literature relating to pathophysiology, measurement, pharmacological management, and rehabilitation techniques for spasticity.

Course Rationale
The purpose of this course is to provide participants with a comparative analysis of traditional and contemporary techniques to assess and manage spasticity based on current research to aid the clinician in employing these techniques effectively to facilitate recovery of motor control.

Course Goals and Objectives
Upon completion of this course, participants will be able to:

1. Identify the pathophysiology of spasticity.
2. Identify the causes of hemiplegic shoulder pain.
3. Differentiate scales utilized to assess muscle tone.
4. Define the role of casting and splinting aid in contracture management.
5. Identify the stages of recovery of motor control.
6. Differentiate current treatment concepts specific to managing spasticity.
7. Select therapeutic interventions to manage increased muscle tone and facilitate motor control.
8. Assess the effectiveness of electrical stimulation for spasticity reduction.
9. Summarize how constraint induced movement therapy and vibration impact muscle tone.
10. Classify various methods pharmacological management of spasticity.

Course Provider – Innovative Educational Services

Provider Conflict of Interest - None

Course Instructor - Jodi Gootkin, PT, Med

Instructor Conflict of Interest - None

Target Audience – Athletic Trainers

Athletic Training Practice Domains - Clinical Evaluation & Diagnosis (0201, 0202, 0203, 0204, 0205); Treatment and Rehabilitation (0401, 0403, 0404, 0405, 0406)

Level of Difficulty – Essential

Course Prerequisites – None

Method of Instruction/Availability – Recorded video available on-demand at Cheapceus.com

Criteria for Issuance of CE Credits – Completion of viewing of 3 hour recorded video, and a score of 70% correct or greater on the course post-test

Continuing Education Credits – Three (3) hours of continuing education credit.

Fees - $34.95

Refund Policy - Unrestricted 100% refund upon request. The request for a refund by the learner shall be honored in full without penalty or other consideration of any kind. The request for a refund may be made by the learner at any time without limitations before, during, or after course participation.

Outline & Schedule

Normal vs. Abnormal Tone
Pathophysiology of Spasticity
Hemiplegic Shoulder Pain
Spasticity Assessment
Contracture Management
Rehabilitation Interventions
Alternative Interventions
Pharmacological Interventions
Discussion of Clinical Interventions

Approval -

Innovative Educational Services is approved by the Board of Certification, Inc. to offer continuing education for Certified Athletic Trainers.

SPASTICITY

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Live Interactive Webinar Presented By:

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Course Overview

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"Spasticity" examines traditional and contemporary interventions used to normalize muscle tone. This course includes a review of current literature relating to pathophysiology, measurement, pharmacological management, and rehabilitation techniques for spasticity.

Course Rationale

3

The purpose of this course is to provide a comparative analysis of traditional and contemporary techniques to assess and manage spasticity based on current research to aid the clinician in employing these techniques effectively to facilitate recovery of motor control.

Goals and Objectives

4

1. Understand the pathophysiology of spasticity.
2. Compare scales utilized to assess muscle tone.
3. Identify how the developmental sequence is utilized to facilitate return to function.
4. Differentiate current treatment concepts specific to managing spasticity.
5. Select therapeutic interventions to manage increased muscle tone and facilitate motor control.
6. Determine the effectiveness of electrical stimulation for spasticity reduction.
7. Summarize how mirror therapy and vibration impact muscle tone.
8. Define the role of contracture management in reducing spasticity.
9. Classify various methods pharmacological management of spasticity.
10. Identify surgical management techniques for spasticity.

Disclaimer

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Application of concepts presented in this webinar is at the discretion of the individual participant in accordance with federal, state, and professional regulations.

Normal Muscle Tone

8

- At rest there is a minimal amount of tension maintained in a muscle that resists passive stretch.
- Resting tone is low enough to allow movement but high enough to support activity.

Muscle Spasm

9

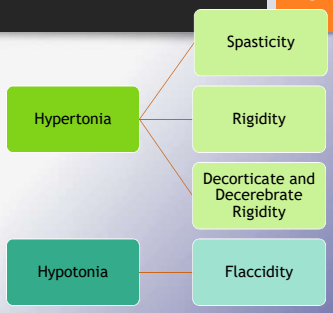
- In an intact neuromuscular system, involuntary contraction of a muscle due to overuse, electrolyte imbalance, or dehydration.
- Often presents in therapy as the body's protective mechanism to avoid further injury or in response to muscular compensations for movement.

Muscle Spasm ⊘ **Spasticity**

Tone Alterations

10

- Resting tone in the muscle changes in response to injury of the nervous system.



Spasticity Definition

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"A disorder of the sensorimotor system characterized by a velocity-dependent increase in tonic stretch reflexes (muscle tone) with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex."

Lance J. W. (1980). "Symposium," in Spasticity: Disordered Motor Control, eds Feldman R. G., Young R. R., Koella W. P., editors. (Chicago: Year Book Medical Pubs;), 485–495

Consider This

Nervous System

12

- The nervous system is subdivided into two primary components:
  - Central Nervous System (CNS)– brain and spinal cord
  - Peripheral Nervous System (PNS)– sensory and motor nerves outside of CNS

Healthy Stretch Reflex

13

- Normally when muscle is elongated, the **muscle spindle** recognize the altered length and speed at which it occurred.
- When stretched quickly, it transmits a signal to the spinal cord **triggering the stretch reflex**.
- Signal sent back down motor neuron to muscle which **develops tension to resist the change in length**.

Lower Motor Neuron Lesion

14

- The healthy stretch reflex response is absent with a lower motor neuron lesion of the peripheral nerve resulting in flaccidity and hyporeflexia.

