Joint Morphogenesis in Brachial Plexus Birth Palsy:
A Proposed Computational Model

Rehab Researchers 2015 Summer Series

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• A model serves as a way to generate a **predicted outcome**.
• **Real-world model:** Stryker Hip Navigation Software
• **Desired outcome:** Acetabular ream depth for **optimal** hip cup placement

Stryker 2009 Lit. # 9100-001-279
• BPBP can severely limit a child’s quality of life during development and into adult years
• Altered muscle forces → changes in bone growth
• Example: Scapular winging

Terzis et al. 2014
Upper extremity overview

http://droualb.faculty.mjc.edu
**Current computational modeling techniques (Taylor et al. 2007)**

1) **Hypothesis:**
Bone growth in the humerus responds to functional adaptation.

2) **Model:**
Musculoskeletal model + finite element model

3) **Predicted Outcome:**
Changes in bone mass density

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1) Functionally relevant parameters, data collection technique

2) Loads, boundary conditions, geometry, material properties

3) Iteratively evaluate model and refine as needed
Additional perspective of joint morphogenesis (Giorgi et al. 2014)

<table>
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<tr>
<th>Biological contribution of growth (e.g. bone remodeling process)</th>
<th>Biological + mechanical contribution of growth (internally and externally applied loads)</th>
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- Adaptive growth based on orthonormal thermal capabilities (isotropic)
Proposed approach and discussion questions

- **Clinical challenge addressed:** Target critical factors that negatively affect bone development.
- **Hypothesis:** Localized changes in bone development of the glenohumeral joint occur with disuse.

1) **Rat model + microCT:** Functionally relevant parameters, data collection technique

2) **OpenSim + Abaqus:** Loads, boundary conditions, geometry, material properties + Finite Element Model (microCT scapula and/or humerus)

3) **Predicted outcome:** Iteratively evaluate model and refine as needed

- **Q1:** How can I discretize/quantify biological contributions of growth?
- **Q2:** Are there advantages to dynamically modifying mechanical contributions from muscle forces?
- **Q3:** What are the key parameters to develop and validate the proposed model?
- **Q4:** Can we identify critical factors from the proposed model that yield clinically relevant information?