Evaluation of trunk control in children with cerebral palsy:
The Trunk Control Measurement Scale

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Disclosure Information
AACPDMS 68th Annual Meeting September 10-13, 2014
Speaker Name: Lieve Heyrman
Hilde Feys

Disclosure of Relevant Financial Relationships
I have no financial relationships to disclose.

Disclosure of Off-Label and/or investigative uses:
I will not discuss off label use and/or investigational use in my presentation

Outline
- Introduction
- State-of-the-art of clinical assessment of trunk control
- Trunk Control Measurement Scale
  - Content and psychometric properties
  - Administration of TCMS and scoring criteria

Trunk control

Introduction
**Trunk control in CP**

**Introduction**

**CLINICAL FINDINGS**
- Increased trunk motion during functional activities
- Increased/decreased tone
- Muscle weakness
- Decreased selectivity of muscle recruitment
- Spinal deformities

Prosser et al. 2010
Morrell et al. 2002
Persson-Bunke et al. 2012
Romkes et al. 2007
Heyrman et al. 2013

**Scientific evidence?**

**Evaluation tools for trunk control?**

- Decreased selectivity of muscle recruitment
- Spinal deformities

**Part 1: Clinical assessment of trunk control**

- Trunk interventional research
- Methodological/descriptive studies

systematic review
Trunk interventional research

- Review of databases
  - Pubmed, Embase, Medline, Web of Science, The Cochrane Library, Psychinfo

- Inclusion criteria:
  - Population: children with CP between 0 – 18 yrs
  - Intervention: focus on trunk
  - Intervention study
  - Full-text, in English

Three types of interventions

- Physical therapy/conceptual treatment
- Other therapy
  - Equipment-supported therapy
  - Taping
  - Electrical stimulation, biofeedback, saddle riding...
  - Hippotherapy

Physical therapy/Conceptual treatments

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Intervention</th>
<th>Trunk assessments</th>
<th>Other assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balbi M et al. 2012</td>
<td>30</td>
<td>Neurofacilitation of Developmental reception vs</td>
<td>GMFM Dim scores</td>
<td>GMFM total scores</td>
</tr>
</tbody>
</table>

1/3 studies: Trunk-specific assessment (PA5)
2/3 studies: General assessment (GMFM Dim B)

GMFM: Gross Motor Function Measure

Head & Trunk Kinematics
### Other therapy

#### Equipment-supported therapy (1)

<table>
<thead>
<tr>
<th>Study</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bertoti DB et al. 1988</td>
<td>5</td>
<td>Biofeedback and visual alone</td>
<td>Trunk assessments</td>
<td></td>
</tr>
<tr>
<td>Butler PB et al. 1998</td>
<td>6</td>
<td>Targeted Training</td>
<td>Segmental Assessment of Trunk Control (SATCo)</td>
<td></td>
</tr>
<tr>
<td>Rostro CB et al. 2008</td>
<td>18</td>
<td>Therapeutic taping paraspinal muscles</td>
<td>GMFM Dim B</td>
<td>GMFM total score</td>
</tr>
<tr>
<td>Herrero P et al. 2012</td>
<td>38</td>
<td>Hippotherapy simulator</td>
<td>Sitting Assessment Scale</td>
<td></td>
</tr>
<tr>
<td>Kuckucki M et al. 1999</td>
<td>25</td>
<td>Saddle riding</td>
<td>COP</td>
<td></td>
</tr>
<tr>
<td>Park ES et al. 2009</td>
<td>26</td>
<td>Electrical stimulation paraspinal muscles</td>
<td>GMFM Dim B</td>
<td>RX spinal angles</td>
</tr>
</tbody>
</table>

#### Equipment-supported therapy (2)

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Intervention</th>
<th>Trunk assessments</th>
<th>Other assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quint C et al. 1998</td>
<td>26</td>
<td>Saddle riding</td>
<td>Passive ROM pelvic tilt</td>
<td></td>
</tr>
</tbody>
</table>