Upper Motor Neuron Syndrome

15

- Injury or disease process of the brain or spinal cord presents with specific signs/symptoms.
  - Spasticity
  - Hyperreflexia
  - Associated Reactions
  - Motor Weakness

Diagnoses

16

- Conditions presenting with spasticity involve upper motor neuron lesions.
  - Cerebral Palsy CP
  - Multiple Sclerosis MS
  - Traumatic Brain Injury TBI
  - Spinal Cord Injury SCI
  - Cerebrovascular Accident CVA
  - Amyotrophic Lateral Sclerosis ALS
  - Parkinson's Disease PD

Pathophysiology of Spasticity

17

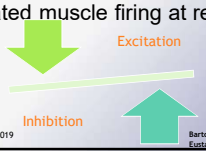
- Several mechanical and neuronal mechanisms have been theorized as result in prolonged disinhibition of the spinal reflexes that result in spasticity.
  - Disrupted descending regulation
  - Denervation supersensitivity
  - Hyperexcitable stretch reflex

Consider This

Disrupted Descending Regulation

18

- Upper motor neuron lesions result in an imbalance of excitatory and inhibitory spinal tracts between the brain and muscles.
- This leads to reduced inhibitory control over the stretch reflex that allows exaggerated muscle firing at rest.



Bartolomeo Eustachi: Brain and Spine Anatomy, c. 1722 Bartolomeo Eustachi (1520?-1574): Tabulae anatomicae clarissimi viri, 1722.

Denervation Supersensitivity

19

- Without inhibition from higher cortical centers over activity occurs due to:
  - Alpha motor neurons form new postsynaptic membrane receptors
  - Adjacent interneurons induce local sprouting creating abnormal synapses

NICHD/M. Sulkowski https://www.flickr.com/photos/nichd/20898962748/in/photolist-fJp4ny-s8nB4M-UX8MNt-UKty9x-xQLDvW-bCJuQB-bwwaA8-MdvqYx-NZjgba-M6k8fp

Connective Tissue Adaptations

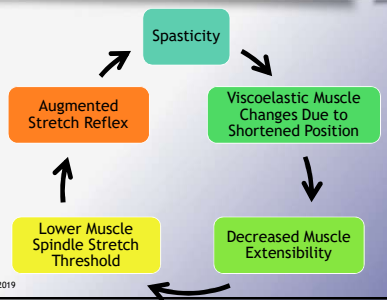
20

- Over time connective tissue mechanical changes alter the length tension relationship of the muscle and contribute to increased muscle spindle stimulation of the stretch reflex.

Flickr"Sookie" Looking Deeper **blogged at: 416style.blogspot.com**

Hyperexcitable Stretch Reflex

21



Classifications of Spasticity

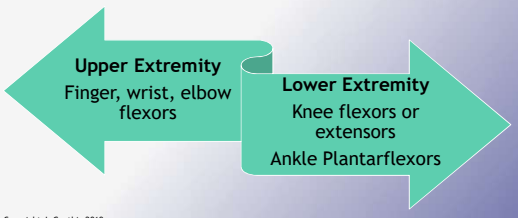
22

- **Generalized**
  - Spasticity affecting more than two regions of the body
- **Regional**
  - Spasticity affecting one or two regions of the body
- **Focal**
  - Spasticity around one joint or isolated muscle(s)

Patterns of Spasticity

23

- Often spasticity tends to present more in specific muscle groups.



Upper Extremity Flexor Tone

24

- Scapular retraction and depression
- Shoulder ADDuction and Internal Rotation
- Elbow Flexion
- Forearm Pronation
- Wrist and Finger Flexion

Lower Extremity Extensor Tone

25

- Pelvic Retraction and Elevation
- Hip Extension, ADDuction, and Internal Rotation
- Knee Extension
- Ankle Inversion and Plantarflexion

Lower Extremity Flexor Tone

26

- Hip ADDuction
- Knee Flexion

Clasp Knife Spasticity

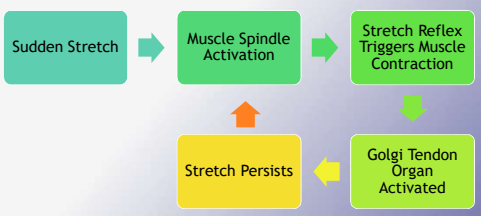
27

- Passive stretch produces initial high resistance to motion followed by sudden letting go allowing passive motion.

Clonus

28

Cyclical spasmodic hyperactivity of both agonist and antagonist muscles.



Rigidity

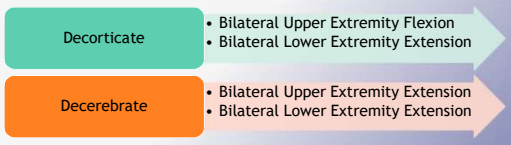
29

Spasticity of both the agonist and antagonist muscles resulting in significant resistance to movement in both directions.

Term	Definition
Cogwheel rigidity	Ratchet-like response to passive motion with alternating letting go and increased resistance
Lead pipe rigidity	Constant resistance from both agonist and antagonist

Decorticate and Decerebrate Rigidity

30



Assessing Muscle Tone

31

- Manual muscle testing is not valid as voluntary muscle contraction cannot be measured when increased tone is present.
- When spasticity is present, manual muscle testing is not applicable.

Modified Ashworth Scale (MAS)

32

- Most widely utilized tool for measuring spasticity.
- Clinician passively moves limb through range of motion to assess resistance to stretch.
- The modification to the original scale differentiates between mild and moderate spasticity.

Consider This

Modified Ashworth Scale Grading

33

Grade	Description
0	No increase in muscle tone
1	Slight increase in muscle tone; catch and release OR minimum resistance at end of ROM when moved in flexion or extension
1+	Slight increase in muscle one; catch followed by minimum resistance throughout the remainder ROM (less than half)
2	Moderate increase in muscle tone throughout most of the ROM, but body part(s) easily moved
3	Marked increase in muscle one; passive movement difficult
4	Affect part(s) rigid in flexion or extension

Bohannon, R.W., Smith, M.B. (1987) Interrater reliability of modified Ashworth scale of muscle spasticity. Phys Ther; 67, 206-7.

