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## The effect of excessive tibial torsion on the capacity of muscles to extend the hip and knee during single-limb stance

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### Abstract

Excessive tibial torsion, a rotational deformity about the long axis of the tibia, is common in patients with cerebral palsy who walk with a crouch gait. Previous research suggests that this deformity may contribute to crouch gait by reducing the capacity of soleus to extend the knee; however, the effects of excess external torsion on the capacity of other muscles to extend the stance limb during walking are unknown. A computer model of the musculoskeletal system was developed to simulate a range of tibial torsion deformities. A dynamic analysis was then performed to determine the effect of these deformities on the capacity of lower limb muscles to extend the hip and knee at body positions corresponding to the single-limb stance phase of a normal gait cycle. Analysis of the model confirmed that excessive external torsion reduces the extension capacity of soleus. In addition, our analysis revealed that several important muscles crossing the hip and knee are also adversely affected by excessive tibial torsion. With a tibial torsion deformity of 30°, the capacities of soleus, posterior gluteus medius, and gluteus maximus to extend both the hip and knee were all reduced by over 10%. Since a tibial torsion deformity reduces the capacity of muscles to extend the hip and knee, it may be a significant contributor to crouch gait, especially when greater than 30° from normal, and thus should be considered by clinicians when making treatment decisions.

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### 1. Introduction

Many children with cerebral palsy walk with excessive flexion of their hips and knees, a movement pattern known as crouch gait. Tibial torsion deformities, characterized by excess twisting about the bone's long axis, are commonly observed in patients with cerebral palsy who walk with a crouch gait. Previous researchers have postulated that excess tibial torsion reduces the ability of muscles to extend the joints (e.g. [1–4]), which may contribute to the crouched posture observed in some patients. This bony misalignment can often be corrected with a derotation

osteotomy (e.g. [5]); however, the indications for surgery are unclear and the outcomes are variable. Understanding if this deformity is a significant contributor to diminished hip and knee extension is an important step in improving the treatment of patients with excess tibial torsion and crouch gait.

There are two possible biomechanical links between crouch gait and tibial deformities. First, excess tibial torsion may reduce the plantar flexion moment arms of muscles crossing the ankle joint. Previous work has established that the soleus and gastrocnemius play an important role in supporting the body during the mid- and late-stance phases of gait [6,7]. If the plantar flexion moment arms of the soleus or gastrocnemius are diminished as a result of the altered musculoskeletal geometry, their capacity to extend the joints and support the body may be reduced, possibly contributing to crouch gait.

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