ST. CATHERINE UNIVERSITY

# *Evidence-Based Interventions for Infants and Children with Atypical Muscle Tone: A Scientific Review*

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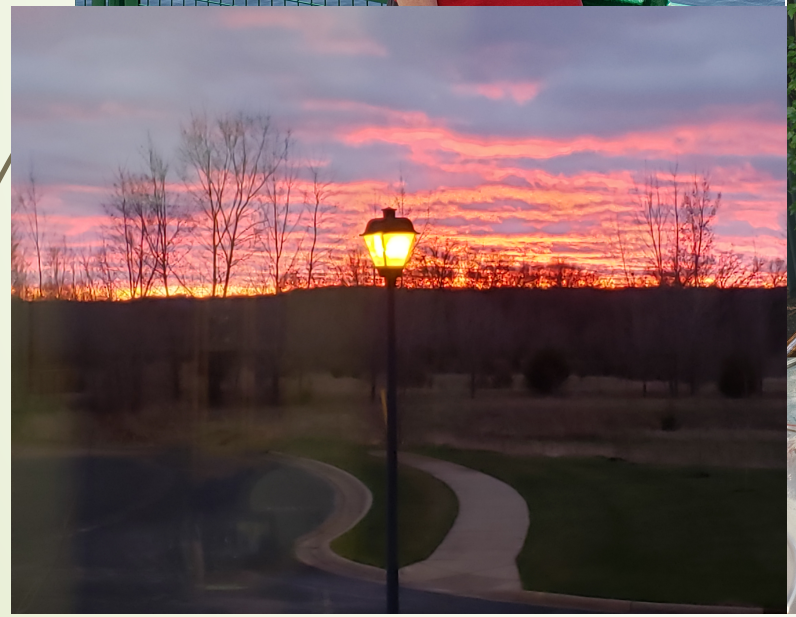
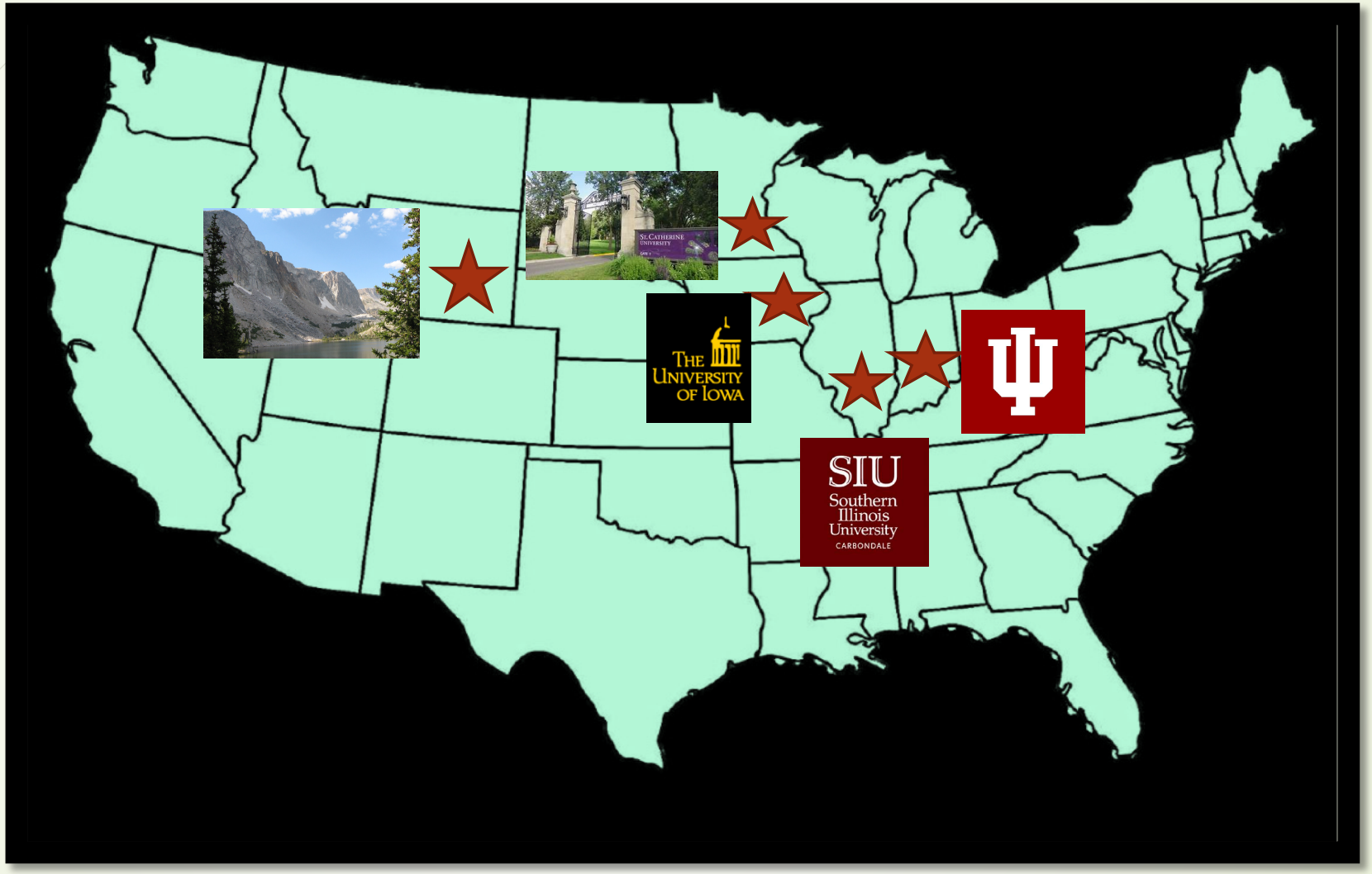
" MORE IS MISSED BY NOT LOOKING THAN BY NOT KNOWING"
THOMAS MCCRAE

# Personal Background





# Professional Background



# My Connections with Mississippi


# Acknowledgements & Disclosures


- Section 1: Interventions for Infants & Children with Low Tone

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- Section 2: Interventions for Infants & Children with High Tone