Modified Ashworth Reliability and Validity

34

- Generally suggested for use with CVA, SCI, and TBI but not recommended for MS
- Criticized for assessing global resistance to passive movement as opposed to stretch reflex hyperexcitability.

Kamper, D. G., Schmit, B. D., et al. (2001). "Effect of muscle biomechanics on the quantification of spasticity." Ann Biomed Eng 29(12): 1122-1134.

Salter, K., Jutai, J. W., et al. (2005). "Issues for selection of outcome measures in stroke rehabilitation: ICF Body Functions." Disabil Rehabil 27(4): 191-207.

Scholtes, V. A., Becher, J. G., et al. (2007). "Clinical assessment of spasticity in children with cerebral palsy: a critical review of available instruments." Developmental Medicine & Child Neurology 48(1): 64-73.

Naghdi, S., Ansari, N. N., Abolhasani, H., Mansouri, K., Ghotbi, N., & Hasson, S. (2014). Electrophysiological evaluation of the Modified Tardieu Scale (MTS) in assessing poststroke wrist flexor spasticity. *NeuroRehabilitation, 34*(1), 177-184.

Modified Tardieu Scale

35

- Considers multiple factors when assessing spasticity.

Velocity of Passive Movement	• **V1** As slow as possible • **V2** Speed of the limb segment falling • **V3** As fast as possible (> natural drop)
Angle of Muscle Reaction	• **R1-** Angle of catch seen at Velocity V2 or V3 • **R2-** Full range of motion achieved when muscle is at rest and tested at V1 velocity
Quality of Muscle Reaction	• **0** No resistance throughout passive movement • **1** Slight resistance throughout with no clear catch at a precise angle. • **2** Clear catch at a precise angle followed by release • **3** Fatiguable clonus (<10secs) occurring at a precise angle • **4** Unfatiguable clonus (>10secs) occurring at a precise angle • **5** Joint immobile

Modified Tardieu Reliability

36

- Appears to be more accurate than Modified Ashworth Scale across multiple populations, but is less frequently utilized in the clinical setting.
  - CVA, TBI, SCI

Singh, P., Joshua, A. M., Ganeshan, S., & Suresh, S. (2011). Intra-rater reliability of the modified Tardieu scale to quantify spasticity in elbow flexors and ankle plantar flexors in adult stroke subjects. *Annals of Indian Academy of Neurology*, *14*(1), 23.

Mehrholz, J., Wagner, K., Meißner, D., Grundmann, K., Zange, C., Koch, R., & Pohl, M. (2005). Reliability of the Modified Tardieu Scale and the Modified Ashworth Scale in adult patients with severe brain injury: a comparison study. *Clinical Rehabilitation*, *19*(7), 751-759.

Akpinar, P., Atici, A., Ozkan, F. U., Aktas, I., Kulcu, D. G., Sarı, A., & Durmus, B. (2017). Reliability of the Modified Ashworth Scale and Modified Tardieu Scale in patients with spinal cord injuries. *Spinal Cord*.

Naghdi, S., Ansari, N. N., Ghorbani-rad, S., Senobari, M., & Sahraian, M. A. (2017). Intra-rater reliability of the Modified Tardieu Scale in patients with multiple sclerosis. *Neurological Sciences*, *38*(1), 93-9

Patient Reported Impact of Spasticity Measure (PRISM) 37

- Patient self-report questionnaire on the impact of spasticity on quality of life.
- Subscales provide perspective on social avoidance/anxiety, psychological agitation, daily activities, need for assistance/positioning, need for intervention, and social embarrassment.

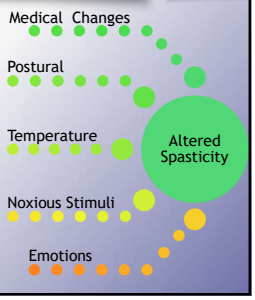
Penn Spasm Frequency Scale 38

- Self-report questionnaire of patient's perception of the frequency and severity of their spasticity.

Part 1 Spasm Frequency	0 = No spasm 1 = Mild spasms induced by stimulation 2 = Infrequent full spasms occurring less than once per hour 3 = Spasms occurring more than once per hour 4 = Spasms occurring more than 10 times per hour
Part 2 Spasm Severity	1 = Mild 2 = Moderate 3 = Severe

Influential Factors 39

- With pediatric patients increased tone may be indicative of illness, pain, anxiety, fatigue or other heightened emotional states.

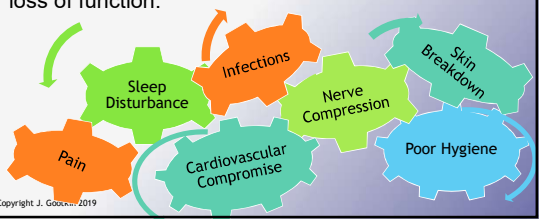


Exacerbating Factors 40

- Monitor the patient for and educate them or caregivers about nociceptive, visceral, or somatic stimuli that may aggravate spasticity.
  - Ingrown nails
  - Pressure sores
  - Bladder retention
  - Constipation
  - Generalized or local infection
  - Skin irritation
  - Exertion

Complications from Spasticity 41

- Normalizing tone is necessary to manage complications of muscle shortening, loading on bony prominences, pain, altered body image, and loss of function.



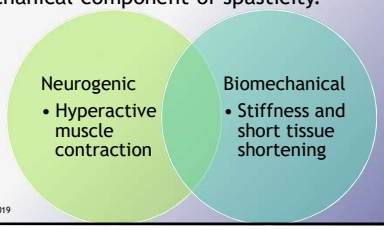
Joint Subluxation 42

- Forces generated by spastic muscles alter forces on femoral head in acetabulum leading to joint subluxation.
  - Can be "silent" or painful
- Progression can contribute to pelvic obliquity and scoliosis.

