Analysis of gait in patients with cerebral palsy after treatment using inverse dynamic musculoskeletal models

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INTRODUCTION

Cerebral palsy (CP) is a lifelong developmental disorder of posture and movement due to non-progressive damage to the brain beginning in early childhood. Two common clinical therapeutic methods are botulinum toxin injection and surgery. So far, and although gait analysis is routine, the analysis of muscle forces for CP patients is not routinely carried out in clinical practice. The aim of this study was to assess whether treatments affect muscle forces during gait and what difference of muscle forces exist between the CP patients and non-CP children.

METHODS AND MATERIALS

This study used an inverse-dynamic musculoskeletal model to calculate nine muscle forces, joint range of motion (RoM) and joint range of moment in the lower limb of the CP children and age-matched non-CP children during gait. Vicon® Nexus software was employed to select the subjects who had good gait data from our clinical gait database. This study included two parts, 1) 28 children with CP and 27 non-CP children were used for group study, and 2) 5 CP children were used for case study. The nine muscles included in the musculoskeletal model were rectus femoris (RF), vastus (VS), hamstring (HA), gluteus (GU), soleus (SO), tibialis anterior (TA), iliacus (IL), gastrocnemius (GS), and biceps femoris (BS). The joint angles and moments and subject body measurements were input into the model to estimate muscle forces. Data collection was carried out in the our gait lab (Figure 1) and all data were collected by a senior clinical gait analyst.

Figure 1. Clinical gait analysis lab

RESULTS

The case study shows that: 1) the change of gait parameters varied from individual to individual after treatment; 2) botulinum toxin injection and surgery were both good at increasing the joint angle RoM and joint moment; 3) surgery was good at increasing the muscle force while injection reduced the muscle force. The study group showed that: 1) the muscle forces in the non-CP children group ranked the highest when compared with post-surgery and post-injection groups, e.g. the normal being 47% and 30% higher than post-surgery and post-injection in TA, and 35% and 20% higher than post-surgery and post-injection in BS; 2) the hip, knee and ankle joint RoM in post-surgery group were less than that in post-injection group, and the knee and ankle joint RoM in the non-CP children group ranked the highest; 3) the hip, knee and ankle joint moment in post-surgery group were less than that in post-injection group, and the hip and ankle joint moment in the non-CP children group ranked the highest, e.g. 30% and 16% higher than post-surgery and post-injection in the hip as in Figures 2-6.

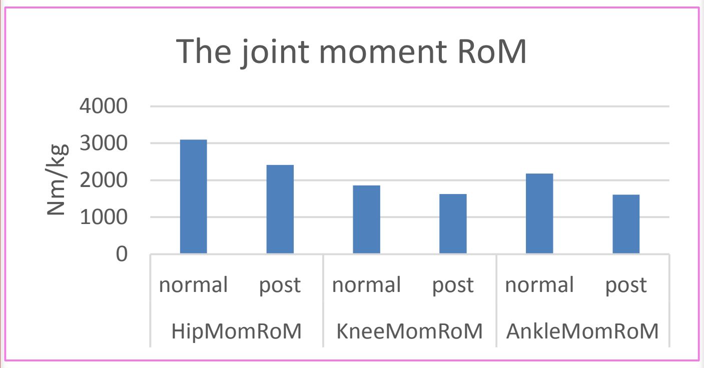

Figure 2. Joint moments comparsion

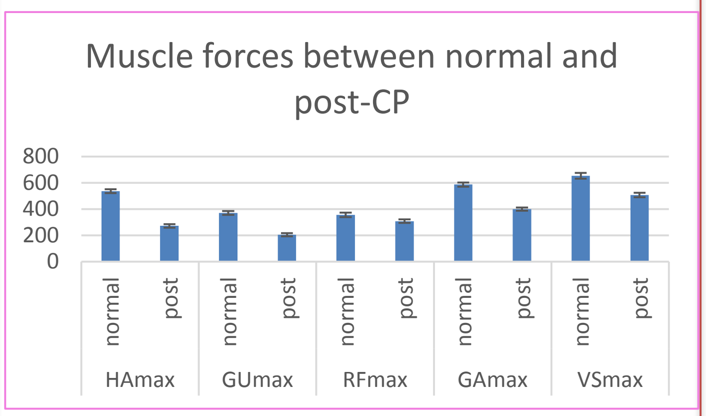

Figure 3. Max muscle force (N/kg)