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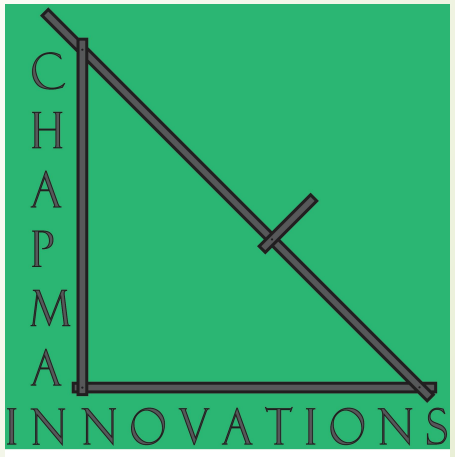
Medbridge courses on Spina Bifida

# Session Objectives:



- **Overall** – To provide a scientific review of the relative effectiveness of physical therapy interventions that are designed to promote gross motor function/development for infants and children with atypical muscle tone.*

- Section 1: **Low Tone**

To review the relative effectiveness of physical therapy interventions that are designed to promote gross motor function for infants and children with low muscle tone

- Section 2: **High Tone/CP**

To review the relative effectiveness of physical therapy interventions that are designed to improve gross motor function for infants and children with spastic cerebral palsy.

- * We excluded aquatic therapy secondary to the relatively robust literature that currently exists

# Types of Literature Reviews – A Reminder …



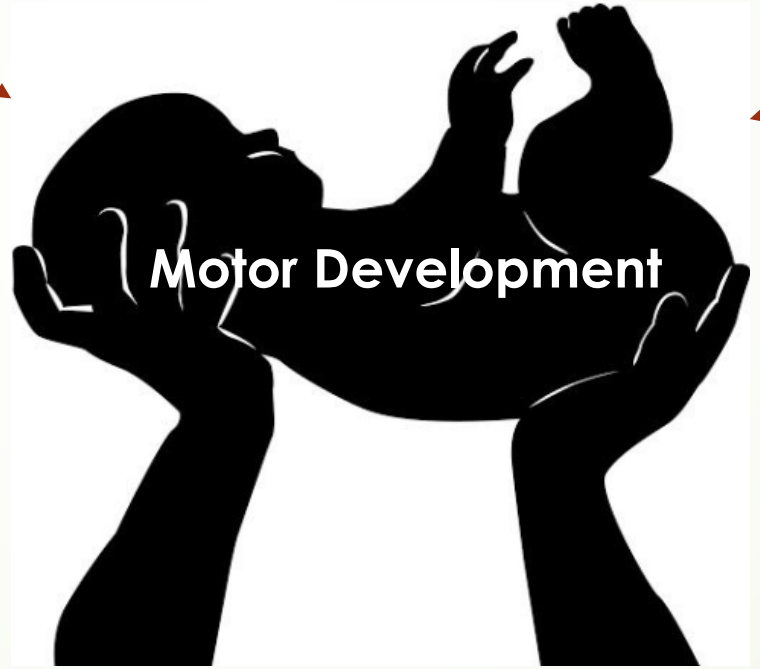
- **Scientific Review** = a critical review of the current published evidenced on a topic that enables inclusion of a variety of types of research

- **Systematic Review** = a review of the evidence on a specific question that uses systematic & explicit methods to identify, select, & critically appraise primary research, and to analyze results from the studies that are included

- **Meta-analysis** = an analysis that combines the statistical results of multiple scientific studies

# Motor Development – A systems approach…

- Definition = …changes in motor skills over time (Clark & Whitall, 1989)