Considerations

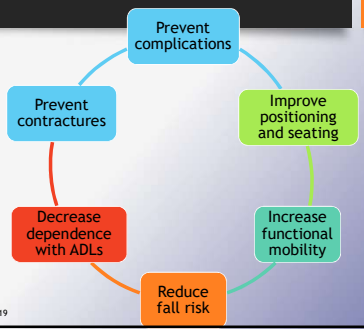
43

- Comprehensive rehabilitation incorporates strategies to address both the neurogenic and biomechanical component of spasticity.



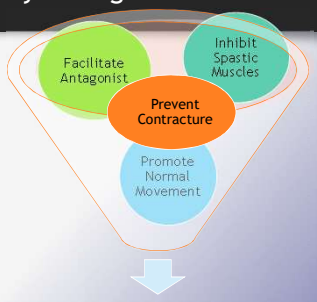
Rehabilitation Goals

44



Spasticity Management

45



Spasticity Management

Positioning

46

- Positioning devices such as towel rolls and wedges provide stability and alignment minimizing the need for compensatory muscle contraction that could lead to a global increase in tone.
- Altering body position can break spastic patterns and assist in minimizing joint contracture.

Consider This

Positioning Strategies

47

- Avoid positions that favor abnormal tone and contribute to soft tissue shortening.

Intervention Selection

48

"Lack of consensus on the basis of spasticity and the associated absence of guidelines for treatment, use of drugs and rehabilitation programmes."

- Multiple techniques are recognized to reduce tone and facilitate return to function.
  - Brunnstrom
  - Bobath
  - Proprioceptive Neuromuscular Facilitation
  - Complementary Techniques
- Work in various developmental sequence postures to encourage antigravity control.

Thibaut, A., Chatelle, C., Ziegler, E., Bruno, M. A., Laureys, S., & Gosseries, O. (2013). Spasticity after stroke: physiology, assessment and treatment. *Brain Injury*, 27(10), 1093-1105.

Developmental Sequence

49

- As we mature, neuromuscular control develops with mastery of a posture then progressing to a more complex one.
- Proximal stability is needed for distal mobility to occur.
- Can utilize developmental posture as position to inhibit the spastic muscle and/or after tone is diminished to allow patient to begin recovering motor control.

Developmental Sequence Positions

50

- Supine
- Prone
- Prone on Elbows
- Prone on Hands
- Quadruped
- Kneeling
- Half Kneeling
- Modified Plantigrade
- Standing

51

Inhibit Spastic Muscles
Weight Bearing
Approximation
Neutral Zone Manual Contacts

Facilitate Antagonist Muscles
Tapping
Active Motion

Promote Functional Use of Extremity

Performed in Various Developmental Postures

Manual Contacts

52

- Description: Use bony prominences as neutral zones to avoid increasing tone.
- Indication: During passive stretching, task specific practice to guide motion, movement into various postures, and caregiver hygiene of patient.

Weight bearing

53

- Prolonged deep pressure over the tendon of a spastic muscle inhibits tone.

Approximation

54

- In a weight bearing posture, approximation through the joint activates join receptors to enhance proprioceptive awareness and inhibit tone.
- Be aware of patient alignment for longitudinally directed forces to occur through the joint.

Tapping

55

- Brisk tapping over the muscle belly opposite the spastic muscle facilitates it to contract.
- Through reciprocal inhibition the spastic muscle will relax.

Skill Progression

56

- Mobility – Obtain Posture

Skill Progression

57

- Stability – Hold Posture accepting challenges at head/neck, pelvis and shoulder

Skill Progression

58

- Controlled Mobility – Weight Shift, lifting and reaching with extremities, trunk rotation

Mages: https://www.pexels.com/photo/boy-in-blue-fitted-cap-playing-bubbles-and-leaning-on-grey-concrete-wall-at-daytime-160917/

Skill Progression

59

- Skill – locomotion within posture

Modified Plantigrade

60

- Allows weight bearing through upper and lower extremity with wide base of support.

Pressure Splints

61

- Transparent inflatable pressure splints support the extremity while stimulating proprioceptive and cutaneous receptors in weight bearing postures.
- Johnstone air splints are distributed by Urias in pediatric through bariatric sizes for the upper and lower extremity.

Sensory Stimulation

62

- Auditory
  - Quiet environment, soft tone of voice with calm emotional overtones and regular rhythm of speech
- Olfactory
  - Avoid strong odors and utilize pleasant scents
- Visual
  - Cool colors, low lighting, and avoid busy patterns
- Vestibular
  - Slow linear acceleration and avoid spinning

Brunnstrom Stages of Recovery

63

- Brunnstrom describes specific stereotypical stages of motor recovery beginning with flaccidity progressing to full motor function return following a stroke.

1. Flaccidity
2. Spasticity Begins
3. Spasticity Increases
4. Spasticity Decreases, some movement out of synergy
5. Spasticity Continues to Decrease, synergy patterns no longer dominate
6. Disappearance of Spasticity
7. Normal Function

Brunnstrom Theory

64

- As reflexive activity emerges, utilize it to create background tone and superimpose volitional control to progress toward functional recovery.
- Interventions can be applied directly to the spastic muscle to reduce its high tone or to the antagonistic muscle to reduce tone through reciprocal inhibition.

Associated Reactions

65

- Movements that occur reflexively as a result of active or resisted movement of another body segment.
- Can be utilized to inhibit spastic muscle directly or through reciprocal inhibition.

Raimiste's Phenomenon

66

- Description: Resisted ABDuction of the lower or upper extremity on one side facilitates ABDuction on opposite side through overflow.
- Indication: Applied to uninvolved limb to inhibit spastic ADDuctors and allow active motion.

Marie Foix

67

- Description: Strong passive flexion of toes initiates flexor withdrawal pattern of the lower extremity with hip and knee flexion.
- Indication: Can break up extensor tone in the lower extremity to facilitate active motion and positioning.

