Quantitative techniques for assessment of upper extremity movement dysfunction

Overview and Objectives

Opportunities

- Clinical assessments
- Activity monitoring
- Kinematics and biomechanics
- Muscle function
- Functional activities
- Cortical activity

Challenges

- Non-cyclical movement
- Many degrees of freedom
- Complex movements
- Large envelope of motion
- No/few standardized protocols
- Clinical Applications?

Need for Standardization

Definition and description of protocols

- Segments of interest – shoulder, elbow, wrist, forearm, hand, thumb
- Coordinate systems
- Marker set-up (Carpinella 2006, Baker 2007)
- Functional movements and activities

Motion Capture Techniques

- 2-D – video capture (Dartfish), electrogoniometry
- 3-D
  - Electromagnetic systems
  - passive marker,
Aviva Wolff, EdD, OTR, CHT  

AACPD Annual Meeting, Montreal 2017

- video/digital based,
- markerless
- cyberglove
- Inertial Sensors/IMUs
- Markerless motion capture

- **EMG** – static vs dynamic, surface vs fine wire

**Purpose**

1. **Clinical Applications**
   - Inform pre-operative surgery
   - Document baseline/progress
   - Measure effect of therapeutic/surgical intervention  
     a. CP hand and UE  
     b. Congenital BP  
     c. Congenital hand anomalies  
     d. Tetaplegia
   - Kinematics of reach to grasp  
     o Phases of reach – reach, grasp, transport, release  
     o Grasp – aperture, hand shaping to object shape/size
   - Measures of muscle stiffness  
     o Shear-wave ultrasound elastography  
     o Neuroflexor
   - Cortical measures of hand function – measures of neuroplasticity  
     o Transcranial magnetic stimulation (TMS)  
     o Diffuser tensor imaging (DTI)  
     o EEG

2. **Research**

Provide quantitative kinematic/kinetic/muscle/cortical data for variety of biomechanical and clinical questions

- Baseline measures
- Measure change over time  
  o Effects of intervention  
  o Natural progression

**Some examples:**

**CP reach and grasp**

- Pediatric Upper Limb Motion Index -PULMI *(Butler, 2009)*
- Arm Profile Score -APS *(Jaspers, 2011)*
• ULEMA, A-MAP, SPM1d-analysis (Pataki, 2010)

Relationship between upper extremity posture and gait

• Upper Limb Deficits during Gait in CP
  a. Decreased elbow and shoulder ROM in hCP with increased elbow flexion (Riad 2011),
  b. Decreased arm swing in CP (Meyns 2011).

• Improvement in lower limb kinematics following UE limb improvements
  a. in adult hemiplegia
    i. Botox – increased gait speed, (Esquenazi, 2008)
    ii. increased stride time, (Hirsch 2005)
  b. In CP
    i. CIMT (Coker, 2010)

• Clinical correlation between changes in arm posture and gait asymmetry
  a. stroke – increased muscle activity with decreased arm movement (Stephenson 2010)

• No change in upper limb with ankle foot orthosis in CP (Schweizer, 2014)

• Simulated stiff elbow study (Trehan, 2014)
  a. Decreased velocity in stiff elbow conditions
  b. Increased stride length

References


Kuhtz-Buschbeck JP, Jing B. Activity of upper limb muscles during human walking. J.Electromyogr.Kinesiol. 2012 Apr;22(2)