Muscle Tone

Environment/Experiences

Neurological Development

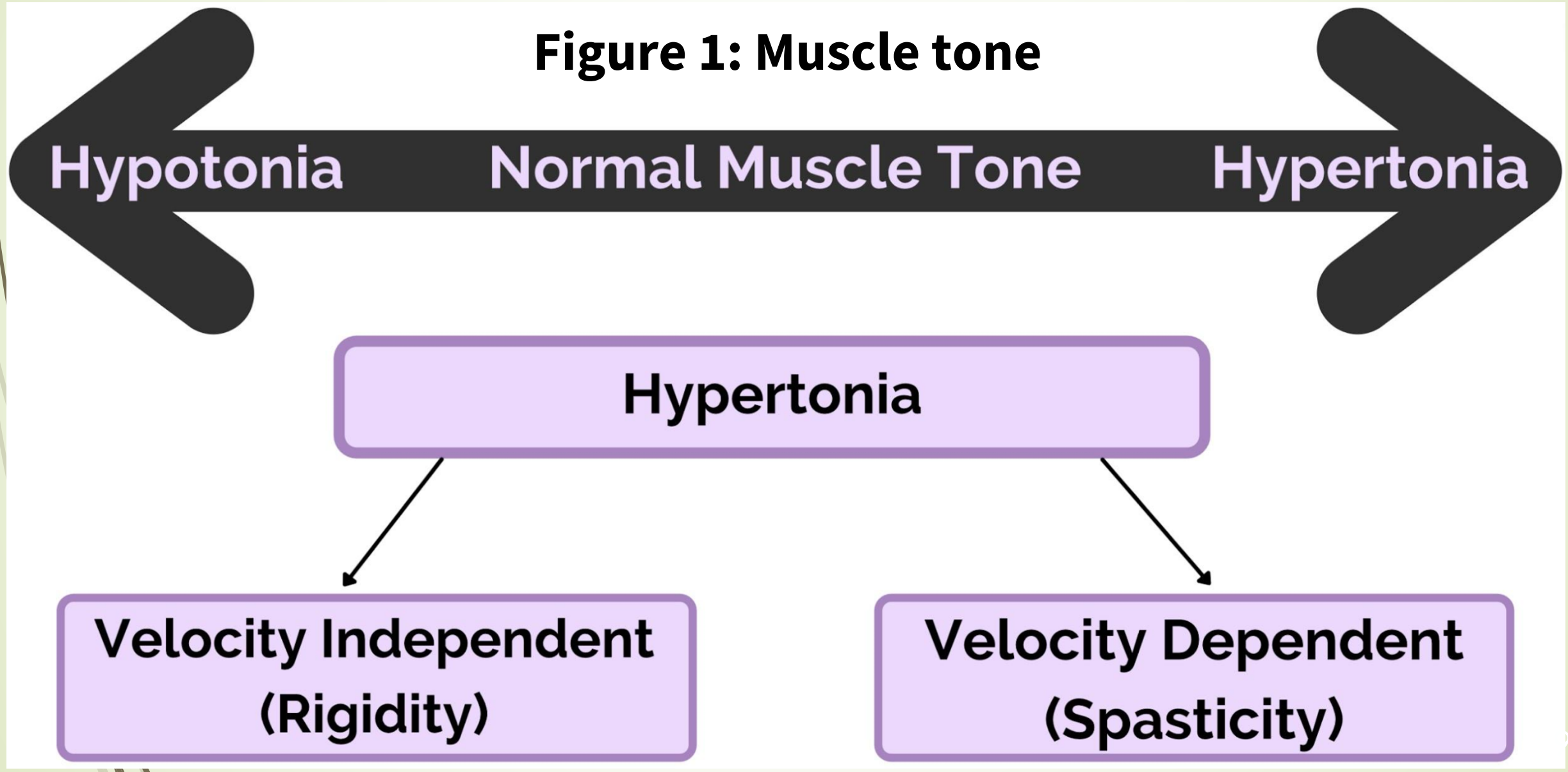
Genetics

Nutrition

Musculoskeletal Development

# Introduction

**Figure 1: Muscle tone**



# A. Methods for Infants & Children with Low Tone


*This set of 55 articles included duplicates & review articles

# Data Bases & Search Terms – Low Tone Review

**Data Bases**: CINAHL; Medline; PubMed; Google Scholar

**Search Terms:** Motor Development, Hypotonia, Infants, Children, Pediatrics, Low Muscle Tone, Weakness, Hypotonia, Down syndrome, Spina Bifida, Physical Therapy, Physiotherapy, Therapy, Interventions, Treatment, Best Practice, Exercise

**Outcome Measures:** Not Applicable

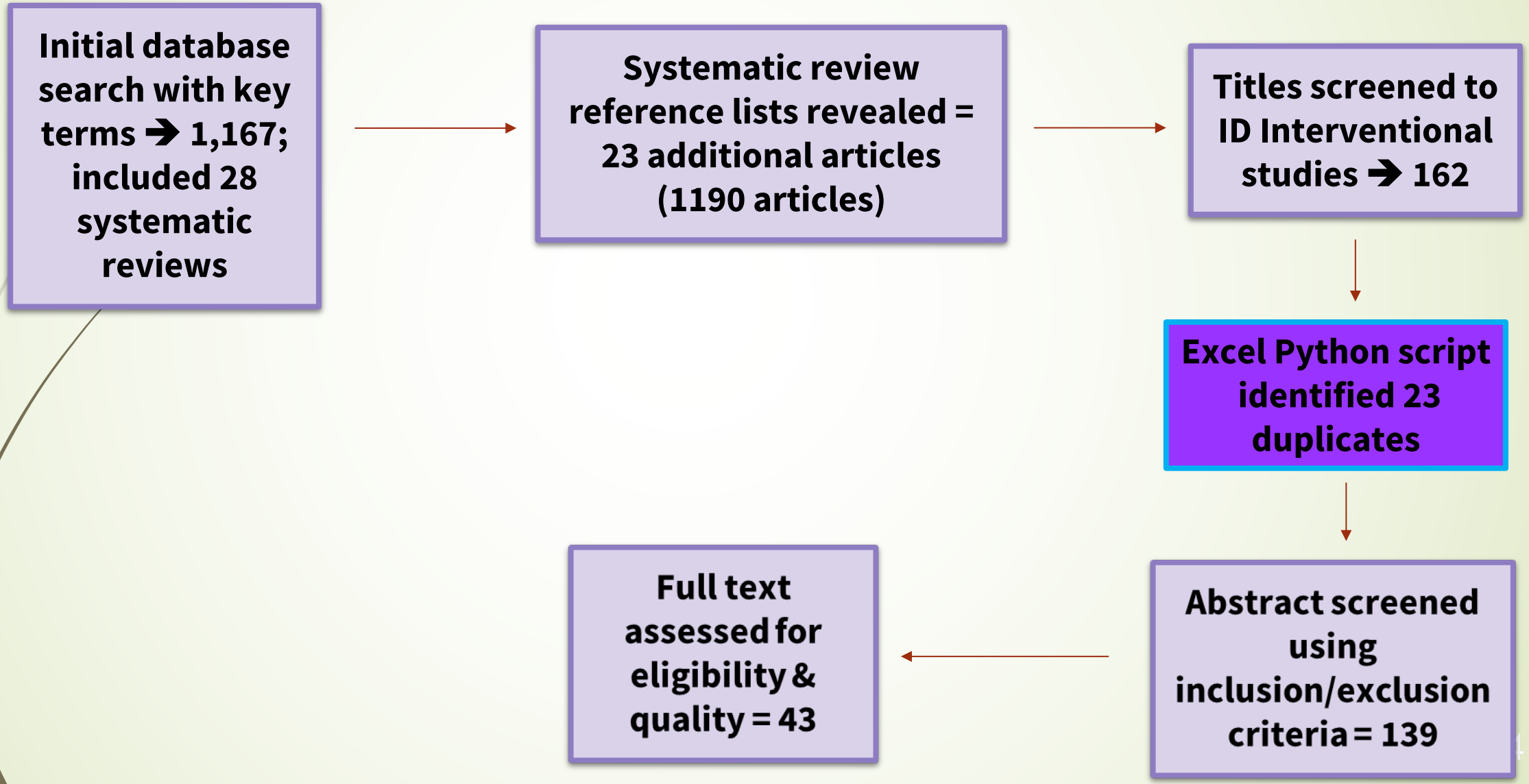
# Inclusion Criteria – Low Tone Review

- ✓ Participants were diagnosed with idiopathic hypotonia or a disease/disorder associated with the presence of hypotonicity as a common trait, e.g. Down syndrome, Spina Bifida, CP, Prader-Willi Syndrome, or Rhett Syndrome
- ✓ Participant group mean age ≤ 13 years of age at the beginning of the study
- ✓ Specific PT interventions for infants & children with low tone that were designed to improve or facilitate gross motor development
- ✓ Original research studies published in 2000 or later