Consider This

Gentle Rocking

68

- Description: Gentle repetitive rocking of the head/neck, scapular and pelvic regions inhibits tone.
- Indications: General inhibition of tone prior to or during task performance when spasticity increases due to volitional effort.

Slow Stroking

69

- Description: Slow overlapping strokes with hand performed skin on skin starting at occiput with continuous contact to coccyx.
- Indication: General inhibition of tone prior to or during task performance when spasticity increases due to volitional effort.

Cryotherapy

70

- Prolonged application of cold to the spastic muscle to inhibit tone.
  - Performed prior to stretching and developmental posture activities focusing on motor control.

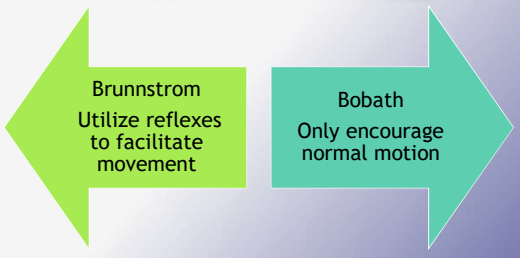
Cryotherapy continued

71

- Quick stroking with ice applied to the antagonist of the spastic muscle facilities its contraction which reduces tone in the spastic muscle through reciprocal inhibition.
  - Apply in the direction of the contraction from insertion to origin.

Brunnstrom vs. Bobath

72



Bobath Theory

73

- Neurodevelopmental Technique (NDT) utilizes handling techniques to facilitate normal movement and automatic postural responses.
- The goal of interventions is to increase sensory input to normalize tone, inhibit abnormal reflexes, and restore motor function.

NDT Techniques

74

- Key points of control using precise manual contacts at various joints facilitate the desired muscle activation supplying the patient with sensory information of correct movement.
- Bilateral symmetrical movements and regaining proximal stability is encouraged.

Consider This

Reflex Inhibiting Postures (RIP)

75

- Avoidance of abnormal movement strategies is encouraged through positions that inhibit spasticity by lengthening shortened muscles.

Humeral External Rotation

76

- Utilizing humeral external rotation through an elbow key point of control increases activation of trunk extensor musculature.

Dos Santos, C. G., Pagnussat, A. S., Simon, A. S., Py, R., do Pinho, A. S., & Wagner, M. B. (2015). Humeral external rotation handling by using the Bobath concept approach affects trunk extensor muscles electromyography in children with cerebral palsy. *Research in developmental disabilities*, *36*, 134-141.

Prayer Position

77

- The patient utilizes body on body contact by lacing fingers of both hands together with the affected thumb ABDucted.
- Can be utilized during the performance of bed mobility and upper extremity dressing.

Key Points of Control

78

- To encourage postural control that is the foundation of movement, NDT uses manual contacts on the shoulder girdle, pelvis, hands, and feet to provide input for normal movement through progressively more challenging developmental postures.

Trunk Inclination

79

- Cradling the involved upper extremity with the uninvolved provides point of control for clinician to support or resist trunk movement in all planes.

Bobath Hand Hold

80

- The clinician maintains the patient's wrist extension, forearm supination with thumb abduction.

Bed Mobility

81

- Segmental movement with facilitation at the scapula and pelvis encourage normal recruitment.

Dynamic Bridging

82

- Bridging permits bilateral weight bearing in a RIP to diminish lower extremity extensor spasticity.

NDT Transfer Technique

83

- Transferring TOWARD the weak side encourages weight bearing, breaks extensor tone by using RIP at UE/LE/trunk, and crossing of midline.
- Traditionally performed WITHOUT a gait belt.

NDT Maximum Assist Transfer

84

- Maximum Assist – patient forward flexed toward involved side with hands in prayer position while clinician assists at greater trochanters and gluteus maximus.

NDT Moderate Assist Transfer

85

- As the patient is able to perform normal movement more independently, the clinician provides assistance at the scapula.

NDT Minimum Assist Transfer

86

- When only minimum assistance through a postural cue to recruit the appropriate muscle for the movement pattern, the hands and knee are utilized by the clinician as manual contacts..

Independent Sit to Stand

87

- Patient utilizes hand over hand contact on involved lower extremity to encourage weight shifting and normalization of tone during active motion.

Proprioceptive Neuromuscular Facilitation (PNF)

88

- Utilizing diagonal patterns of movement that cross midline and are spiral in nature, sensory input stimulates motor control.
- Upper and lower extremity patterns are named for the motion occurring at the proximal joint (hip or shoulder)
  - D1 Flexion and D1 Extension
  - D2 Flexion and D2 Extension

PNF Upper Extremity Diagonal 1

89

Diagonal One (D-1) - SHIELD	COMMAND
D-1 Flexion: Flexion - ADDuction - External Rotation Start with arm out to side, hand open Close hand, TURN (follow thumb) Bring arm up and across face to opposite ear	"Squeeze my hand, turn, pull up and across"
D-1 Extension: Extension - ABDuction - Internal Rotation Start with arm across face, hand closed Open hand, TURN (follow thumb) Sweep arm out to side	"Open hand, turn, push down and out"

PNF Upper Extremity Diagonal 2

90

Diagonal Two (D-2) SWORD	COMMAND
D-2 Flexion: Flexion - ABDuction - External Rotation Start with hand "in pocket", fisted Open hand, TURN (follow thumb) Bring arm to overhead position	"Open hand, turn, push up and out"
D-2 Extension: Extension - ADDuction - Internal Rotation Start in overhead position, hand open Close hand, TURN (follow thumb) Bring hand back to "in pocket" position	"Squeeze my hand, turn, pull down and across"

PNF Lower Extremity Diagonal 1

91

Diagonal One (D-1) HEEL IN POCKET	COMMAND
D-1 Flexion: Flexion - ADDuction - External Rotation Leg out to side (abducted and extended) Ankle moves into dorsiflexion Bring foot across body with knee flexed - heel to opposite knee ("in pocket")	"Foot up, heel in, pull up and across"
D-1 Extension: Extension - ABDuction - Internal Rotation Start with "foot in pocket" Ankle moves into plantar flexion Sweep leg out to side	"Foot down, heel out, push down and out"

PNF Lower Extremity Diagonal 2

92

Diagonal Two (D-2) FIRE HYDRANAT	COMMAND
D-2 Flexion: Flexion - ABDuction - Internal Rotation Start with leg extended and adducted Ankle moves into dorsiflexion Pull leg into abduction and internal rotation --"fire hydrant"	"Foot up, heel out, pull up and out"
D-2 Extension: Extension - ADDuction - External Rotation Start with leg in "fire hydrant" position Ankle moves into plantar flexion Push leg down into extension and adduction	"Foot down, heel in, push down and in"

Lumbrical Grip

93

- Manual contact through the thenar and hypothenar eminence.