4/12 studies: **Trunk-specific assessments (SATCo, SACND)**

6/12 studies: **General assessments (GMFM Dim B, Chailley Levels of Ability)**

### Other therapy

#### Hippotherapy (1)

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Intervention</th>
<th>Trunk assessments</th>
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<tbody>
<tr>
<td>Bertoti DB et al. 1988</td>
<td>11</td>
<td>Hippotherapy</td>
<td>Posture assessment scale</td>
<td></td>
</tr>
<tr>
<td>Cherng RJ et al. 2004</td>
<td>14</td>
<td>Hippotherapy</td>
<td>GMFM Dim E</td>
<td>Tone hip adductors</td>
</tr>
<tr>
<td>Hamill IV et al. 1998</td>
<td>2</td>
<td>Hippotherapy</td>
<td>Trunk kinematics</td>
<td></td>
</tr>
<tr>
<td>Hamill E et al. 2007</td>
<td>1</td>
<td>Hippotherapy</td>
<td>Sitting Assessment Scale</td>
<td>GMFM Dim B</td>
</tr>
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<td>Hayunglo J et al. 2012</td>
<td>45</td>
<td>Hippotherapy</td>
<td>COP</td>
<td></td>
</tr>
<tr>
<td>Kwon JY et al. 2011</td>
<td>32</td>
<td>Hippotherapy</td>
<td>Pediatric Balance Scale</td>
<td>GMFM Dim B</td>
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#### Hippotherapy (2)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>McGibbon NH et al. 1996</td>
<td>5</td>
<td>Hippotherapy</td>
<td>GMFM Dim E</td>
<td>Gait parameters</td>
</tr>
<tr>
<td>Shurtleff TL et al. 2010</td>
<td>12</td>
<td>Hippotherapy</td>
<td>Barrel test (head &amp; trunk kinematics)</td>
<td></td>
</tr>
</tbody>
</table>

3/10 studies: **Trunk-specific assessment (PAS, SAS)**

1/10 studies: **General assessments (GMFM Dim B)**
<table>
<thead>
<tr>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical assessment tool</strong></td>
</tr>
<tr>
<td>Posture assessment scale</td>
</tr>
<tr>
<td>Sitting assessment scale</td>
</tr>
<tr>
<td>Sitting Assessment for children with Neuromotor dysfunction</td>
</tr>
<tr>
<td>SATCo</td>
</tr>
<tr>
<td>Chailey Levels of Ability</td>
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<td>GMFM Dim B</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Segmental Assessment of Trunk Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Assessment of static trunk control during upright sitting, during head movements and during external perturbation</td>
</tr>
<tr>
<td>- Scoring 0-1 (present/absent) at 7 segmental levels of trunk</td>
</tr>
<tr>
<td>- Excellent intra- and interrater reliability and concurrent validity (Butler et al. 2010)</td>
</tr>
<tr>
<td>- Limited detail on trunk control</td>
</tr>
<tr>
<td>- Limited evaluation of psychometric properties</td>
</tr>
<tr>
<td>Measures static aspects of trunk control only</td>
</tr>
<tr>
<td>Highly valuable in children with limited functional abilities (GMFCS IV &amp; V)</td>
</tr>
</tbody>
</table>

Butler PB 2010
**Part 1: Clinical assessment of trunk control**

- **Trunk interventional research**
- **Methodological/descriptive studies**

**Spinal Alignment and Range of Motion Measure**
- Evaluation of static trunk control only
  - Sitting
    - Sagittal, frontal and transverse plane
    - Range of motion
      - Mainly lower limbs

**Seated Postural Control Measure**
- Postural performance during functional activities in sitting

Bartlett & Purdie 2005

Fife 1991
Trunk Impairment Scale

- Assessment of trunk control in sitting in **stroke** patients
- Three subscales
  - Static sitting balance
  - Dynamic sitting balance
  - Coordination
- Scoring on 2 to 4-point ordinal scale
- Total score = 23