# Exclusion Criteria – Low Tone Review

- ✓ Interventional Studies published before 2000
- ✓ Interventional techniques that may require an advanced certification or specialization, e.g. hippotherapy, dry needling, acupuncture
- ✓ Interventions that may be inappropriate for a PT to implement based on the MN state practice act
- ✓ Systematic & Cochrane Reviews

# B. Methods for Infants & Children with High Tone



# Data Bases & Search Terms – High Tone Review

**Data Bases:** CINAHL; Medline; PubMed; Cochrane Library

**Search Terms:** Pediatrics, Children, Physical Therapy, Rehabilitation, Gross Motor Function, Spasticity, Cerebral Palsy,

**Outcome Measures:** Gross Motor Function Measure (GMFM); Pediatric Evaluation Disability Inventory; Gait Speed

# Inclusion Criteria – High Tone Review

- ✓ Clinical diagnosis of spasticity secondary to cerebral palsy
- ✓ Participant mean age ≤ 13 years of age at the beginning of the data collection process
- ✓ Studies including specific physical therapy interventions that were designed to improve or facilitate gross motor function in infants/children with spastic cerebral palsy
- ✓ Original research studies

# Exclusion Criteria – High Tone Review

- ✓ Studies published before the year 2000
- ✓ Interventional techniques which may require advanced certification or specialization (e.g., hippotherapy, dry needling, or acupuncture)
- ✓ Interventions that may be inappropriate for a physical therapist to implement based on the MN state practice act
- ✓ Systematic & Cochrane reviews

# Quality Assessment Process for Low & High Tone Reviews

1. Four student researchers were split randomly into two pairs.
2. The final articles were divided between 2 pairs of students.
3. Each researcher individually evaluated their assigned group of articles using the appropriate quality assessment tool.
4. Quality scores were determined for each study.
5. Any between-rater discrepancies were averaged.

# Quality Assessment Tool: PEDro Scale

| | |
|---|---|
| **Applied to:** | Randomized Clinical Trials |
| **Total Points:** | 10 |
| **Quality Scores:** | Moderate quality = 6-7/10<br>High quality ≥ 8/10 |
| **Exemplar Criteria:** | Baseline similarity, randomization, allocation concealment, blinding, potential bias, statistical analysis and comparison |

# Quality Assessment Tool: Newcastle-Ottawa Scale

| | |
|---|---|
| **Applied to:** | Case-Control Studies |
| **Total Points:** | 10 |
| **Quality Scores:** | Moderate quality ≥ 6/10 |
| **Exemplar Criteria:** | Certainty of diagnosis, control selection, representativeness, randomization, statistical analysis, ascertainment of outcome(s) |

# Quality Assessment Tool: National Heart, Lung, Blood, Institute (NHLBI)

| | |
|---|---|
| **Applied to:** | Case Series Studies |
| **Total Points:** | 9 |
| **Quality Scores:** | Moderate quality ≥ 5/9 |
| **Exemplar Criteria:** | Study design/consecutive cases, validity of outcome measures, potential bias, description of intervention, study power, adequate follow-up period (≥ 4 weeks) |