"The Groove"

94

- The clinician's body position needs to be in the same diagonal as the pattern the patient is performing to ensure appropriate proprioceptive input.

Rhythmical Rotation

95

- Description: Smooth low rate rotation of the extremity through the long axis of the joint while progressing through the PNF diagonal.
- Indication: decrease spasticity in entire extremity prior to or during active motion to reduce tone.

Consider This

Rhythmic Initiation

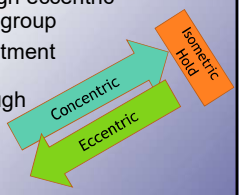
96

- Description: Progression from passive → active assisted → active → resisted movement through the diagonal pattern.
- Indication: Can be utilized for passive range of motion. With active motion, technique allows proprioceptive feedback to initiate movement and build strength.

Agonistic Reversals

97

- Description: Concentric performance of pattern followed by isometric hold at end range then return to start position through eccentric contraction of same muscle group
- Indication: continuous recruitment of agonist muscle group to inhibit spastic muscles through reciprocal inhibition.



Complementary Interventions

98

- Therapeutic advances continue to explore different applications of traditional techniques and new strategies that can be utilized to diminish spasticity and encourage normal motion.
  - Electrical Stimulation
  - Mirror Therapy
  - Vibration Treatment

Electrical Stimulation

99

- Application directly to the spastic muscle can induce sensory habituation at the spinal cord level.
- Electrical stimulation applied to the antagonist of the spastic muscle triggers reciprocal inhibition inducing relaxation of the spastic muscle.
  - Typical strengthening parameters for NMES are utilized with a longer ramp up time.

Consider This

Transcutaneous Electrical Nerve Stimulation (TENS)

100

- A combination of parameters has been utilized to target different anti-nociceptive responses.
- Low Rate TENS induces endorphin release that reduces motor neuron excitability.
- High Frequency Conventional TENS reduces nociceptive input through the gate control theory.

Park, J., Seo, D., Choi, W., & Lee, S. (2014). The effects of exercise with TENS on spasticity, balance, and gait in patients with chronic stroke: a randomized controlled trial. *Medical science monitor: international medical journal of experimental and clinical research, 20*, 1890.

Mirror Therapy

101

- Patient is positioned to view non-affected limb in mirror envisioning it is the affected limb while performing motions.
- Reduction of tone in the affected limb may be necessary prior to positioning the limb with the mirror.
- Movement of the non-affected side should promote motions of the antagonistic muscles to reduce tone and encourage motion.

Rothgangel, A. S., & Braun, S. M. (2013). Mirror therapy: Practical protocol for stroke rehabilitation. *Munich: Pflaum Verlag. doi: 10.12855/ar. sb. mirrortherapy. e2013 [Epub], Rothgangel AS, Braun SM.*

Mirror Therapy Research

102

Population	Outcome
CVA within first 12 months	Improved proximal and distal UE function
CVA within first 2 weeks	LE Motor recovery, balance, and mobility improvement equal to control group
TBI subacute or chronic phase	Slightly lower grade spasticity and improved UE motor ability and posture

Lee, M. M., Cho, H. Y., & Song, C. H. (2012). The mirror therapy program enhances upper-limb motor recovery and motor function in acute stroke patients. *American journal of physical medicine & rehabilitation, 91*(8), 689-700.
Mohan, U., babu, S. K., Kumar, K. V., Suresh, B. V., Misri, Z. K., & Chakrapani, M. (2013). Effectiveness of mirror therapy on lower extremity motor recovery, balance and mobility in patients with acute stroke: A randomized sham-controlled pilot trial. *Annals of Indian Academy of Neurology, 16*(4), 634-639. http://doi.org/10.4103/0972-2327.120496
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Vibration Treatment

103

- Isolated Muscle Vibration
  - Used after inhibition techniques are performed on spastic muscle.
  - Antagonist to the spastic muscle is placed on passive stretch.
  - Hand held vibration device applied from insertion to origin of the muscle with gentle pressure as patient actively contracts.
  - Reduces spasticity through reciprocal inhibition.

Vibration Treatment

104

- Whole Body Vibration (WBV)
  - Repetitive stimulation of the sensory motor system through mechanical stimuli to modulate the reflex activity and decrease spasticity.

Complication of Spasticity: Joint Contracture

105

- Increased mechanical resistance to passive motion may be secondary to alterations in tendon compliance and muscle fiber shortening.
- Mechanical changes in sarcomere length contribute to muscle stiffness as the optimal muscle tension is reset to a shorter resting length.
- This in turn can contribute to increased spasticity.

Consider This

Common Contractures

106

- Upper Extremity
  - Frozen Shoulder
  - Elbow, wrist and finger flexion
- Lower Extremity
  - Hip and Knee Flexion
  - Ankle Plantar Flexion

Contracture Management

107

- Traditional methods aim to maintain muscle length through splinting, positioning and stretching.
- Evidence on effectiveness of interventions varies.

