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BIOMECHANICS OF A CROUCHED GAIT CAUSED BY SPASTIC CEREBRAL PALSY IN CHILDREN

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ABSTRACT

Cerebral palsy is a leading disorder of the developing brain. One of the most common movement abnormalities among children with cerebral palsy is a crouched gait.

Rigid-body models of the skeleton have been used to calculate and compare the net moments exerted about the lower-limb joints during normal walking in children and adults [1]. However, the individual muscle forces causing these moments are as yet unknown. Based on the finding that the net joint moments are similar for walking in children and adults, it is currently assumed that function of the individual leg muscles in children is similar to that in healthy adults [1-3].

The aim of this study was to examine the gait patterns in healthy children walking at their natural speed and to compare muscle function in this population to that in children with a clinical diagnosis of crouch gait resulting from spastic cerebral palsy (CP). Gait experiments were conducted on four healthy children aged 7 to 11 yrs and one CP patient aged 12 yrs.

Kinematic, ground force, and muscle EMG data were recorded simultaneously for each subject. Twenty-five passive retroreflective markers were placed on both the left and right sides of the body to measure the three-dimensional positions of 14 body segments: forefoot, hindfoot, shank, and thigh of each leg, upper and lower arms, plus pelvis and one segment including head and torso. Ground-reaction forces and moments were measured using two six-component, strain-gauge force plates. Paired surface EMG electrodes were attached to both legs to record activity from 10 leg muscles in each leg. Figure 1 shows a comparison of the joint angles measured at the hip, knee, and ankle for one gait cycle for the healthy subjects and the subject walking with a crouched gait. A musculoskeletal computer model was developed for each of the normal subjects and the CP patient. Each model had the same kinematic structure as described in [4]. The skeleton was represented as a 10-segment, 23 degree-of-freedom articulated chain. Details of the model skeleton are given in [5]. The net moments exerted about the joints were found using inverse dynamics.

The hip extensor moment calculated in early stance was greater for the CP patient than for the healthy subjects. An increase in hip extensor moment may have been due to an

increase in the passive force exerted by the hamstrings muscles. Knee flexion also was larger in stance for the CP patient, which may have been brought about by co-contraction of the hamstrings and rectus femoris. Increased knee flexion in stance was accompanied by an increase in the extensor moment generated at the knee. Finally, peak dorsiflexion angle at the ankle was greater for the CP patient than the controls, which may have been caused by weakness of the soleus combined with lever arm dysfunction at the ankle. The plantarflexor moment exerted about the ankle was greater in early stance and smaller in late stance compared to the controls.

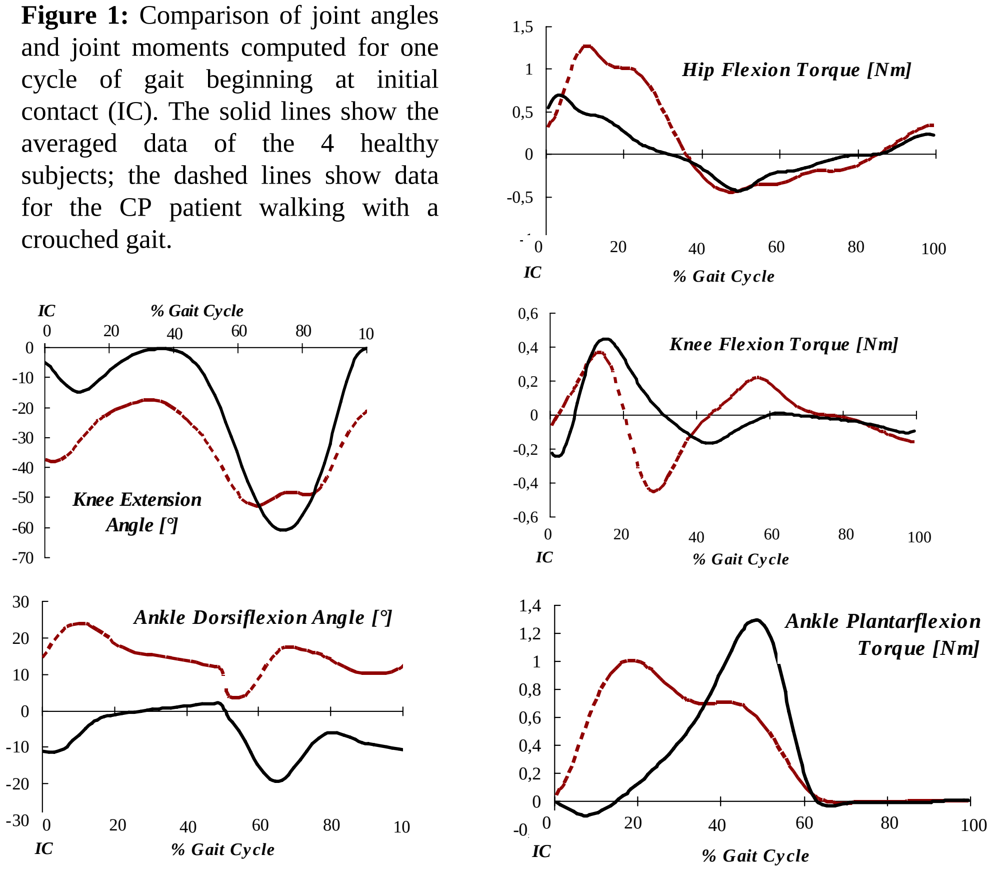

Figure 1: Comparison of joint angles and joint moments computed for one cycle of gait beginning at initial contact (IC). The solid lines show the averaged data of the 4 healthy subjects; the dashed lines show data for the CP patient walking with a crouched gait.

Our future work involves recording gait data for a greater number of CP patients and controls. These data will be used as input to subject-specific musculoskeletal models of the lower limbs to evaluate individual leg-muscle forces during gait. This information, in turn, will be used to quantify how individual muscles contribute to support and forward progression in normal and CP gait.

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