Subject Specific 3D Lower Limbs Muscle Reconstructions for Children with Cerebral Palsy

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Introduction

Cerebral Palsy (CP) results from a lesion in the immature brain. It results in abnormalities of muscle strength and tone (spasticity), and joint movement. Soft tissue treatments and surgeries concern in general botulinum toxin injection, muscle lengthening, tendon transfer, etc. Information on musculo-skeletal geometry is then necessary for surgery planning. 3D skeletal reconstructions for lower limbs are possible using stereoradiography technique [1]. The aim of this study is to assess specific subject 3D muscles reconstructions for children with CP.

Methods

MRI acquisitions were performed for 3 healthy children (9, 11 and 14 yo) and 1 CP patient (diplegic girl, 8 yo). Horizontal slices in T1on 3 tesla GE machine were provided from iliac spine to foot (thickness 4mm, gap 5mm). A specific technique [1], by selecting contours on few slices, was used to obtain subject specific 3D reconstructions in lying position of 19 muscles at left and right lower limbs: *maximus gluteus, medius and minimus gluteus, tensor fascia-lata, ilio-psoas, maximus adductor, longus and brevis adductor, semimembranosus, semitendinosus, gracilis, sartorius, biceps femoris longus, biceps femoris brevis, rectus femoris, vastus medialis, vastii intermedius lateralis, anterior tibial, lateral gastrocnemius, medial gastrocnemius and soleus.*

Volumes, Physiological Cross Sectional Areas (PCSA) and Lengths of muscles were calculated. Two operators had done the reconstructions to evaluate reproducibility of parameters.

Subject specific lower limbs bones reconstructions in 3D are provided for the same subjects using stereoradiography technique [2]. 3D muscle reconstructions in standing position were then obtained by applying elastic transformation on 3D muscles in lying position, based on anatomical landmarks both on stereo radiographic 3D reconstructions and MRI slices.

Muscles insertions areas are obtained on each reconstruction based on anatomical knowledge. Muscle-tendon length ratio is then calculated.

Results and Discussion

Subject specific 3D reconstructions of 19 muscles were obtained for each lower limb side. Volumes, PCSA and lengths were calculated. Loss of muscle volumes were found for the patient with CP especially for *adductors* (100cm^3 less than healthy subjects), *rectus femoris, vastii, gluteii, and soleus* (80cm^3 less than healthy subjects). Reproducibility was 8% (8.5cm^3) for volumes, 7% (1.8cm^2) for PCSA and 6% (1.7cm) for lengths.

MRI data combined with skeletal reconstructions allowed us to obtain 3D reconstructions of muscles in standing position. Muscle-tendon

length ratios were evaluated for the CP patient and showed shortened muscles and lengthened tendons for *soleus, maximus adductor and biceps femoris*.

Conclusions

Subject specific 3D muscles geometry can be obtained combining MRI and stereoradiography data. Muscle-tendon unit deficiencies and volume loss can be observed and quantified. The subject specific 3D approach combining gait analysis and musculo-skeletal reconstructions provides accurate data for clinicians and allows a better treatment decision making.

References

[1] Jolivet E. et al. (2008), Volumic patient-specific reconstruction of muscular system based on a reduced dataset of medical images, *CMBBE In Press*

[2] Assi A et al. (2007), Specific 3D Reconstruction for children lower limbs using a low dose biplanar X-Ray system. Reproducibility of clinical parameters for Cerebral Palsy patients. *SB 07, CMBBE, Vol 10, Supplement 1*.

Acknowledgments

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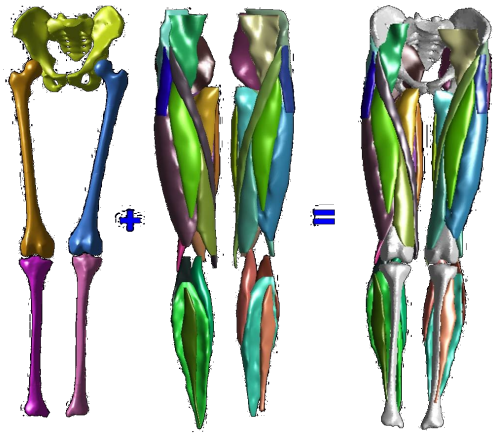

Figure 1: Specific subject 3D musculo-skeletal reconstruction for a healthy child (11 years old)

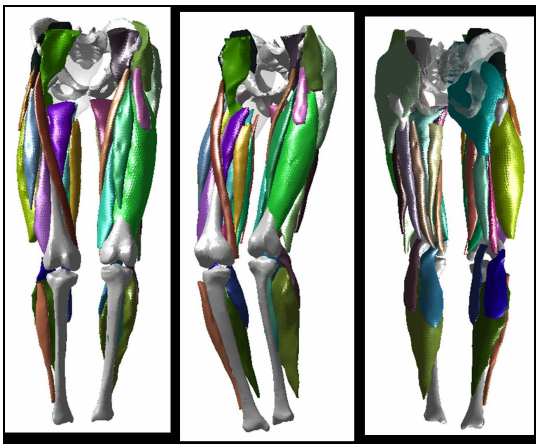

Figure 2: Specific subject 3D musculo-skeletal reconstruction for a CP patient (8 years old)