ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

Bilateral shoulder strength profiles in children with brachial plexus palsy and typically developing children

[1,2,3] Sylvain Brochard, [1]Katharine Alter, [1]Lindsey Curatalo and [1]Diane Damiano

[1] Rehabilitation medicine department, Clinical center, NIH, Bethesda, MD, USA
[2] Rehabilitation medicine department, University Hospital of Brest, France
[3] LaTIM INSERM U1101, Brest, France
Email: sylvain.brochard@chu-brest.fr

SUMMARY

The aim of this study was to report and compare the shoulder strength and imbalance profiles of the non-dominant and dominant shoulder in children with brachial plexus palsy (BPP) and typically developing (TD) children. In 15 children and adolescents with unilateral BPP and 11 controls, the bilateral maximal isometric shoulder strength was recorded using a hand held dynamometer in flexion/extension, internal/external rotation, and abd/adduction. Shoulder strength asymmetry in children with BPP was larger than in TD children. Asymmetry was due to a global weakness of impaired shoulders but also to a significant increase of strength in the dominant side in children with BPP. The two main affected directions were extension and external rotation with significant consequences in term of strength imbalance in external/internal and extension/flexion directions. Multidirectional assessment of shoulder strength provides an individualized evaluation of shoulder profiles and dysfunction. Coupled to our findings in TD children this may help in targeting a "normal" shoulder strength profile which might prevent for gleno-humeral deformities in children with BPP.

INTRODUCTION

In children with brachial plexus palsy (BPP), the involvement of different nerve roots at birth and the varying degrees of recovery after birth may induce a complex profile of muscle weakness in the upper-limb. During growth persistent shoulder muscle weakness and imbalance contributes to muscle contracture and shoulder joint deformity [1]. Although they are central to the understanding of shoulder function and the pathogenesis of joint deformity weakness and imbalance are rarely reported in this population [2]. A comprehensive assessment of the shoulder strength profiles in children with brachial plexus palsy would provide a better understanding of shoulder dysfunction and may help in targeting muscles groups for treatments which aimed at preventing joint deformity or enhancing function. The primary aim of this study was to report and compare the shoulder strength and imbalance profiles of the non-dominant and dominant shoulder of children with BPP and typically developing (TD) children (within and between population comparisons). Our central hypothesis was that muscle strength in all three planes of motion on the non-dominant shoulder of children with BPP would be weaker than those on the other shoulders with the greatest difference seen in the direction of external rotation, as based on the literature [2].

METHODS

Fifteen children and adolescents with unilateral BPP (mean age=11.19, SD=3.66) were recruited. Eleven controls within the same age range were enrolled (mean age=11.08, SD=2.65). No statistically significant differences were found between the two samples for age, height, body mass and body mass index. Strength was recorded using a hand held dynamometer (JTech Commander PowerTrack II Muscle Dynamometer). In order to improve consistency between trials, sides and children, the following items were standardized: (1) Position of the observer, hand held dynamometer and the child for each direction assessed (2) order of the muscle test, (3) verbal encouragement. The same observer carried out all the assessments which has been shown to improve reliability of the assessment [3]. After a time of familiarization with the set-up and warm up, the children laid on an examination bed in order to minimize trunk compensation. For all tasks the children were asked to push "as hard as you can" without moving the elbow and using their shoulder as much as possible. In order to prevent any upper-arm compensation movement a strap was used around the trunk and the lower part of the upper-arm maintaining the elbow close to the body during the internal/external rotation assessment.

Every child underwent 3 trials of a maximal isometric contraction of 3 seconds in flexion/extension, internal/external rotation, and abd/adduction of both shoulders. The 3 trials in each direction were recorded in Newtons (N). This force was multiplied by the distance between the posterior acromion and the lateral epicondyle for flexion, abduction, adduction and extension to obtain a moment in Nm. For external and internal rotation, the force was multiplied by the distance between the lateral epicondyle and the radial styloid. In order to decrease the bias of the Mass for the between population comparison moment values were normalized by the Mass of the child (Kg). For the purpose of comparison the maximal value of the 3 trials were used.

A signed rank Wilcoxon paired test was used to test between sides comparisons and a Mann Whitney U test was used to compare children with BPP and TD children. The level of significance was set at $p<0.05$.

RESULTS AND DISCUSSION

In children with BPP, muscles in the non-dominant shoulders showed significantly less strength than muscles of the dominant shoulders in all directions (Table 1). Extension and external rotation were the weakest directions showing mean percentage between both shoulders (non dominant shoulder over dominant shoulder) of 23.51% (p=0.001) and 27.23% (p=0.001). Flexion and abduction were the strongest directions showing values of 69.23% (p=0.009) and 65.51% (p=0.001) respectively. In TD children there were also significant differences in flexion and abduction with mean percentage between both shoulders (non dominant shoulder over dominant shoulder) of 89.81% (p=0.041) and 91.80% (p=0.017), however other directions were not different between sides.

