Shoulder Muscle Atrophy and its Relation to Strength in Children with Obstetrical Brachial Plexus Palsy

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Introduction
- Obstetrical brachial plexus palsy (OBPP) has an incidence rate up to 5.1/1000. In 34% of the cases, long term disability remains.
- The partial denervation of the shoulder muscles in OBPP induces a complex profile of muscle atrophy and force imbalances between agonist and antagonist muscle pairs.
- Treatment and prevention of shoulder muscle strength imbalances are major therapeutic goals.

Objectives
- To evaluate the degree of atrophy of the gleno-humeral muscles and quantify changes in agonist-antagonist muscle volume balance.
- To quantify the relation between these volumes and the maximum voluntary isometric joint moment they produce in three degrees of freedom.

Methods
- 12 children and adolescents with unilateral OBPP (mean age=12.43 years, median Narakas score=2) were enrolled in this ethically approved case-controlled study.
- 3D magnetic resonance images of both shoulders were acquired, the unimpaired shoulder serving as a reference.

Results

Reliability
- The inter-rater reliability for quantifying muscle volumes was excellent (ICC=0.962-0.999).

![Figure 3: Inter-observer reliability of muscle volume measurement](image)

Gleno-humeral muscle atrophy in children with OBPP
- All the main movers of the gleno-humeral joint were significantly atrophied. The PM and deltoid were the least affected and the TM, supraspinatus, and subscapularis muscles the most affected.

Muscle imbalance
- The varying degrees of muscle atrophy led to significant changes in antagonist/agonist volume ratios for external/internal rotation (transverse plane imbalance), extension/flexion (sagittal plane imbalance), and ab/adduction (frontal plane imbalance).

![Figure 4: Trophicity of the gleno-humeral muscles in the impaired shoulders expressed as a percentage of the unimpaired shoulders trophicity](image)

Muscle-volume-torque relationship
- Coefficients of determination (R²) between muscle volume and strength were weaker on the impaired side than on the unimpaired side, and no significant relation was found in external rotation.

<table>
<thead>
<tr>
<th>Torque Direction</th>
<th>Muscles</th>
<th>Impaired</th>
<th>Unimpaired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexion</td>
<td>Ant deltoid</td>
<td>0.94</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>Supraspinatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td></td>
<td></td>
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<tr>
<td>Extension</td>
<td>Post deltoid</td>
<td>0.86</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>TM</td>
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<tr>
<td>Abduction</td>
<td>Supraspinatus</td>
<td>0.59</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Total deltoid</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>I-tm</td>
<td></td>
<td></td>
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<tr>
<td>Adduction</td>
<td>PM</td>
<td>0.76</td>
<td>0.90</td>
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<td></td>
<td>Subscapularis</td>
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<tr>
<td>Internal rotation</td>
<td>Subscapularis</td>
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<td>0.86</td>
</tr>
<tr>
<td></td>
<td>External rotation</td>
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<td>0.95</td>
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</tbody>
</table>

Table 1: Adjusted R² values for muscle-volume-torque relationship

Discussion

Gleno-humeral muscle trophicity in children with OBPP
- All muscles were more atrophied than in previous studies.
  1, 2, 3, 4, 5, 6.
- The 3D models took into account the whole volume and geometrical complexity of the shoulder muscles.
- The children were older than in previous studies.
- This highlights the involvement of all the main movers of the shoulder in OBPP. Thus, future clinical and research studies should consider the complete set of shoulder muscles.
- Since the pectoralis major was well preserved, it is a major attractive target in rehabilitative and surgical strategies.

Three-dimensional imbalance
- It is likely these three plane imbalances play a key role in shoulder dysfunction and the gleno-humeral deformity genesis.
- There is a greater volume imbalance in the sagittal plane than in the other planes, which has been neglected in previous studies.
- 3D imbalances in children with residual strength have to be evaluated and targeted in order to prevent gleno-humeral deformities.

Muscle-volume-torque relationship
- The weaker association between muscle volume and strength in the impaired side suggests that other variables, in addition to atrophy, may contribute to the loss of strength, especially in external rotation.

References