Objectives:

• Discuss Developmental Coordination Disorder characteristics and criteria
• Discuss current treatment approaches for children with Developmental Coordination Disorder
• Assess the use of strength training as an effective intervention for children with Developmental Coordination Disorder

Objectives:

• Develop a clinical rationale for strength training in this population
• Apply the treatment principles to current cases of children with Developmental Coordination Disorder

Who am I?

• Graduated Boston University with an MSPT (2000) and a DPT (2005)
• PCS
• Owner/Founder of Starfish Therapies
• Co-author of ‘Strength Training for a Child With Suspected Developmental Coordination Disorder’ (Pediatric PT Summer 2013)

What is DCD?

• DSM-IV Criteria
  • Performance substantially below what is expected
  • Interferes with academics or ADL’s
  • Not due to a general medical condition
  • If mental retardation is present the motor difficulties are above what is expected

What is DCD?

• DSM-IV
  • Incidence
    • 6% kids aged 5-11
  • Characteristics
    • ‘marked impairments in the development of motor coordination’
    • interferes with successful, efficient completion of daily activities
Compensatory Strategies

- Associated Movements (Licari)
  - Excessive and unnecessary
  - Decrease effectiveness/fluency of movement
- Cocontraction (Utley)
  - ‘Lock out’ degrees of freedom
  - Occurs in typical development
  - Can’t unlock at same rate as peers

Feedback vs Feedforward Control

- Feedback (Jover)
  - Similar motor response as peers
- Feedforward (Jover)(Smits-Engleman)(Elders)
  - Use past movement experiences
  - Prepare/predict movement requirements
  - More variability and decreased coordination
  - Larger end point errors
  - Greater variability in force production

Current Treatment Approaches

- Systematic Review (Hillier)
  - Any form of intervention better than none
  - No indication that one type is better than the rest
  - Most reviewed Sensory Integration and Perceptual Motor Therapy
  - Outcomes are task specific
  - Kids with DCD do not catch up

Current Treatment Approaches

- Top Down vs Bottom Up (Barnhart et al)
- Bottom Up
  - Hierarchical theories of motor control
  - Activate higher levels of neuronal functioning
  - Sensory Integration Therapy (SIT)
  - Process Oriented Approaches
  - Perceptual Motor Therapy (PMT)
**Current Treatment Approaches**

- **Top Down**
  - Problem solving – Dynamical systems theory
  - Task Specific Intervention
  - Cognitive Approach (GPDC framework)
  - Cognitive Approach maintains and generalizes tasks better than all bottom up approaches

**Strength Training**

- Kaufman and Schilling
  - 12 week strength training program for 5 y.o. boy with DCD
  - 1 year of activity based intervention with limited results
  - Improved: BOT-2, dynametric force production, static and dynamic proprioception in UE and LE

**Stages of Learning**

- **(Campbell)**
  - Cognitive Stage
    - Have the general idea of the movement but not how to execute it
  - Associative Stage
    - Skills are refined with practice
  - Autonomous Stage
    - Motor skill is learned and little cognitive effort is required to execute it

**Tying it Together**

- Cognitive Stage
  - Feedforward Control
  - Blocked Practice

**Why Strength Training and DCD?**

- Strength training principles in children
- Develop and improve strategies at cognitive stage of motor learning
- Blocked practice
- Prolonged experience with isolated, simple joint movements
- Available evidence on mechanisms for strength gains in children and effective motor learning

**Universal Exercise Unit**

- Pulley system
- Allows low weights and high repetitions
- Controlled movement
- Blocked Practice
Case Study - Subject
- 6 year, 11 month old girl
- Dx of apraxia and hypotonia
- h/o limited, poorly maintained progress with activity level intervention
  - 3 EOC over a 2 year period
  - Improvement with repeated practice but degraded performance without consistent practice
- BOT-2 and PDMS-2 scores -1.5 to -2 SD
  - With 2x/week -1 SD

Case Study – Clinical Impression
- Difficulty/failure with age appropriate motor tasks
- History demos lack of substantial and sustained progress with past EOC
- Practice of whole task may not be sufficient to effectively learn new motor skills

Case Study – Hypothesis
- Effective recruitment and activation of muscles for feedforward control of coordination and motor planning are possible impairments related to difficulties with acquisition and performance of gross motor tasks

Case Study – Tests and Measures
- Participation Level
  - Canadian Occupational Performance Measure (COPM)
### Case Study – Tests and Measures

- **Activity Level**
  - Developmental Coordination Disorder Questionnaire (DCDQ’07)
  - Test of Gross Motor Development (TGMD-2)
  - Bruininks-Oseretsky Test of Motor Proficiency (BOT-2)
  - Traversing monkey bars