Assesses static and dynamic aspects of trunk control

Verheyden G et al. 2004

Trunk Impairment Scale

- Evaluation of reliability and validity of TIS in **children with CP**
  - Results:
    - excellent intra- and interrater reliability (Saether et al. 2011, 2013)
    - evidence for construct validity (Saether et al. 2013)
    - High correlations with GMFM and GMFCS levels

Limitations of TIS

- Unilateral involvement of stroke <-> uni- and bilateral involvement in CP
- Not all movements planes were included
- Movements beyond the BOS were not included

Trunk Control Measurement Scale (TCMS)

Part 2: Trunk Control Measurement Scale

- Content of the scale
- Evaluation of psychometric properties
Scale requirements

- Isolated trunk control
  - Only sitting
  - Feet unsupported
- Static and dynamic trunk control
- Active trunk movements in three planes
  - Insights into strengths and weaknesses of child’s trunk control
  - Targeted intervention
- Information on performance

Trunk Control Measurement Scale

- Static sitting balance
  - Maintaining stable trunk during upper and lower limb movements
  - Item 1 - 5
- Selective movement control
  - Selective trunk movements in three planes within base of support
  - Item 6 - 12
- Dynamic reaching
  - Reaching tasks: active trunk movements beyond base of support
  - Item 13 - 15

Psychometric properties of TCMS

- Inter-rater & test-retest reliability
- Construct validity
- Discriminative ability
  - CP vs TD children
  - Subgroups of CP
    - Topography
    - Functional abilities (GMFCS-levels)

A clinical tool to measure trunk control in children with cerebral palsy: the Trunk Control Measurement Scale

Heyman et al. Res Dev Disabil 2011; 32; 2624-2635
- Participants
  - N= 26 spastic CP
  - GMFCS level I-III
  - Age 8 – 15yrs (11.2 ± 2 yrs)
- N= 30 TD children
- Age-matched

Results – reliability

<table>
<thead>
<tr>
<th>TCMS total</th>
<th>Static sitting balance</th>
<th>Selective movement control</th>
<th>Dynamic reaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICC int rater</td>
<td>0.98</td>
<td>0.98</td>
<td>0.94</td>
</tr>
<tr>
<td>ICC test-retest</td>
<td>0.97</td>
<td>0.94</td>
<td>0.91</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SEM</th>
<th>SDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interrater</td>
<td>1.68 (2.9%)</td>
</tr>
<tr>
<td>Test-retest</td>
<td>1.97 (9.43%)</td>
</tr>
</tbody>
</table>

Excellent interrater and test-retest reliability

Small measurement errors

Results – construct validity

<table>
<thead>
<tr>
<th>TCMS</th>
<th>GMFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Dim A</td>
</tr>
<tr>
<td>Total TCMS</td>
<td>0.88</td>
</tr>
<tr>
<td>Static sitting balance</td>
<td>0.83</td>
</tr>
<tr>
<td>Selective movement control</td>
<td>0.86</td>
</tr>
<tr>
<td>Dynamic reaching</td>
<td>0.81</td>
</tr>
</tbody>
</table>
### Results – construct validity

<table>
<thead>
<tr>
<th>TCMS</th>
<th>Dim A (lying)</th>
<th>Dim B (sitting)</th>
<th>Dim C (crawling)</th>
<th>Dim D (standing)</th>
<th>Dim E (walking/jumping)</th>
<th>GMFM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>0.88</td>
<td>0.25</td>
<td>0.67</td>
<td>0.77</td>
<td>0.85</td>
<td>0.89</td>
</tr>
</tbody>
</table>

#### Evidence for construct validity

- **Selective movement control**
  - Median: 0.86
  - IQR: 0.25

- **Dynamic reaching**
  - Median: 0.81
  - IQR: 0.37

### Results – discriminative ability

<table>
<thead>
<tr>
<th></th>
<th>CP Median (IQR)</th>
<th>TD Median (IQR)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total TCMS</strong></td>
<td>33.5 (25-42)</td>
<td>53.5 (51-57)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Static sitting balance</strong></td>
<td>17 (16-18)</td>
<td>20 (20-20)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Selective movement control</strong></td>
<td>13 (10-16)</td>
<td>24 (22-27)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Dynamic reaching</strong></td>
<td>4 (1-9)</td>
<td>10 (10-10)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