Diagnosis	Intervention	Outcome
CVA	Wrist splint vs. no splint	Both lost 17 degrees
CP	Hamstring Stretching and Quadricep electrical stimulation vs. Stretching	Combined intervention slightly more effective

Lannin, N. A., Cusick, A., McCluskey, A., & Herbert, R. D. (2007). Effects of splinting on wrist contracture after stroke. *Stroke, 38*(1), 111-116.
Khalili, M. A., & Hajihassanie, A. (2008). Electrical simulation in addition to passive stretch has a small effect on spasticity and contracture in children with cerebral palsy: a randomised within-participant controlled trial. *Australian Journal of Physiotherapy, 54*(3), 185-189.

Orthotics

108

- Medicare considers an orthosis a rigid or semi-rigid device that supports a weak or deformed body member, or restricts or eliminates motion in a diseased or injured part of the body.
- Dynamic devices provide static low load prolonged stretch and encourage functional motion.
  - Elbow Wrist Hand Orthosis
  - Wrist Hand Orthosis
  - Knee Ankle Foot Orthosis
  - Ankle Foot Orthosis

Ankle Foot Orthosis

109

- When knee genu recurvatum is present use of an AFO set in slight dorsiflexion will create a flexion moment at the knee at midstance to limit the hyperextension.

Contracture Management

110

"The effect of stretching on spasticity and contractures is still largely evidence free; however, there is no evidence that it is harmful."

Stretch to Prevent Contracture

Inhibition Techniques to Reduce Spasticity

Encourage Functional Mobility

Kheder, A., & Nair, K. P. S. (2012). Spasticity: pathophysiology, evaluation and management. *Practical neurology*, *12*(5), 289-298.

Muscle Stretching

111

- The proposed benefits of slow gentle stretching to prevent contractures varies.
  - Prevent formation of cross bridges in collagen
  - Maintain passive length of soft tissue
  - Decrease excitability of lower motor neurons

Stretching Evidence

112

- Slow prolonged stretching with frequent consistent application may improve outcomes.

Diagnosis	Intervention	Outcome
CVA	Prolonged shoulder and wrist stretch vs. no stretching	Both lost 13-15 degrees
SCI	Dorsiflexion prolonged stretch vs. no stretching	Gain of 2 degrees with stretch Loss of 2 degrees without stretch

Prabhu RKR, Swaminathan N & Harvey LA. (2013). Passive movements for the treatment and prevention of contractures. Cochrane Database of Systematic Reviews, 1-31.
Turton, A. J., & Britton, E. (2005). A pilot randomized controlled trial of a daily muscle stretch regime to prevent contractures in the arm after stroke. *Clinical Rehabilitation*, *19*(6), 600-612.
Harvey, L. A., Herbert, R. D., Glinsky, J., Moseley, A. M., & Bowden, J. (2009). Effects of 6 months of regular passive movements on ankle joint mobility in people with spinal cord injury: a randomized controlled trial. *Spinal cord*, *47*(1), 62.

Stretching Technique

113

- Avoid quick stretching that my facilitate stretch reflex.
- Use bony prominences as neutral zones to avoid increasing tone during stretching.

Velocity of Stretch

114

- Research using EMG monitoring of muscle response to stretch velocity indicates that not all spastic muscle demonstrates the same activation patterns.

Diagnosis	Intervention	Outcome
CP	Stretch velocity compared through EMG monitoring	> 50% demonstrated increased tone with low velocity stretching

Schless SH, Desloovere K, Aertbeliën E, Molenaers G, Huenaerts C, et al. (2015) The Intra- and Inter-Rater Reliability of an Instrumented Spasticity Assessment in Children with Cerebral Palsy. PLOS ONE 10(7): e0131011.

Myofascial Loading

115

- Myofascial connections that envelop the muscle and neurovascular structures demonstrate loading that may cause sarcomere strain.

de Bruin M, Smeulders MJ, Kreulen M, Huijing PA, Jaspers RT (2014) Intramuscular Connective Tissue Differences in Spastic and Control Muscle: A Mechanical and Histological Study. PLOS ONE 9(6): e101038. https://doi.org/10.1371/journal.pone.0101038 http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0101038

Myofascial Loading continued

116

- Histological examination reveals thickening of myofibril perimysium which is proposed to contribute to passive muscle stiffness in spastic muscles.
- Myofascial release may be beneficial to influence the intramuscular connective tissue.

de Bruin M, Smeulders MJ, Kreulen M, Huijing PA, Jaspers RT (2014) Intramuscular Connective Tissue Differences in Spastic and Control Muscle: A Mechanical and Histological Study. PLoS ONE 9(6): e101038. https://doi.org/10.1371/journal.pone.0101038
Schleip, R., Naylor, I. L., Ursu, D., Melzer, W., Zorn, A., Wilke, H. J., ... & Klingler, W. (2006). Passive muscle stiffness may be influenced by active contractility of intramuscular connective tissue. *Medical hypotheses*, 66(1), 66-71.

Transcriptional Profiling

117

- Exploration is expanding to analysis genetic factors contributing to increases in skeletal muscle extracellular matrix which is associated with increased passive stiffness.

Smith LR, Chambers HG, Subramaniam S, Lieber RL (2012) Transcriptional Abnormalities of Hamstring Muscle Contractures in Children with Cerebral Palsy. PLOS ONE 7(8): e40686. https://doi.org/10.1371/journal.pone.0040686 http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0040686

Pharmacological Management

118

Generalized	• Oral Medications
Regional	• Intrathecal Baclofen
Focal	• Botulinum Toxin A

Intrathecal Baclofen

119

- Programmable perfusion pump is implanted with catheter into subarachnoid space to deliver baclofen.
- Mechanism of action believed to be binding to inhibitory GABA receptor sites at the spinal level.

Intrathecal Baclofen Benefits

120

- Reduced systemic side effects as medication is delivered directly to GABAergic neurons in spinal cord.
- Steady symptom management day and night.

Intrathecal Baclofen Complications

121

- Superficial surgical site infections may be managed with antibiotic therapy.
- Monitor patient for infection at catheter site that can easily spread to central nervous system.
- Catheter malfunction can occur.
- Remind patient about adhering to refill schedule.