# RESULTS for Infants & Children with Low Tone

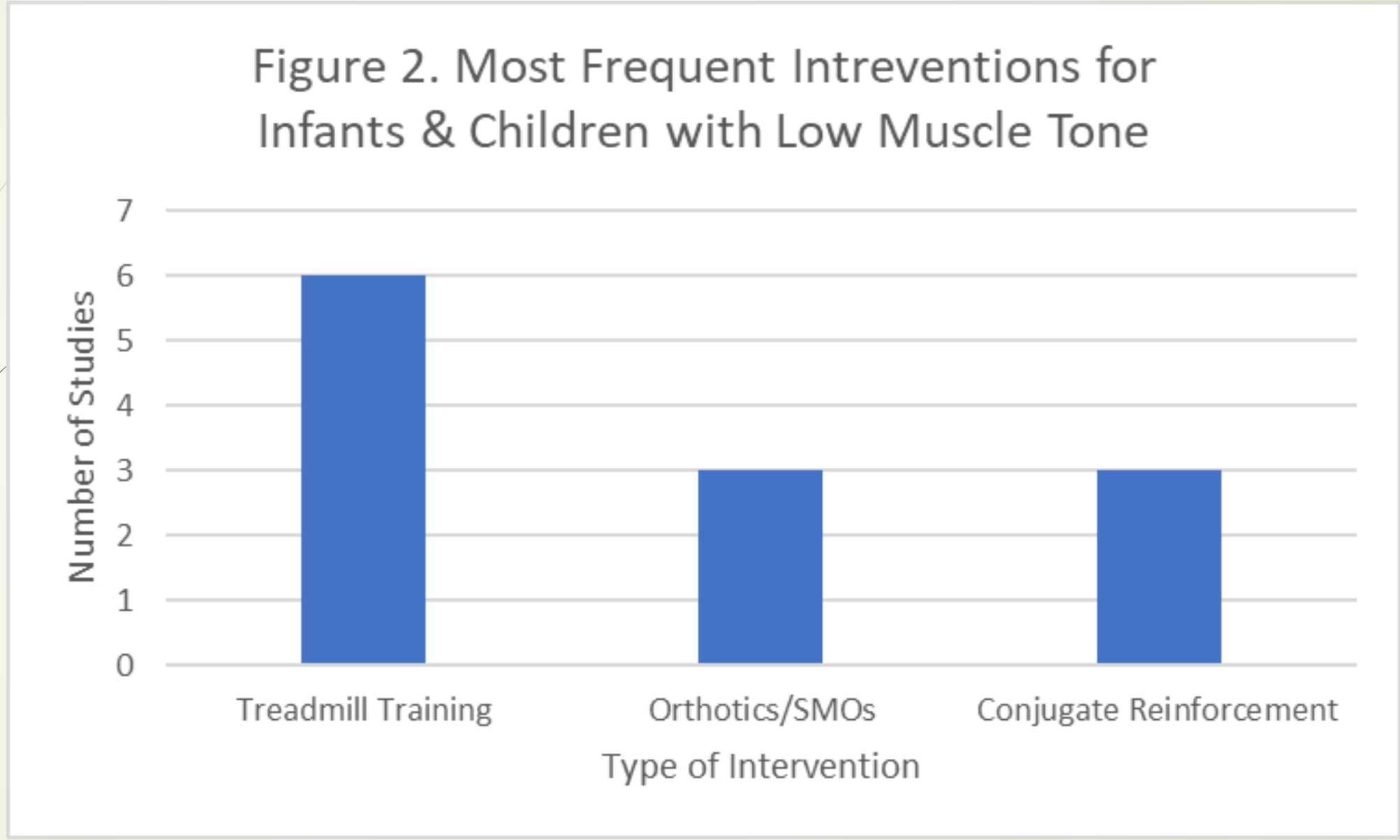


Figure 2. Most Frequent Intreventions for Infants & Children with Low Muscle Tone
Number of Studies
7
6
5
4
3
2
1
0
Treadmill Training
Orthotics/SMOs
Conjugate Reinforcement
Type of Intervention

# Intervention Parameters: Treadmill Training for Infants & Children with Low Tone

**Treadmill Belt Speed =** .15m/s to .3m/s; Mean = .2m/s

**Frequency =** 5 days/week

**Duration =** 8 to 12min/session

**Intensity can be individualized =** based on an infant's step rate ➔ Belt speed can be increased from 10 steps/min to >30 steps/min & Ankle weights can be added based on a % of calf mass, e.g. 15%, 30% of calf mass & the infant's step rate

# Intervention Results: Treadmill Training for Infants & Children with Low Tone

https://youtu.be/03_ZFLPRIEE

- ✓ Infants with low tone who received TM training ➔
- ✓ Walked earlier in life
- ✓ Showed improved gait parameters, i.e. longer step length, improved joint kinematics, cadence, decreased double support phase,
- ✓ Improved gait speed
- ✓ Higher intensity, i.e increased belt speed, ankle weights ➔ to greater improvements in stepping & gait patterns

# Quality Ratings: Treadmill Interventions for Infants & Children with Low Tone

- ✓ All 6 studies TM studies supported improved stepping patterns &/or gait parameters with infants with low tone who received TM training walking earlier in life
- ✓ Collectively, these studies were rated to be of moderate quality.
- ✓ Quality Scores ranged from 7.5-9 on either the Newcastle-Ottawa Scale or the NHLBI scale and 6-7/10 on the PEDro Scale

# Intervention Parameters: Orthotics/SMOs for Infants & Children with Low Tone

- Orthotic/SMO interventions ranged from 3 weeks to 6 months
- Cascade DAFO Hotdogs with medial posting, Custom hard orthotics with medial posting, & flexible SMOs
- Daily wear when the child was active with shoes
- https://youtu.be/Wt0EPV6U4oA


# Intervention Results: Orthotics/SMOs for Infants & Children with Low Tone

- ✓ Older infants (18 mon)& young children (5 yr old) with low tone showed improved:
  - Improved arch height
  - Improved ability to rise to stand, standing, lowering, cruising, stepping forward per Peabody Test of Motor Development
  - Improved walking, running, jumping immediately & after 7 weeks of wear & balance per BOT balance subtest after 7 weeks of wear

# Quality Ratings: Orthotic/SMO Interventions for Infants & Children with Low Tone

- ✓ All 3 orthotic/SMO studies supported improved biomechanics, gross motor skill development, walking ability & gait biomechanics for older infants/children and functional mobility for younger infants
- ✓ Collectively, these studies were rated to be of moderate quality.
- ✓ Quality Scores ranged from 7-7.5-9 on either the Newcastle-Ottawa Scale or the NHLBI scale and 6/10 on the PEDro Scale

# Intervention Parameters: Conjugate Reinforcement for Infants with Low Tone

- **Frequency:** 1x/month
- **Intensity:** Average 1 to 1.5 minute trials
- **Duration:** 1-4 months
- **Infant Ages:** 4-7 months at entry into the study
- **Paradigm:** Baseline, Acquisition, Extinction

# Intervention Results: Conjugate Reinforcement for Infants with Low Tone

Pre-walking infants with low tone generate more leg movements & kicks:

- ✓ When 1 leg is tethered to the mobile
- ✓ Immediately after they have had 1 leg tethered to the mobile, e.g. extinction condition

