Medial gastrocnemius muscle volume in ambulant children with unilateral and bilateral cerebral palsy aged 2-9 years

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Background:

The calf is an important group of muscles for vertical support and forward propulsion during walking. The calf is commonly impaired in children with cerebral palsy (CP) and receives the focus of treatments such as botulinum toxin, surgery, and physiotherapy.

In ambulant children with CP the volume of the impaired calf muscle is reduced by 22-60%1-3 compared to typically developing (TD) peers with the difference in volume already present by the age of 2-5 years.3 Calf muscle volume increases linearly with age in children with CP and TD children however the muscle volume in children with CP increases less with age.4 One longitudinal study describing lower limb muscle growth in pre-school age children with CP has shown that the growth of the medial gastrocnemius (MG) across 12 months was 0.34ml/month versus TD 0.90 ml/month.3 Calf muscle growth in children with unilateral (UCP) and bilateral cerebral palsy (BCP) is unknown.

Aim:

1. To determine whether ambulatory children with UCP and BCP aged 2-9 years had different MG muscle growth rates.
2. To determine whether growth rates of the CP children were different to a group of TD.

Methods:

In 50 UCP, 50 BCP and 78 TD children freehand 3D ultrasound was used to image the MG muscle of the most impaired lower limb in the children with CP and the right lower limb in the TD children. (Figure 1). The mean volume of three separate scans was recorded.

A linear regression was used to determine the relationship between age and MG muscle volume. The slope of the regression line was defined as the muscle growth rate in ml/month. The equality of slopes across groups was tested using a generalized linear model, p<0.05.

Results:

The MG muscle growth rate in children with UCP was 0.17ml/month, BCP 0.48ml/month and TD children 0.73ml/month. The growth rate of the UCP group was significantly less than the BCP and TD groups. The slope for BCP and TD were not significantly different but were offset.

Conclusion:

Reduced muscle growth in children with UCP may be the result of learned behavioural suppression of loading of the impaired lower limb and overcompensation by the unimpaired limb during weight bearing activities of daily living.


Table 1. Participant characteristics. Mean±SD. Significant difference to TD group *p<0.05, **p=0.001.

<table>
<thead>
<tr>
<th></th>
<th>UCP (N=50)</th>
<th>BCP (N=50)</th>
<th>TD (N=78)</th>
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</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>66±18</td>
<td>64±19</td>
<td>64±16</td>
</tr>
<tr>
<td>GMFCS (I/II)</td>
<td>32/18</td>
<td>21/29</td>
<td>-</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>18.4±3.9</td>
<td>17.9±3.8*</td>
<td>19.8±4.3</td>
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<tr>
<td>Height (cm)</td>
<td>103.0±11.9*</td>
<td>104.1±10.6</td>
<td>108.8±12.1</td>
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<td>Fibula length (cm)</td>
<td>21.2±3.6</td>
<td>20.5±3.4*</td>
<td>22.3±3.4</td>
</tr>
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<td>Ankle MDF (deg)</td>
<td>1.1±11.5**</td>
<td>1.2±12.1**</td>
<td>25.5±4.1</td>
</tr>
</tbody>
</table>

Treatment History: 12 UCP and 13 BCP children had received no lower limb BoNT-A treatments. 38 UCP and 37 BCP children had received mean 3.1±1.5 and 3.0±1.4 previous BoNT-A treatments to the calf and/or hamstring (6-14 U/kg Bwt, 100U/1-2ml). Participants may have received physiotherapy, casting and/or orthoses treatment.

Figure 1. Freehand 3DUS integrates B-mode ultrasound and 3D motion capture enabling each frame of the ultrasound scan to be positioned in 3D space. When scanning the MG muscle, the cross-section of the muscle within each frame can be segmented to create a rendered 3D image for volume measurement.

Figure 2. Child age (months) versus MG muscle volume (ml). UCP (blue), BCP (red) and TD (black) with regression lines. Regression equations: UCP MG volume = 15.81 + 0.17*age, r²=0.14; BCP MG volume = -0.45 + 0.48*age, r²=0.34 and TD MG volume = 1.14 + 0.73*age, r²=0.45.

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