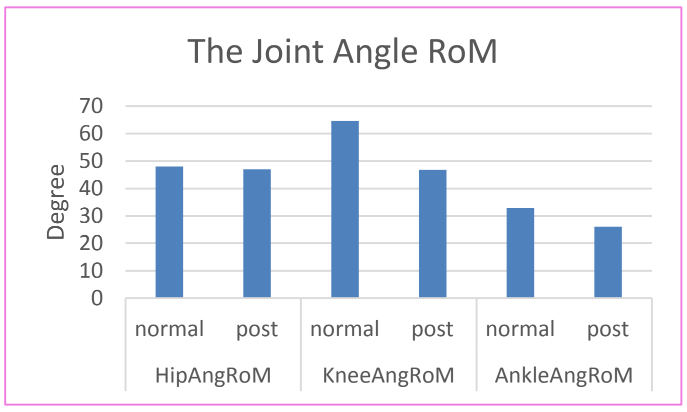

Figure 4. Comparsion of joint angles

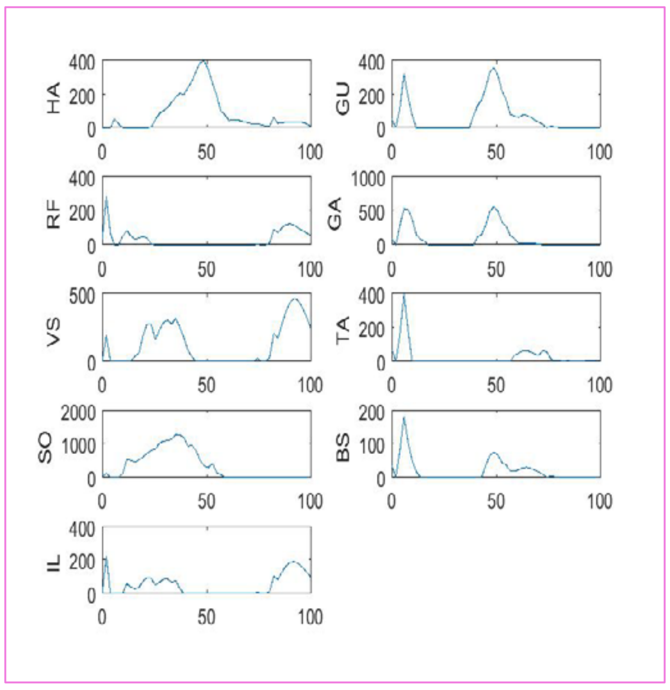

Figure 5. Musclee force after injection in CP

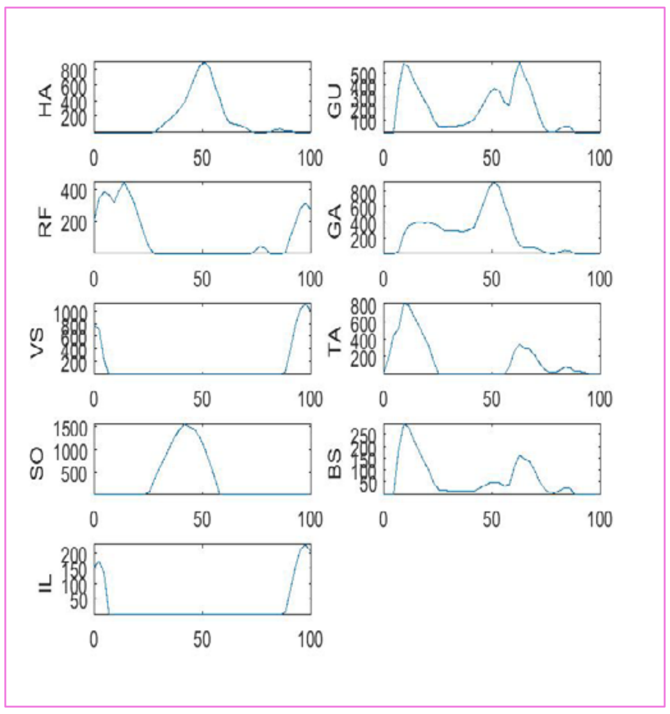

Figure 6. Muscle forces in normal subject

DISCUSSION

This pilot study indicates it is possible to apply inverse-dynamic musculoskeletal model in analysis of CP children. In the future, more CP subjects with pre- and post-treatment gait data should be investigated to confirm the initial results.

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