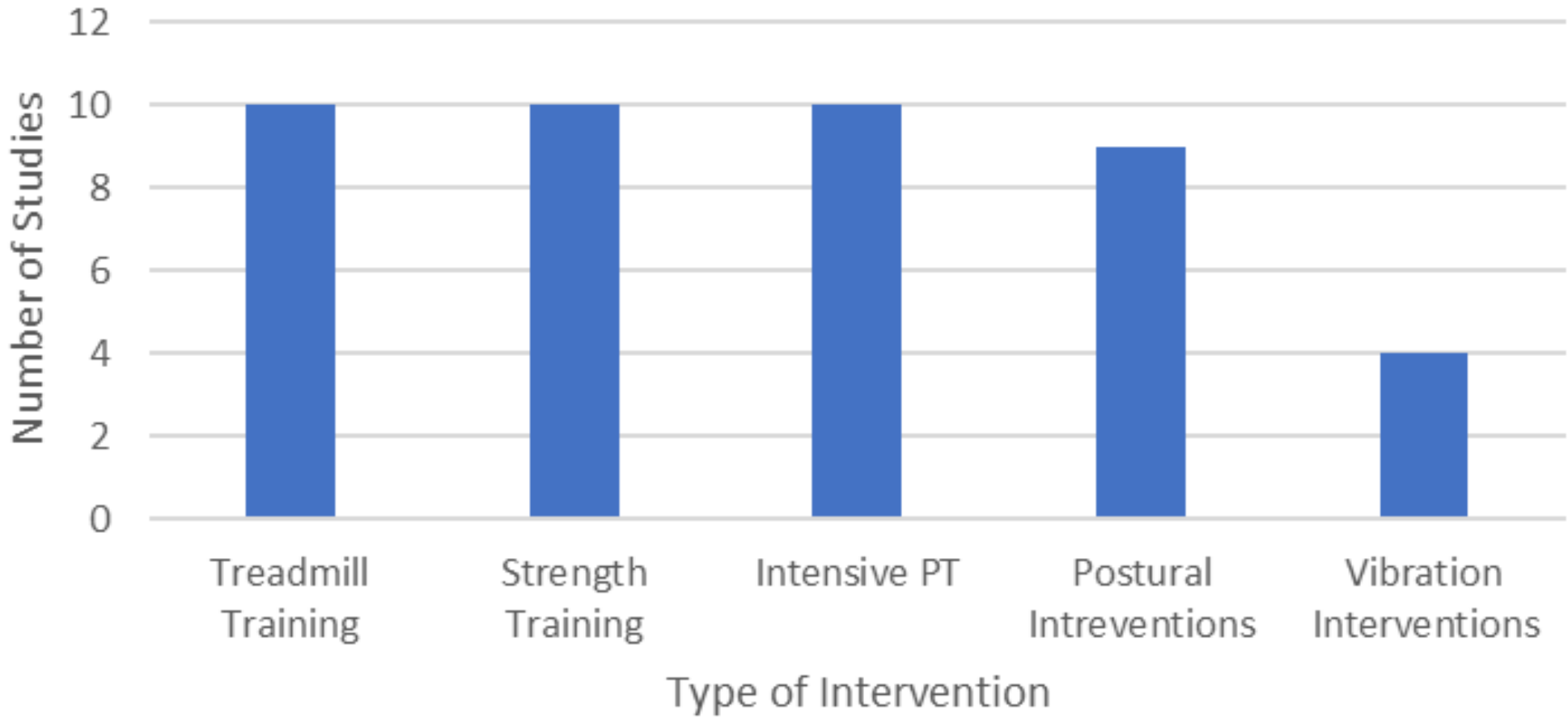
# Quality Ratings: Conjugate Reinforcement Interventions for Infants with Low Tone

- ✓ All 3 studies demonstrate that pre-walking infants with low tone are able to generate more leg movements &/or kicks when they have 1 leg tethered to an overhead mobile & immediately following having 1 leg tethered to an overhead mobile
- ✓ All 3 papers were rated to be of moderate quality
- ✓ Quality ratings = 7/9 for all 3 papers

# Stretch Break!!

# RESULTS for Infants & Children with High Tone

Figure 3. Most Frequent Interventions for Infants & Children with High MuscleTone



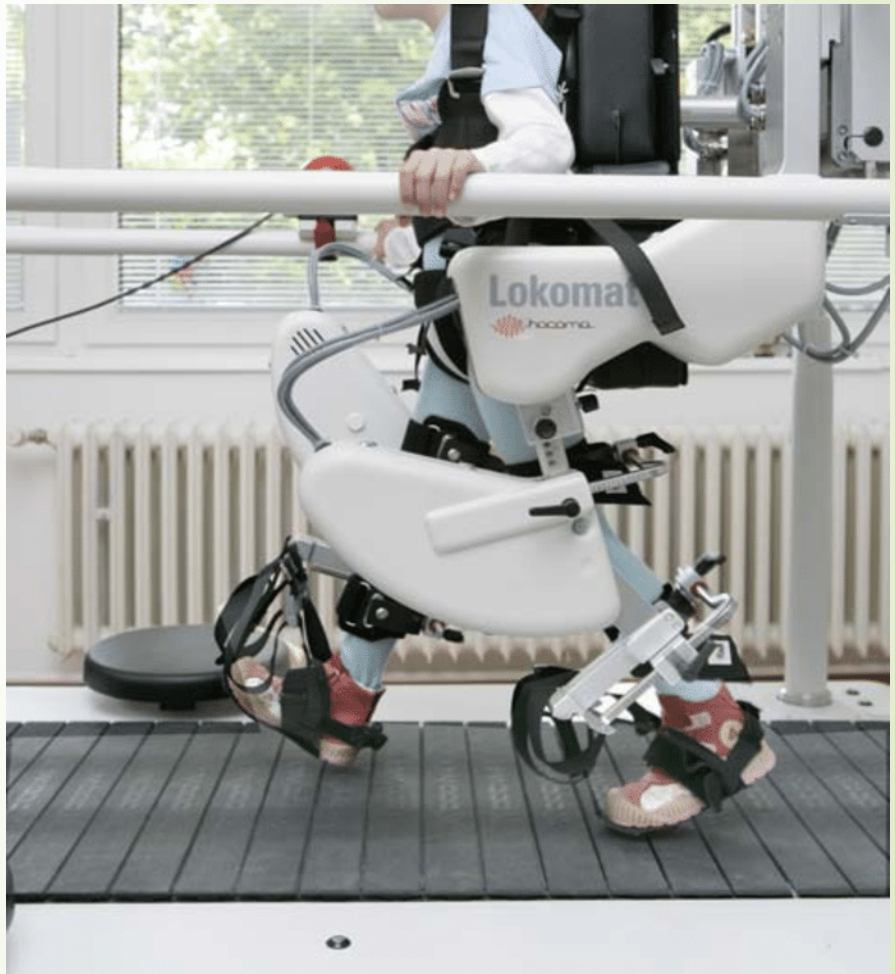
# Intervention Parameters: Treadmill Training for Children with High Muscle Tone