Consider This

Intrathecal Baclofen Research

122

Diagnosis	Study	Outcome
CP	Systematic review 15 studies	Improved gait quality and gross motor function
SCI	Systematic review 8 studies	Reduced Modified Ashworth scores and improved function
MS SCI CP	12 patients followed pre and 1 year post pump implantation	Reduced Modified Ashworth scores Fat body mass increased Lean body mass decreased Resting body metabolic rate unchanged

Pin, T. W., Mccartney, L., Lewis, J., & WAUGH, M. C. (2011). Use of intrathecal baclofen therapy in ambulant children and adolescents with spasticity and dystonia of cerebral origin: a systematic review. *Developmental Medicine & Child Neurology*, 53(10), 885-895.
McIntyre, A., Mays, R., Mehta, S., Janzen, S., Townson, A., Hsieh, J., ... & Teasell, R. (2014). Examining the effectiveness of intrathecal baclofen on spasticity in individuals with chronic spinal cord injury: a systematic review. *The journal of spinal cord medicine*, *37*(1), 11-18.
Skogberg, O., Samuelsson, K., Ertzgaard, P., & Levi, R. (2017). Changes in body composition after spasticity treatment with intrathecal baclofen. *Journal of rehabilitation medicine*, *49*(1), 36-39.

Botulinum Toxin A (BoNT-A)

123

- Injected Botulinum Toxin A binds to presynaptic nerve endings in the spastic muscle where it inhibits acetylcholine release subsequently diminishing the muscle's ability to contract.
- During the months after injection, nerve sprouting reverses the neurolytic injection effects.

Benefits of BoNT-A

124

- Global side effects are avoided as the treatment is locally targeted at the spastic muscle to induce selective weakening of contraction.
- The treatment is used in combination with therapeutic interventions and splinting.

BoNT-A Black Box Warning

125

WARNING: DISTANT SPREAD OF TOXIN EFFECT

See full prescribing information for complete boxed warning.

The effects of BOTOX and all botulinum toxin products may spread from the area of injection to produce symptoms consistent with botulinum toxin effects. These symptoms have been reported hours to weeks after injection. Swallowing and breathing difficulties can be life threatening and there have been reports of death. The risk of symptoms is probably greatest in children treated for spasticity but symptoms can also occur in adults, particularly in those patients who have an underlying condition that would predispose them to these symptoms. (5.2)

- Monitor patients for signs of adverse effects:
  - Toxic spread - swallowing, breathing, and speech difficulties.
  - Bronchitis and upper respiratory tract infections.

https://www.accessdata.fda.gov/drugsatfda_docs/label/2011/103000s5232lbl.pdf

BoNT-A Research

126

Cohort	Assessments	Outcome
CP	Spasticity ROM UE Function Self-care	All improved for up to 9 months
CVA TBI CP MS SCI	Physician report of patient satisfaction outcomes	Upper Extremity improved ADL, hygiene, pain, body image Lower Extremity improved gait, posture, clonus, pain, social life

- According to the FDA, safety and efficacy is not yet established and treatment does not replace usual rehabilitation therapies.

Lin Y-C, Huang C-Y, Lin I-L, Shieh J-Y, Chung Y-T, Chen K-L (2015) Evaluating Functional Outcomes of Botulinum Toxin Type A Injection Combined with Occupational Therapy in the Upper Limbs of Children with Cerebral Palsy: A 9-Month Follow-Up from the Perspectives of Both Child and Caregiver. PLoS ONE 10(11): e0142769. https://doi.org/10.1371/journal.pone.0142769
Picelli, A., Baricich, A., Cisari, C., Paolucci, S., Smania, N., & Sandrini, G. (2017). The Italian real-life post-stroke spasticity survey: unmet needs in the management of spasticity with botulinum toxin type A. *Functional neurology*, *32*(2), 89.
FDA (2011) BOTOX Highlights of Prescribing Information.
https://www.accessdata.fda.gov/drugsatfda_docs/label/2011/103000s5232lbl.pdf

Surgical Procedures

127

- Surgery may be indicated to manage chronic spasticity that is interfering with functional mobility, causing pain and deformity that does not benefit from therapy and pharmacological management.

Selective Dorsal Rhizotomy (SDR)

128

- The sensory afferent fibers in the dorsal root of the spinal cord are selectively cut to decrease the sensory stimulus triggering the reflex arc and spasticity.
- Therapy must address underlying weakness that is unmasked following procedure.

Z-Plasty

129

- Small surgical cuts in the tendon of a contracted muscle are made.
- As healing occurs the tendon elongates permitting greater range of motion.
- Common in the Achilles for dorsiflexion and the thumb or finger flexors.

Conclusion

130

- Spasticity is the result of over activity of the stretch reflex.
- Early intervention is important to prevent contracture that can exacerbate the increased tone.
- Effectiveness of techniques will vary by patient with ongoing reassessment necessary to improve functional outcomes.
- Work across disciplines for consistency and frequency including family members who may be care givers.

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Spasticity
Resource Links

Modified Ashworth Scale
http://www.rehabmeasures.org/PDF%20Library/Modified%20Ashworth%20Scale%20Instructions.pdf

Modified Tardieu Scale
http://www.rehabmeasures.org/Lists/RehabMeasures/DispForm.aspx?ID=1038

Patient Reported Impact of Spasticity Measure
http://www.parqol.com/page.cfm?id=89

https://www.researchgate.net/profile/Karon_Cook2/publication/5605456_Development_and_validation_of_Patient_Reported_Impact_of_Spasticity_Measure_PRISM/links/00b7d522614f780c2e000000/Development-and-validation-of-Patient-Reported-Impact-of-Spasticity-Measure-PRISM.pdf

Penn Spasm Frequency Scale
http://www.rehabmeasures.org/Lists/RehabMeasures/DispForm.aspx?ID=971