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Effect of fine wire electrode insertion on gait patterns in children with hemiplegic cerebral palsy

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ABSTRACT

Background: Fine wire electromyography (EMG) is commonly used for surgical decision making in equinovarus foot deformity. However, this invasive technique may have the unwanted effect of altering the gait of children with cerebral palsy (CP). The purpose of this study was to determine if fine wire insertion into the posterior tibialis muscle affects temporal-spatial parameters and hindfoot kinematics during gait in children with equinovarus secondary to hemiplegic CP.
Methods: 12 children with hemiplegic CP who presented with an equinovarus foot (mean age 12.5 yrs, four right-sided, eight left-sided) were recruited. Temporal-spatial parameters and 3-D segmental foot and ankle kinematic gait data were collected utilizing standard gait analysis and the Milwaukee Foot Model (MFM). Three representative trials with and without fine wire electrode insertion were compared to determine the effect of electrode placement in the posterior tibialis on temporal spatial-parameters and hindfoot sagittal, coronal and transverse plane kinematic peaks, timing of kinematic peaks, and excursions.
Results: No significant differences in any temporal-spatial or kinematic parameters were observed between "with wire" and "without wire" conditions. Strong correlations were observed among the gait parameters, with the exception of cadence, for the two conditions.
Discussion: Fine wire insertion into the posterior tibialis had no measurable effect on the gait of individuals with equinovarus secondary to hemiplegic CP. This suggests that the simultaneous collection of segmental foot and ankle kinematics and fine wire EMG data of the posterior tibialis is acceptable for surgical decision making in this patient population.

1. Introduction

The use of electromyographic (EMG) patterns for surgical decision making in the lower extremities of children with cerebral palsy (CP) has become commonplace, and more recently it has been used to assist with understanding the pathomechanics associated with equinovarus foot [1]. A combination of surface electrodes for the more superficial musculature (anterior tibialis and gastrocnemius) and fine wire electrodes for deeper musculature (posterior tibialis) is used to determine the primary neuromuscular contributor(s) of the deformity [2]. Previously reported EMG studies have demonstrated that varus deformity in children with hemiplegic CP resulted from the anterior tibialis alone in 34% of cases, posterior tibialis alone in 33%, both muscles in 31%, and muscles other than the anterior or posterior tibialis in 2% [3]. In order to reliably use this assessment technique the question must be answered as to whether the introduction of a fine wire electrode alters the existing gait pattern, as young children can experience a combination of pain, anxiety, and discomfort associated with the technique. This becomes problematic when EMG and kinematic data are collected simultaneously for the purpose of surgical decision making.

Fine wire electrodes have been found to result in alterations in temporal-spatial parameters in children with diplegic CP [4]. Specifically, significant reductions were identified in cadence, walking velocity, step length of the measured limb, and step length of the non-measured limb when children were instructed to walk at a self-selected velocity. Although these findings implied that caution should be taken when utilizing these data collected simultaneously with 3-D kinematics for surgical decision making, it must be noted that all of the measures were temporal-spatial

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Table 1
Group averages and standard errors (SE) of temporal-spatial parameters with and without a fine wire electrode in the posterior tibialis.

Temporal-spatial gait parameters: group averages			
Variable	With wire trials average (SE)	Without wire trials average (SE)	*p* value
Walking speed (m/s)	0.94 (0.05)	0.95 (0.07)	n.s.
Cadence (steps/min)	116.98 (4.32)	118.70 (4.26)	n.s.
Step length: measured leg (m)	0.47 (0.03)	0.46 (0.04)	n.s.
Step length: non-measured leg (m)	0.49 (0.02)	0.50 (0.02)	n.s.

parameters. Fatigue might have been another factor for the reported gait alterations since the internal electrode trials were always conducted last. Also, this study only examined children with diplegic CP. Equinovarus deformity is most common in children with hemiplegic CP who have consistently been described as having improved gait and lower extremity function compared to children with diplegia [5].

