

TIME FREQUENCY ANALYSIS OF MYOELECTRIC SIGNALS FROM CHILDREN WITH CEREBRAL PALSY: A NEW MUSCULAR CO-CONTRACTION ASSESSMENT TECHNIQUE

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INTRODUCTION

Cerebral palsy (CP) encompasses many chronic neuromuscular disorders that are characteristically manifested as abnormal motor control, due to involuntary muscular spasticity and antagonistic co-contraction. This often results in inefficient ambulation and diminished postural control. Current motion analysis assessment techniques can quantify joint kinetics and kinematics, however, these methods fail to address muscular co-contraction, which is a fundamental mobility constraint in CP. Electromyography (EMG) is also commonly used to describe qualitatively muscle activation patterns, but analysis of co-contraction has received little attention (Unnithan, 1996) and is notoriously difficult to quantify.

Ankle-foot orthoses (AFOs) are commonly prescribed for CP treatment intervention to decrease muscular tone by disrupting the spasticity pattern through maintenance of a neutral ankle joint position. To date, kinematic gait and balance analyses have failed to quantify systematically the efficacy of AFO use, despite well-documented improvements in walking velocity, stride length, and single limb support time (Carlson *et al.*, 1997). Examination of joint mechanics may not provide all pertinent information about muscular efficiency and ambulatory metabolic cost. Recent developments in the time-frequency analysis of EMG using wavelets (vonTscharnier, 2000) resolve the intensity (power) of the signal into its time-varying components at different frequencies. This technique provides previously unavailable insight into the underlying motor strategies employed with or without AFO use. The purpose of this study was to investigate the use of EMG wavelet analysis techniques to quantify the co-contraction experienced by children with CP.

METHODS

Gait analysis was conducted on four children with spastic diplegia or quadriplegia, ranging in age from 9-20 yr. Three-dimensional (3D) kinematic and kinetic data were acquired using bilateral lower-extremity reflective marker placement (3/segment) and an eight-camera, high-speed motion analysis system (Motion Analysis Corporation, Santa Rosa, CA; EVA© software). Force plate (Kistler, 9286; 1200 Hz), EMG (Noraxon, Scottsdale, AZ; 1200-2400 Hz) and video (120 Hz) data were collected during 5 successful trials for each AFO condition (with or without AFOs). 3D joint kinematics (joint angle, stride length, cadence) and kinetics (joint moments, ground reaction forces) (Kintrak© software, Motion Analysis Corp, Santa Rosa, CA) were calculated.

EMG analysis consisted of resolution of the myoelectric signal into 10 frequency bands with centre frequencies ranging from 6.9 to 330.6 Hz. (vonTscharnier, 2000). For comparison, EMG data were collected during level walking from 3 adults with no history of neuromuscular disorders.

RESULTS AND DISCUSSION

Comparison of normal adult EMG to a child with CP revealed substantial differences in frequency patterns (Fig. 1) and correlation coefficients (Fig. 2) between the right tibialis anterior (TA) and lateral gastrocnemius. (LG) The figures show greater muscle co-contraction in the CP child when compared to a normal adult, which occurs at specific myoelectric frequencies.

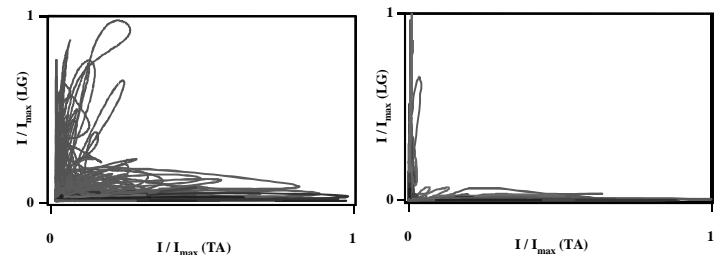


Figure 1 Exemplar myoelectric signal intensity (I) graded from high (blue) to low (red) frequency bands for a child with CP (left) and normal adult (right) across 10 steps

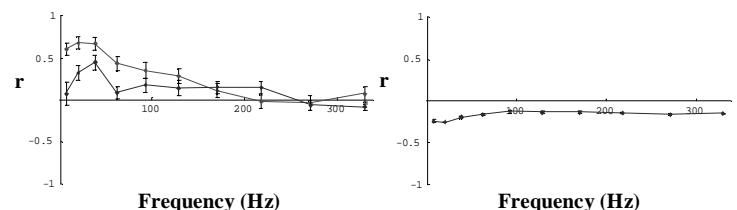


Figure 2 Exemplar correlation coefficients (r) (mean, SE) for child with CP (left) with (red) and without (blue) AFOs and normal adult (right) across 10 steps.

Use of the EMG wavelet analysis technique may improve discrimination of the treatment efficacy when coupled with traditional kinematic and kinetic walking analyses.

SUMMARY

Differences in muscle activation patterns were evident between normal adults and children with CP and, within each child, between shod and AFO trials. Data from this new technique may improve our understanding of strategies used by CP children for gait and postural control.

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