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The effect of tibial torsion on the dynamic function of the soleus during gait

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Abstract

An induced acceleration analysis (IAA) model was used to investigate the effect of tibial torsion on the ability of the soleus to support and propel the body during gait. The IAA approach is well suited for this study because it allows soleus action to be quantified in the presence of varying amounts of tibial torsion, while other factors such as body configuration and muscle activation are held constant. The results of the analysis showed that excess tibial torsion shifts the induced knee joint accelerations toward flexion, valgus and external rotation, and diminishes body center-of-mass support and propulsion. This analysis supports the concept that bony mal-alignment can lead to 'lever arm dysfunction'. The objective data correlate with previous clinical observations related to valgus stress, crouch and the role of the soleus in level walking. The IAA model provides a tool for examining various aspects of abnormal gait independently and quantitatively.

Keywords: Induced acceleration; Soleus; Lever arm dysfunction; Tibial torsion

1. Introduction

The ankle plantarflexors play an important role in preventing crouch gait through a mechanism called the plantar flexion knee extension couple (Fig. 1a). During the mid-stance phase of normal gait, the center of pressure (COP) of the ground reaction force (GRF) moves distally on the foot, creating a large external dorsiflexion moment at the ankle. This moment is balanced by a large internal ankle plantarflexion moment, generated primarily by the soleus. The internal ankle moment results in a sagittal plane angular acceleration of the tibia that drives the knee in a posterior direction. By forcing the knee rearward, the line of action of the GRF remains in front of the knee joint center, thereby maintaining an external extensor moment on the knee. During this portion of the normal gait cycle, the knee is generally flexed no more than 15°. The synergy of a relatively extended knee along with an applied external extension moment results in a stable, supportive configuration requiring a relatively small internal knee moment. If the ankle plantarflexors do not generate an adequate moment, the rearward acceleration of the tibia is reduced, the knee joint center remains in a relatively anterior position and the knee joint flexes excessively (Fig. 1b). This pathological condition requires quadriceps activation and additional metabolic energy consumption. The patello-femoral pressures are greatly increased and a number of harmful consequences can occur. Thus the dynamic function of the ankle plantarflexors is critical to maintaining normal gait.

The dynamic function of the plantarflexors, defined as the ability of the plantarflexors to accelerate the body joints and segments, remains poorly understood despite its pivotal role in gait. As an example, consider the tendo-achilles lengthening (heel cord lengthening) procedure. This procedure is generally performed in an effort to correct equinus gait by lengthening a tight/spastic gastrocnemius. However, due to a shared insertion, the soleus is simultaneously lengthened, and thereby weakened. In diplegic children, the soleus is

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