In addition to temporal-spatial parameters, 3-dimensional hindfoot kinematics can provide quantitative data regarding possible alterations in walking due to fine wire insertion into the posterior tibialis. A method for calculating hindfoot kinematics has been described by Kidder et al. and has been validated for use in children [6,7]. The Milwaukee Foot Model (MFM) is a four-segment foot and ankle kinematic model that uses passive surface markers to quantify motion of the tibia, hindfoot, forefoot and hallux. Unique to the MFM is the use of radiographic offset measurements in anterior/posterior, lateral, and a coronal-plane hindfoot view to relate the underlying orientation of the bony anatomy to the surface markers, i.e. neutral referencing [8]. The kinematics are expressed with the tibia referenced to the global coordinate axes, and the remaining segments are represented in a distal relative to the next proximal segment relationship using an Euler System.

The purpose of the present study is to determine if fine wire insertion into the posterior tibialis affects the gait pattern of children with hemiplegic CP and equinovarus. We tested the hypothesis that reductions in cadence, walking velocity and step length will be similar in children with hemiplegia to those previously reported for children with diplegic CP. We also hypothesized that fine wire electrode insertion will alter hindfoot

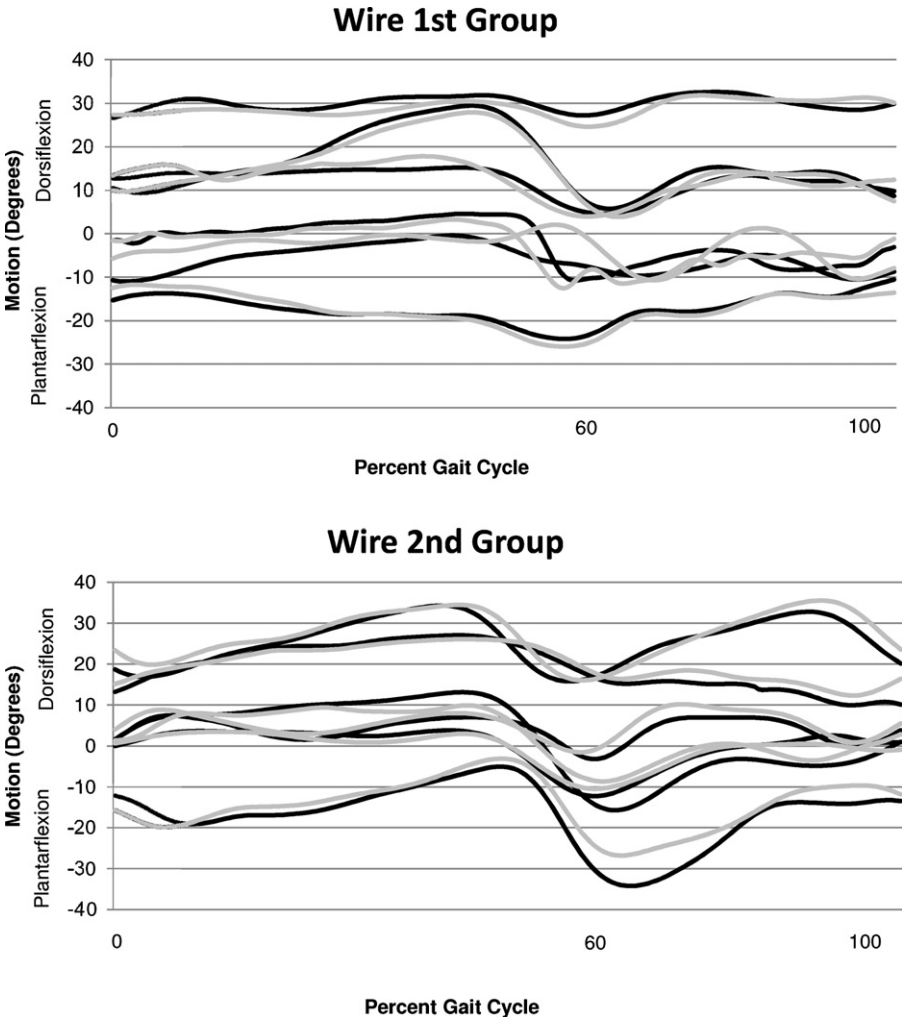

Fig. 1. Individual sagittal plane hindfoot kinematic plots of the twelve participants with (black) and without (gray) a wire electrode in the posterior tibialis. Participants were separated into a "Wire 1st" group or a "Wire 2nd" group depending on when during testing the participants had the wire electrode inserted.