- **Treadmill Belt Speed =** individualized based on child's gait quality, e.g. single leg knee control or % of max over-ground walking speed, e.g. .25 m/sec

- **Frequency =** 2 - 6 sessions/week for 20 - 30 minute sessions

- **Duration =** 3 – 12 weeks

- **Variables =** Traditional; Robot-enhanced repetitive treadmill therapy (ROBERT); Virtual reality; Backwards walking; Eyes open vs. eyes closed



# Intervention Results: Treadmill Training for Children with High Tone

Children with spastic CP who received treadmill training:

- ✓ Improved gait quality, gait speed, endurance, & motor function per GMFM & PEDI scores
- ✓ Improved functional balance & motor control (joint proprioception)
- ✓ Attained walking skills earlier in life
- ✓ Required less support for walking

# Quality Ratings: Treadmill Training for Children with High Tone

- ✓ All 10 studies supported improved gross motor function&/or improved gait patterns for children with high tone
- ✓ 9/10 articles were rated to be of moderate quality or higher
- ✓ PEDro Scale scores = 5.5-8.5/10 & NHLBI scores = 6.5-7/9

# Intervention Parameters: Strength Training Interventions for Children with High Tone

- **Frequency =** 3-4 sessions/week
- **Intensity =** 30-60 minutes/session
- **Duration =** 5-24 weeks
- **Variables =** Multi-joint movements; High velocity movements; Progressive load; Lower extremity focus, e.g. DFs; Functional movements, e.g. sit to stands, step-ups and stair climbing; Virtual cycling,

# Results: Strength Training Interventions for Children with High Tone

- Children with spastic CP who received strength training:
  - Improved aerobic capacity and gait speed
  - Decreased muscle tone
  - Enhanced muscle strength
  - Improved gross motor function
  - Quality of Life

- Of those studies that <u>did not</u> demonstrate improvements in gross motor function, children with spastic CP exhibited isolated strength gains

# Quality Ratings: Strength Training for Children with High Tone

- ✓ 9/10 studies supported improved gross motor function for children with high tone
- ✓ All 9 studies were rated to be of moderate quality or higher
- ✓ PEDro Scale Scores = 5.5-8/10 & NHLBI scores = 8.5-9/9
- ✓ NOTE: The study that did not support improved gross motor function was also rated to be of moderate quality

# Intervention Parameters: Intensive PT for Children with High Tone

- **Frequency =** 4-6 sessions/week
- **Intensity =** 45 minutes to 6 hours/day
- **Duration =** 2-24 weeks
- **Variables =** Body weight supported treadmill training; Goal-directed activity; Therasuit; Play activities

# Results: Intensive PT Interventions for Children with High Tone

- ✓ Children with spastic CP who received intensive training:
  - Improved overground gait speed
  - Increased ambulation distance
  - Improved basic motor abilities & self-care

*Example of Therasuit*

- ✓ Of those studies that did not demonstrate improvements in gross motor function, children with spastic CP exhibited initial improvements in gross motor function that were not statistically significant

# Quality Ratings: Intensive PT for Children with High Tone

- ✓ 6/10 supported using intensive PT interventions to improve gross motor function in children with high tone
- ✓ 9/10 studies were rated to be of moderate or higher quality
- ✓ PEDro Scale scores = 6-9/10; NHLBI scores = 7.5-8.5/9; & Newcastle score = 2.5/10

# Parameters: Postural Interventions for Children with High Tone

- **Frequency =** 2-6 sessions/week
- **Intensity =** 30-75 minutes per session
- **Duration =** 4-12 weeks

- **Variables =** Kinesiotaping; Neuromuscular electrical stimulation (NMES); Neurodevelopmental treatment (NDT); Sensory/proprioceptive tasks

# Results: Postural Interventions for Children with High Tone

- ✓ Children with spastic CP who received posutural training:
  - Improved sitting posture & postural control
  - Enhanced postural alignment
  - Improved gross motor function

- ✓ Of those studies that <u>did not</u> demonstrate improvements in gross motor function, children with spastic CP exhibited improved head & visuomotor control

# Quality Ratings: Postural Interventions for Children with High Tone

- ✓ 7/9 studies supported using improved gross motor function for children with high tone
- ✓ PEDro Scale Scores = 4-8/10 & NHBLI score = 6/9
- ✓ NOTE: The 2 studies that did not support using postural interventions to improve gross motor function for children with high tone were of poor quality

# Parameters of Vibration Interventions for Children with High Tone

- **Frequency =** 2-9 sessions/week
- **Intensity =** 10-15 minutes per session with vibration of 12Hz to18Hz
- **Duration =** 12-24 weeks


- **Variables =** Whole body vibration; Side alternating whole body vibration; Tilt table

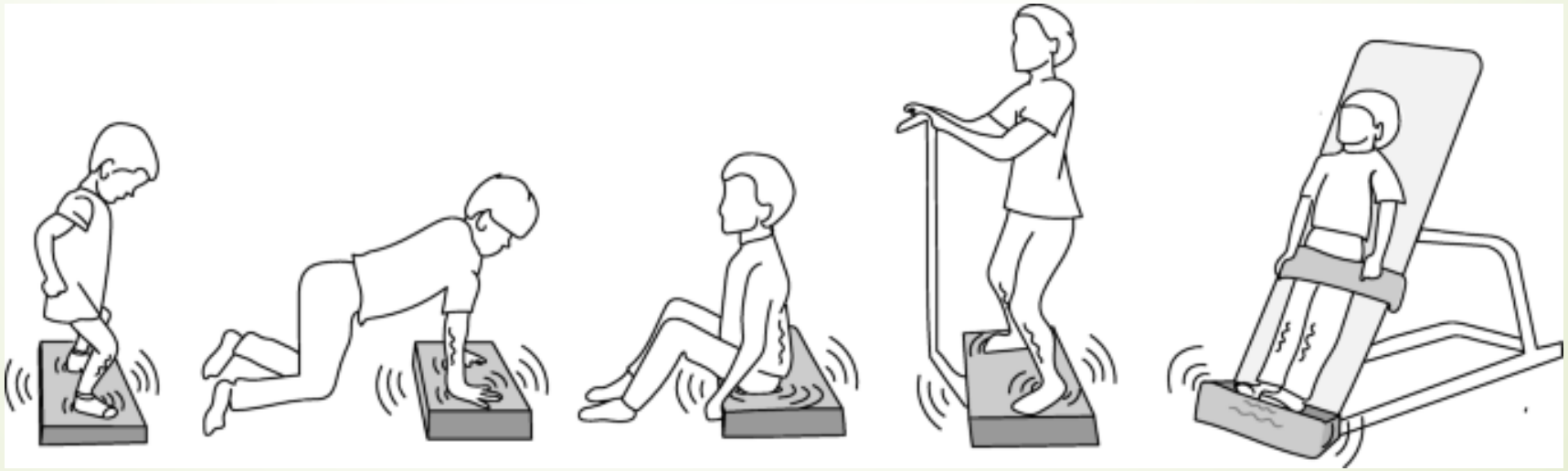
# Results: Vibration Interventions for Children with High Tone