- **Impairment Level**
  - BOT-2
  - Functional Strength Measures

### Table 1: Operational definitions for GMD + functional strength measures describing performance, instructions and data recording.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre: Reaches</td>
<td>Asked to reach in front of her with arm spread and raise up onto her toes as many times as she is able. Hand rows were recorded until she was unable to lift hands from the ground.</td>
</tr>
<tr>
<td>Posterior</td>
<td>Asked to perform a posterior pelvic tilt with her legs held straight. She received verbal cues and a hand held under her back for tactile cues. Time was recorded until contractions were released as increased by feel and visual feedback.</td>
</tr>
<tr>
<td>Pollo Tilt</td>
<td>Asked to maintain a bridge without stabilization and without moving her feet. She received verbal cues. Time was recorded until she lowered her hips.</td>
</tr>
<tr>
<td>Plank</td>
<td>Asked to hold a straight line from head to heels with weight on forearms and neck and hands was recorded until she lowered to the ground.</td>
</tr>
<tr>
<td>Trunk</td>
<td>Asked by her trunk up onto an extended position with her hips and legs extended on the table. She received verbal cues. Time was recorded until she lowered her trunk.</td>
</tr>
<tr>
<td>High From</td>
<td>Asked to support her body weight by holding onto a bar. Time was recorded until she lowered it to the ground.</td>
</tr>
</tbody>
</table>

### Case Study – Examination

- **COPM**
  - Average Performance Rating – 4.2/10
  - Average Satisfaction Rating – 9.2/10
- **DCDQ’07**
  - 17 – within the suspected DCD range

- **TGMD-2**
  - Standard Scores 7 and 8
- **BOT-2**
  - -1.2 to -1.7 standard deviations
  - Monkey Bars
  - Traversed 0

### Pre-Test Video
**Case Study – Examination**
- Strength
  - BOT-2: -1.8 SD
- Functional Measures:
  - Decreased ability to repetitively activate and/or maintain a muscle contraction against gravity
  - Increased co-contractions and associated movements
  - Decreased ability to coordinate muscle groups, stabilize and activate isolated muscle activity

**Case Study – Evaluation**
- BOT-2
  - ‘well below average’ gross motor skills
  - Range consistent with DCD
  - Difficulty with quality and coordination of complex movements in standardized and functional measures
  - Demonstrates poor control
  - Utilizes compensatory strategies
    - Co-contraction to lock out degrees of freedom

**Case Study – Intervention**
- Strength training program to promote blocked practice of isolated simple joint movements
- Decrease co-contractions at joint and associated movements during motor skills
- 24 strength training sessions
- Enhance learning feedforward control of simple motor skills
- Universal Exercise Unit
  - Resistance through pulley weight system

**Case Study – Intervention**
- Strength gains in children
  - Improved motor unit recruitment at neurological level
  - Not muscle hypertrophy at tissue level

**Measure** |**Observation** |**Implication** |**Exercise**
--- |--- |--- |---
Bilateral | Bilateral horizontal line extension (knee flexion/extension) with single leg support | • Improvement in stability of lower extremity musculature | • Bridgeing bilaterally
Proximal | Bilateral | Bilateral lateral line extension with single leg support | • Improvement in stability of lower extremity musculature | • Bridgeing bilaterally
Distal | Bilateral | Bilateral | • Improvement in stability of lower extremity musculature | • Bridgeing bilaterally
Bilateral | Bilateral vertical line extension | Bilateral | • Improvement in stability of lower extremity musculature | • Bridgeing bilaterally

**Specific joint chosen based on impairment level deficits found during examination**
**Case Study – Outcomes**

- After 24 strength-training sessions:
  - Participation Level (COPM)
    - Reported improvements via self-assessment
  - Clinically significant improvement of 4 mean points for satisfaction
  - Non-clinically significant change of 1 mean point for performance

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<table>
<thead>
<tr>
<th>Exercise</th>
<th>Observation</th>
<th>Impairment</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Sit (HOT-1)</td>
<td>• Raised at 90 degrees of knee flexion</td>
<td>• Supine bilateral hip and knee flexion</td>
<td>• Supine unilateral hip and knee flexion</td>
</tr>
<tr>
<td></td>
<td>• Yelled to keep back against the wall</td>
<td>• Supine bilateral hip flexibility</td>
<td>• Supine unilateral hip and knee flexion</td>
</tr>
<tr>
<td></td>
<td>• Attempted to walk but fell further in front</td>
<td>• Supine bridging</td>
<td>• Supine unilateral trunk extension</td>
</tr>
<tr>
<td>Push-Up (HOT-2)</td>
<td>• Unable to maintain a stable body while bending hips over to lower trunk</td>
<td>• Supine unilateral hip abduction</td>
<td>• Supine bilateral hip and knee flexion</td>
</tr>
<tr>
<td></td>
<td>• Dropped initial body to ground in frontal position</td>
<td>• Supine unilateral hip and femur extension</td>
<td>• Supine unilateral hip extension</td>
</tr>
<tr>
<td>V-Up (HOT-3)</td>
<td>• Unable to maintain trunk extension with arms and legs extended</td>
<td>• Supine bilateral hip and knee extension</td>
<td>• Supine unilateral hip and knee flexion</td>
</tr>
</tbody>
</table>

