METHODS FOR 3D UPPER EXTREMITY MOTION ANALYSIS & CLINICALLY AVAILABLE DATA ANALYSIS TOOLS

Ellen Jaspers, PT, PhD
Cristina Simon-Martinez, MSc, PhD candidate
Disclosure Information
AACPDM 71st Annual Meeting | September 13-16, 2017

Speaker Name:
Ellen Jaspers, Cristina Simon-Martinez

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

Disclosure of Off-Label and/or investigative uses:
We will not discuss off label use and/or investigational use in any of our presentations.
FLOWCHART

1. Data acquisition
2. Data analysis
3. Data interpretation
4. Clinical application
1. Data acquisition

**SUBJECT PREPARATION - MARKER PLACEMENT**

- Minimum 3 markers / segment

**NOT JOINT MOVEMENT**

- Calibration procedure (CAST)
  
  Link anatomical landmarks to segments

**MEASUREMENT OF JOINT MOVEMENT**

- Data acquisition (movement protocol)

*Wu et al., ISB recommendations for upper extremity motion analysis, J. Biomech 2005*

*Capazzo et al., CAST procedure, J. Biomech 1995*
MOVEMENT PROTOCOL

- Reach tasks (different directions)
  - forwards
  - sideways
  - upwards

- Reach to grasp tasks (different object orientation)
  - little ball
  - vertical cylinder

- Gross motor tasks (ADL related)
  - hand to mouth
  - hand to head
  - hand to contralateral shoulder

Protocol as currently applied in the Clinical Motion Analysis Laboratory of the University Hospital Pellenberg, Leuven, Belgium

Jaspers et al. Gait Posture 2011;33:568-575
CHALLENGES

• Standardization of set up
• Palpation of anatomical landmarks of interest
• Marker visibility
2. Data analysis

CLINICAL TOOLS

• None provided by different commercially available gait analysis tools
• Upper Limb Evaluation in Motion Analysis (U.L.E.M.A.)
  • Open source software (GitHub)
  • Matlab based
  • Windows compatible

https://github.com/u0078867/ulema-ul-analyzer
3. Data interpretation

**UPPER LIMB ANGLES**

**TRUNK**
- lateral bending
- rotation
- posterior
- anterior
- extension
- flexion
- heterolateral
- homolateral

**SCAPULA**
- protraction
- retraction
- lateral
- medial
- posterior
- anterior
- elevation

**SHOULDER**
- elevation plane
- sagittal plane
- frontal plane
- elevation
- internal
- external
- 0°
- 45°
- 90°
- 135°

**ELBOW**
- flexion
- extension
- pronation
- supination

**WRIST**
- extension
- flexion
- radial deviation
- ulnar deviation

*Elevation = negative angle*

Pearl et al. 1992

GCMAS SYMPOSIUM 2017
UPPER LIMB REPORTS

Fig. 3 from “Maileux L, Simon-Martinez C, Feys H, Jaspers E. Upper Extremity Movement Pathology in Functional Tasks. Handbook on Human Motion. Springer 2017”
UPPER LIMB SUMMARY SCORE

Reference data
Child with uCP

RMS differences (degrees)

INFORMATION ON AMOUNT OF MOVEMENT PATHOLOGY

NO INFORMATION ON DIRECTION OF MOVEMENT PATHOLOGY

NO INFORMATION WHEN IN CYCLE THE PATHOLOGY IS MOST PRONOUNCED

Jaspers et al. Gait Posture
2011;34:227-33
• Multiple tasks
• Multiple joint angles
• Dependency of joint angles
NEW TOOLS - SPM

Statistical Parametric Mapping 1d

1. Allows hypothesis testing over the entire spectrum
2. Reduces chances of incorrectly rejecting the null-hypothesis

- Open source software (GitHub)
- Matlab based
- Windows compatible

4. Clinical application

**Patient information**

- Boy, 14y7m
- Left hemiplegia
- MACS II
- MAS score elbow pronators 2, elbow flexors 1

**BTX intervention**

- 160 U Pronator Teres
- 40 U Pronator Quadratus
- No adverse events

<table>
<thead>
<tr>
<th>EVALUATION PRE (4m) AND POST (60d) BTX</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical evaluation</strong></td>
</tr>
<tr>
<td>• ROM, spasticity (MAS), muscle strength (MRC, grip strength)</td>
</tr>
<tr>
<td><strong>UL-3DMA</strong></td>
</tr>
<tr>
<td>• Reach to grasp a vertically oriented object</td>
</tr>
<tr>
<td>• Spatiotemporal parameters</td>
</tr>
<tr>
<td>• Movement pathology (A-MAP)</td>
</tr>
</tbody>
</table>
# PRE-POST BTX COMPARISON

## Passive Range of Motion (degrees)

<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elbow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Extension</td>
<td>-5</td>
<td>0</td>
</tr>
<tr>
<td>Supination</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>Pronation</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td><strong>Wrist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>Extension</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

## Spasticity (MAS scores)

<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elbow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Extensors</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pronators</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Wrist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Extensors</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Fingers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Extensors</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thumb</td>
<td>1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

## Muscle (MRC) & Grip Strength (ratio, %)

<table>
<thead>
<tr>
<th></th>
<th>PRE</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elbow</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Extensors</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Pronators</td>
<td>2.5</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Wrist</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexors</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Extensors</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Grip strength</strong></td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

- ↑ ROM elbow supination
- ↓ spasticity elbow & wrist flexors, elbow pronators
- ↓ strength elbow pronators
- ↓ grip strength
## PRE-POST BTX COMPARISON

<table>
<thead>
<tr>
<th>SPATIOTEMPORAL PARAMETERS</th>
<th>PRE</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (sec)</td>
<td>1.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Speed (cm/sec)</td>
<td>815</td>
<td>778</td>
</tr>
<tr>
<td>Index of curvature</td>
<td>1.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Time at Vmax (% cycle)</td>
<td>29</td>
<td>18</td>
</tr>
</tbody>
</table>

Slower and less straight movement trajectory post BTX
PRE-POST BTX COMPARISON

MOVEMENT PATHOLOGY (A-MAP)

↓ MOVEMENT PATHOLOGY

- TOTAL movement pathology (APS)
- Elbow flexion-extension
- Elbow pro-supination
- Shoulder elevation plane
- Shoulder rotation
PRE-POST BTX COMPARISON

SUMMARY – BTX-A TREATMENT IN ELBOW PRONATORS

- ↑ ROM elbow supination
- ↓ spasticity elbow & wrist flexors, elbow pronators
- ↓ strength elbow supinators
- ↓ grip strength

↓ total movement pathology
- Improved elbow movement pattern
- Improved shoulder movement pattern

Slower and less straight movement trajectory