BICEPS-TRICEPS ACTIVATION DURING REACHING TASKS THAT REQUIRE FOREARM SUPINATION IN PATIENTS WITH CEREBRAL PALSY COMPARED TO HEALTHY CONTROLS: PRELIMINARY RESULTS

1Marije de Bruin, 1Michiel Kreulen, 1Mark Smeulders, 2DirkJan Veeger, and 3 Sicco Bus
1Department of Plastic, Reconstructive and Hand Surgery, Academic Medical Center, Amsterdam, The Netherlands
2Research Institute MOVE, Faculty of Human Movement Sciences, VU University, Amsterdam, The Netherlands
3Department of Rehabilitation Medicine, Academic Medical Center, Amsterdam, The Netherlands
* Corresponding author: m.debruin@amc.uva.nl

SUMMARY
We aimed to describe the underlying compensatory movement mechanisms during a functional reaching and grasping task in patients with cerebral palsy (CP). Subjects were tested in a laboratory setting using an 8-camera Vicon 3D movement analysis system. Clusters of 9mm markers were placed on thorax, scapulae, upper arms, forearms and hands. Electromyographic signals of biceps and triceps of the affected arm in patients and the preferred arm in control subjects were measured during the tasks that provoke elbow extension and pronation (picking up a disk) or supination (picking up a glass). Patients showed higher variability in biceps-triceps activation ratio (AR) during reaching and grasping tasks than control subjects. There were no differences in AR within the groups. Results on EMG-data coupled to 3D-kinematic outcomes will be presented.

INTRODUCTION
Cerebral Palsy (CP) is a non-progressive neurological disorder, resulting in spasticity and contractures in several joints of the upper and lower extremities, which lead to poor gait and hand function. To compensate for the lack of available range of motion in the affected joints, patients integrate additional degrees of freedom in the movement strategy during reaching and grasping, such as trunk anteflexion and extrinsic forearm rotation [1,2]. To improve functional abilities in children with CP, various treatments exist, e.g. upper extremity surgery or botulin toxin injections. The choice for a certain intervention is often based upon assumptions regarding muscle characteristics and control. For instance, biceps overactivity or biceps shortening in patients with excessive elbow flexion is assumed to result from spastic control. In some cases, biceps could enforce compensatory movements during functional tasks yielding extreme elbow flexion. In these cases, primary focus of treatment should not be biceps itself, but the underlying deformity that induces the compensatory mechanisms. We hypothesized that the pronation deformity in the wrist of CP patients is compensated by using the biceps for supination in addition to the supinator of the forearm. However, because the biceps is also a strong elbow flexor, we would expect the triceps to be activated to overcome the flexion moment and achieve extension of the elbow towards the object. To verify this assumption, we performed three-dimensional movement analysis and measured biceps-triceps co-contraction with the goal to gain a better understanding of the mechanisms underlying compensatory movements in the upper extremity during a reaching and grasping task.

METHODS
Patients with CP (n=10; mean age 14 years) and healthy control subjects (n=10; mean age 14 years) performed functional movement tasks that provoke elbow extension and pronation (picking up a disk) or supination (picking up a glass). Objects were placed at 1.5 forearm’s length in front of the subject. Patients could all actively extend the elbow to at least 130°. Subjects were tested in a laboratory setting using an 8-camera Vicon 3D movement analysis system. Clusters of 9mm markers were placed on thorax, scapulae, upper arms, forearms and hands. Local coordinate systems and segment rotations were defined according to the ISB standard proposal for the upper extremity [3]. Electromyographic signals of biceps and triceps of the affected arm in patients and the preferred arm in control subjects were measured during the tasks using a TeleMyo 2400R telemetric system (Noraxon) and using SENIAM as guideline for electrode placement [4]. EMG signals (sampling frequency 1000Hz) were preamplified, band-pass filtered (from 10 to 400Hz) and after that smoothed with a low-pass filter (5Hz). Biceps and triceps activation were used to calculate biceps-triceps activation ratio (AR) [5]. Signals were normalized to maximum voluntary contractions (MVCs) and subsequently used for calculation of biceps-triceps co-contraction index (CI) [6]. Outcomes of 3D-kinematic measurements will be coupled to EMG-data. EMG-data outcomes were compared between study groups (i.e. CP versus control) and within study groups (i.e. functional tasks with supination versus tasks with pronation) using the student’s t-test. Furthermore, joint angles during the functional tasks were related to EMG-data.

RESULTS AND DISCUSSION
Preliminary analyses showed increased elbow flexion during reaching and grasping tasks in CP patients when compared to control subjects. To reach the objects, patients compensated by flexing the trunk forward and laterally (i.e. extrinsic forearm rotation)[7], whereas control subjects perform the task using elbow flexion and forearm supination. As expected, within the patient group, reaching that required supination was performed with an elbow that was somewhat more flexed than...
was the case for reaching that required pronation. Overall, the elbow of patients was in flexion during the tasks although they achieved more extension during isolated flexion and extension of the elbow. Quantification of kinematic data will be presented.

Overall, t-tests showed no significant differences in AR or CI within and between groups (Figure 1). Triceps was not extensively recruited to extend the elbow and biceps did not seem to be recruited to enforce supination of the forearm. Apparently, patients do not try to overcome the pronation deformity intrinsically when objects are placed at reaching distance. When the object is moved closer to the patient, the alternative solution to supinate via compensatory movements seems more evident [8]. Conceivably, patients avoid the energy consuming and extension obstructing co-activation strategy until objects are within grasping distance.

The cause of the limited range of motion and extremely pronated forearm position in children with CP is unknown [7]. Pronator teres could be responsible for the increased pronation moment as a result of muscle contracture, or because of dysfunctional reflex activity during active supination. Biceps brachii has a high relative supination moment (based on moment arm and muscle physiological cross-sectional area) [7]. Therefore, biceps is likely to be recruited to overcome a high pronation moment in the forearm. However, the strong flexor function of the muscle causes simultaneous elbow flexion that obstructs reaching out to an object. The study results suggest that, instead of the expected high co-contraction of biceps and triceps to overcome pronation deformity and high flexion moment at the elbow, patients use compensatory trunk anteflexion and lateroflexion and humerus endorotation to reach the object. The high variability of AR within the patient group suggests that patients have various movement strategies (e.g. biceps activation versus postural compensation) to reach an object. It is plausible that these various strategies are correlated with the ratio of biceps-triceps-activation. These correlations will be presented. Apparently, patients do not use intrinsic compensation by means of biceps activation to try to enforce supination when they have to reach out to an object. The comparison of AR during the functional tasks and during isolated pro- and supination will be presented.

CONCLUSIONS

CP patients do not recruit the biceps to overcome insufficiency to supinate the forearm when objects are placed at a reaching distance in front of them. AR was not different between patients and controls. Furthermore, there was no difference in AR between the reaching that required supination and the reaching that required pronation. The lack of difference in AR and CI between patients and controls implies that, in the majority of our patients, biceps did not suffer from spastic control. This knowledge may help to improve surgical decision-making.

ACKNOWLEDGEMENTS

This study was conducted with financial support of the Phelps Foundation for Aid to Children with Spasticity.

REFERENCES