Table 2: GED’s strength measures, observations of quality of movement during strength measures, identified impairments based on quality of movement, and exercises selected to target impairments.

<table>
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<th>Observation</th>
<th>Impairment</th>
<th>Exercise</th>
</tr>
</thead>
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<tr>
<td>Supine unilateral hip flexion</td>
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<tr>
<td>Supine bilateral hip extension to neutral with knee immobility</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Supine bilateral hip extension to neutral with knee immobilization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supine unilateral hip abduction with knee immobilization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supine unilateral hip adduction with knee immobilization</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Supine unilateral knee flexion in neutral with knee immobilization</td>
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<tr>
<td>Supine bilateral hip and knee flexion</td>
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<tr>
<td>Supine unilateral hip and knee flexion</td>
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<td></td>
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<td>Supine bridging</td>
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<tr>
<td>Supine unilateral hip extension</td>
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<tr>
<td>Supine unilateral hip extension</td>
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<td></td>
</tr>
</tbody>
</table>

Table 3: UE exercises included in GED’s strength training program. All unilateral exercises performed on left and right sides.
Case Study – Outcomes

• Activity Level
  • DCDQ’07
    • Post-intervention scores no longer within suspected DCD range
  • TGMD-2
    • Non-clinically significant changes (↑ locomotor subsection, ↓ object control subsection)

Case Study – Outcomes

• Activity Level cont.
  • BOT-2
    • Clinically significant increase in balance and bilateral coordination
    • Non-clinically significant decrease in running speed and agility
    • Monkey Bars
      • Increase of 10 monkey bars

Test of Gross Motor Development - Second Edition

Case Study – Outcomes

• Impairment Level
  • BOT-2
    • Non-clinically significant increase in strength subtest
  • Functional Strength
    • Decreased co-contractions and associated movements observed
    • Improved heel raises, posterior pelvic tilt, bridging, plank, trunk extension, hanging from a bar
What Does It All Mean?

- Use of blocked practice for isolated simple joint movements via strength training
- Gains in participation and activity level function
- Ability to use feedforward control and isolate without compensations

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What Does It All Mean?

- Repetitive blocked practice demonstrated potential for increased stability and coordinated movement
- Did not result in changes on skills requiring control of locomotion and movement through the environment
- Locomotion and movement through environment require efficient use of momentum (not addressed with this intervention)

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Additional Functional Strength Testing

<table>
<thead>
<tr>
<th>Measure</th>
<th>Qualifier</th>
<th>Pre</th>
<th>Post</th>
<th>Δ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bent-Raiser</td>
<td>Legs straight</td>
<td>8.4 seconds</td>
<td>14.8 seconds</td>
<td>+6.4</td>
</tr>
<tr>
<td>Bridging</td>
<td></td>
<td>5.7 seconds</td>
<td>24.2 seconds</td>
<td>-18.5</td>
</tr>
<tr>
<td>Plank</td>
<td></td>
<td>5.8 seconds</td>
<td>12.2 seconds</td>
<td>+6.6</td>
</tr>
<tr>
<td>Trunk Extension</td>
<td></td>
<td>4.1 seconds</td>
<td>10.3 seconds</td>
<td>+6.2</td>
</tr>
<tr>
<td>Hang from bar</td>
<td></td>
<td>8.7 seconds</td>
<td>10.9 seconds</td>
<td>+2.2</td>
</tr>
</tbody>
</table>

Table 4: Pre- and post-test scores for G.D.’s functional strength measures. Δ column indicates change between pre- and post-test measures.

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What Does It All Mean?

- Improvements in functional strength
- Improved stabilization
- Decreased co-contractions and associated movements
- Selected Intervention had + affect on motor learning
- More effective coordination of available degrees of freedom

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Compensatory Strategies Part 2
Monkey Bar Video

Questions?

References:

• Smits-Engleman BCM, Westenberg Y, Duysens J. Children with developmental coordination disorder are equally able to generate force but show more variability than typically developing children. *Hum Movement Sci.* 2008;27:296-309.

References:

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