### Aim

**Study 2**

**Clinical characteristics of impaired trunk control in children with spastic cerebral palsy**

### Methods

Study 3

![Images of participants]  
- N=38  
- N=46  
- N=16  
- N=47  
- N=28  
- N=16  
- N=9

### Results – topography

#### Study 2

<table>
<thead>
<tr>
<th>TCMS (range)</th>
<th>Hemiplegia med (IQR)</th>
<th>Diplegia med (IQR)</th>
<th>Quadriplegia med (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total TCMS</td>
<td>44.5 (37-50)</td>
<td>40 (30-46)</td>
<td>13.5 (9-21.5)</td>
</tr>
<tr>
<td>Static sitting balance</td>
<td>18 (18-20)</td>
<td>18 (16-20)</td>
<td>8 (5-11.5)</td>
</tr>
<tr>
<td>Selective movement control</td>
<td>5 (2-8)</td>
<td>1 (0-3.5)</td>
<td></td>
</tr>
<tr>
<td>Dynamic reaching</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Study 3

<table>
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<tr>
<th>TCMS (range)</th>
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<td>Selective movement control</td>
<td>5 (2-8)</td>
<td>1 (0-3.5)</td>
<td></td>
</tr>
<tr>
<td>Dynamic reaching</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results – GMFCS levels

<table>
<thead>
<tr>
<th>TCMS (range)</th>
<th>Level I</th>
<th>Level II</th>
<th>Level III</th>
<th>Level IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCMS (0–58)</td>
<td>med (IQR)</td>
<td>med (IQR)</td>
<td>med (IQR)</td>
<td>med (IQR)</td>
</tr>
<tr>
<td>Static sitting balance</td>
<td>0–20</td>
<td>18–20</td>
<td>16–18.5</td>
<td>9–16</td>
</tr>
<tr>
<td>Selective movement</td>
<td>0–28</td>
<td>16–22</td>
<td>13–18.5</td>
<td>7.5–10</td>
</tr>
<tr>
<td>Dynamic reaching</td>
<td>0–10</td>
<td>6–10</td>
<td>2.5–8</td>
<td>0.5–2</td>
</tr>
</tbody>
</table>

Part 3: Assessment of TCMS

- Sitting without back, arm or feet support
  - Thighs in full contact with table
  - Hands rest on the legs, close to the body
- No shoes, orthoses, or braces
  - Light hand braces are allowed

Psychometric properties of TCMS

- Inter-rater & test-retest reliability
- Construct validity
- Discriminative ability
- Responsiveness to change?
General instructions

- Upright sitting at the start + during performance
- Each item is performed three times
  - BEST performance counts
- Bilateral / left & right scores
- Indicate compensations on score sheet

Static sitting balance

- Testing procedure
  - Verbal explanation
  - Demonstration if needed (items 2, 4 and 5)
  - ‘keep your trunk as stable as possible’

Dynamic sitting balance

- Selective movement control
- Dynamic reaching

Dynamic sitting balance

- Selective movement control
- Dynamic reaching
Selective movement control

- Testing procedure
  1. Verbal explanation & demonstration of tester
  2. Demonstration on patient with manual guidance
  3. Patient performs under (manual) guidance of tester
  4. ACTUAL PERFORMANCE – three attempts
     - BEST performance counts
     - After each attempt: feedback on performance

Dynamic sitting balance

- Selective movement control

Dynamic reaching

- Reaching distance
  - Forearm length (olecranon -> proc styloideus)
    - Left & right

- Testing procedure
  - Verbal explanation
  - Three attempts (each side for items 14 and 15)
  - Arms as straight as possible to determine reaching distance
Thank you for your attention