In all directions agonist/antagonist strength ratios (e.g extension over flexion) between the non-dominant and dominant shoulders in TD children were similar whereas significant differences appeared in extension/flexion and external/internal rotation ratios in the impaired shoulder of children with BPP (Figure 1). The ratio of extension over flexion strength for the non-dominant shoulder of children with BPP was 29.38% which was significantly lower than the ratio of the non-dominant shoulder of TD children (85.37%, p=0.001). The ratio of external rotation over internal rotation strength for the non-dominant shoulder of children with BPP was 45.5% which was significantly lower than the non-dominant shoulder of the TD children (76.81%, p=0.001).

Shoulder strength of the dominant sides of children with BPP showed higher mean value than strength of the shoulder of the dominant side of TD children (% of BPP over TD of 120% to 147.62% depending on directions). Noticeably strength in adduction was significantly higher than children with TD (+147.62%, p=0.021).

CONCLUSIONS

This study shows that shoulder strength asymmetry in children with BPP is larger than in TD children. This significant asymmetry is due to an overall weakness of the impaired shoulder but also to a significant increase of the strength in the dominant side in children with BPP. The two main affected directions were extension and external rotation with consequences in term of strength imbalance in external/internal and extension/flexion directions. Further studies may correlate weakness and imbalance to gleno-humeral deformities. However multidirectional assessment of shoulder strength provides an individualized evaluation of shoulder profiles and dysfunction. Coupled to our findings in TD children this may help in targeting a "normal" shoulder strength balance in children with BPP which might prevent for gleno-humeral deformities in children with BPP.

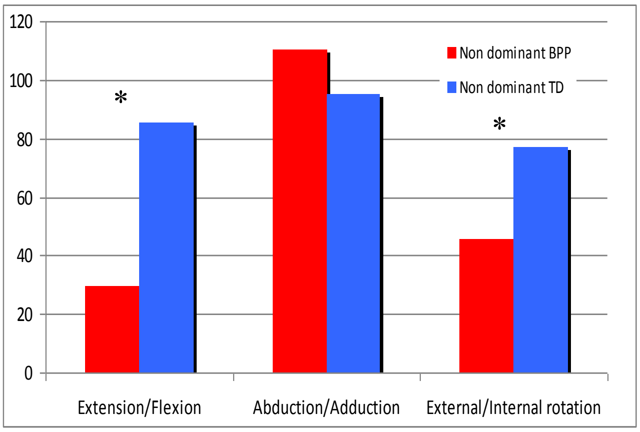

Figure 1: Ratios between agonist and antagonist muscles in non-dominant shoulder of TD children (Dark red) and children with BPP (light blue). (Extension over flexion, abduction over adduction and external rotation over internal rotation). * = $p<0.05$.

ACKNOWLEDGEMENTS

Sylvain Brochard was granted by the University Hospital of Brest, the French Society of Physical Medicine and Rehabilitation (SOFMER), the French Society of Research in Children with Disabilities (SFERHE) and the National Institutes of Health, USA (NIH).

REFERENCES

1.Waters PM, et al., *J Bone Joint Surg Am*. **91**:2367-75, 2009.
2.Kirvajeinen MO, et al., *Acta Orthop*. **82**: 69-75, 2011.
3. Eek MN, et al. *Arch Phys Med Rehabil*. **87**:1091-9, 2006.

Table 1: Strength asymmetry in children with BPP and TD children. SD=Standard deviation, Nm=newton.meters

	BPP						**TD**					
	Dominant		**Non dominant**		**Mean ratio** (%)	*p*	**Dominant**		**Non dominant**		**Mean ratio** (%)	*p*
	Mean (Nm/kg)	SD	Mean (Nm/kg)	SD			Mean (Nm/kg)	SD	Mean (Nm/kg)	SD		
Flexion	0.64	0.33	0.45	0.37	**69.23**	**0.009**	0.49	0.17	0.42	0.12	**89.81**	**0.041**
Extension	0.48	0.21	0.12	0.17	**23.51**	**0.001**	0.39	0.09	0.35	0.12	89.07	0.062
Abduction	0.59	0.27	0.36	0.17	**65.51**	**0.001**	0.49	0.09	0.44	0.14	**91.80**	**0.017**
Adduction	0.62	0.29	0.35	0.21	**58.57**	**0.001**	0.42	0.09	0.39	0.09	93.64	0.286
Internal Rotation	0.45	0.25	0.25	0.27	**51.46**	**0.001**	0.33	0.13	0.32	0.11	100.23	0.79
External Rotation	0.31	0.12	0.08	0.06	**27.23**	**0.001**	0.24	0.06	0.23	0.04	97.76	0.374