- ✓ Children with spastic CP who received vibration training in 2/4 studies showed:
  - Improved gross motor function, gait, & balance
  - Decreased spasticity

- ✓ In 2/4 articles vibration was found to be safe & feasible but children with high tone did not show Improved gross motor function

# Quality Ratings: Vibration Interventions for Children with High Tone

- ✓ 2/4 articles supported using vibration to improve gross motor function, gait, balance in children with high tone
- ✓ PEDro Scale Scores for 4/4 articles = 6-8/10



# DISCUSSION

# Interventions for Children with Atypical Muscle Tone are Marked by:

- **A wide variety of:**
  - ✓ Interventions
  - ✓ Intervention parameters, e.g. duration, intensity
  - ✓ Outcome measures, e.g. GMFM, QoL, isolated strength
  - ✓ Quality ratings ➔ mostly moderate quality studies

- ✓ Suggestion: Be an 'informed consumer' ➔ Evidence Guided Practice

# Intervention Recommendations

# PT Interventions for Infants & Children with Low Muscle Tone

**Treadmill Training** with individualized intensity levels based on infant's step rate to facilitate walking & gait quality

**Orthotics & SMOs** to improve arch height, select aspects of gross motor function, & improve walking, running & jumping

**Conjugate Reinforcement** to increase how often pre-walking infants with low tone move their legs & kick

# PT Interventions for Infants & Children with High Muscle Tone

**Treadmill training** to improve gait, endurance, functional balance, & motor control

**Strength training** to improve aerobic capacity, gait speed, & gross motor function and decrease muscle tone

**Intensive PT** to improve gait speed, ambulation distance (endurance), basic motor skills (mixed support)

**Postural Interventions** to improve sitting posture, postural control & alignment, & improve gross motor function

**Vibration Interventions** may improve gross motor function

# Study Limitations

**Populations**: Hypotonia & Spastic CP

**Mean group age:** ≤ 13 at entry into study

**Publications:** Original articles published in English since 2000

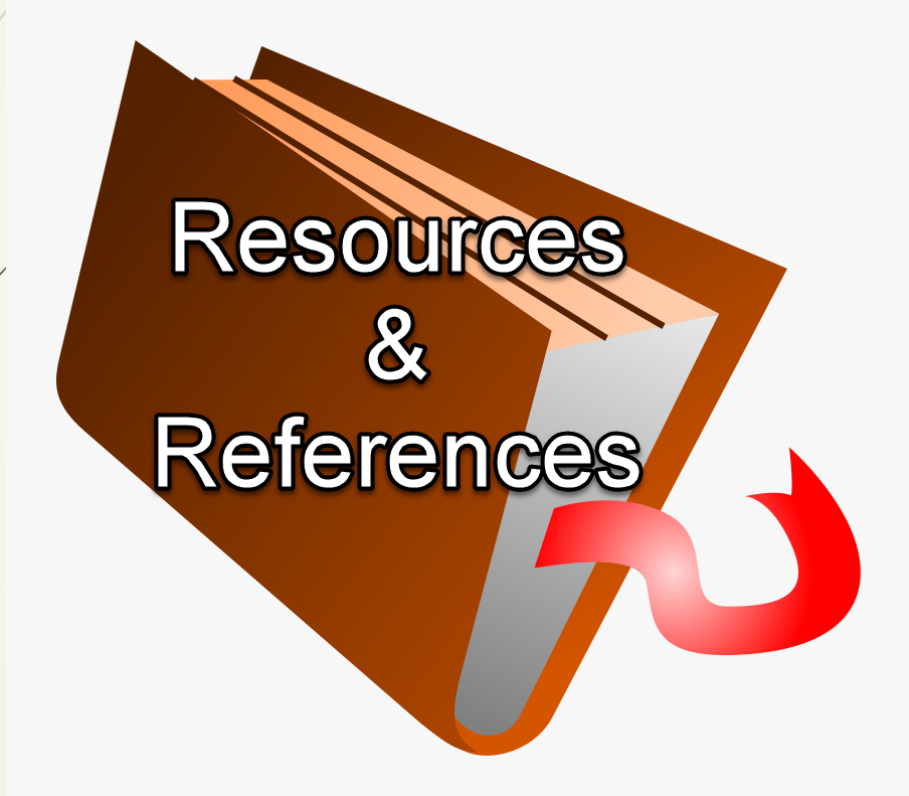
**Outcome(s) of Interest** = Motor Development &/or Gross Motor Function

**Interventions:** Within the scope of the MN PT Practice Act &/or excluded advanced certification or specialization

# Future Research Directions

- Better designed postural intervention studies
- Longer longitudinal Studies
- More consistent intensive intervention dosage parameters
- Additional diagnoses that result in high tone
- Increase diversity, e.g. race, ethnicity of participants
- Ask parents/caregivers what interventions & outcomes are most important to them & their child
- Larger sample sizes

# References are available upon request via ddchapman@stkate.edu




# Questions?

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