NEW INTERPRETATION ON EMG CHARATERISTICS OF SPASTIC CEREBRAL PALSY DURING A REHABILITATIVE WALKING EXERCISE

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The purpose of this study is to interpret the EMG characteristics of spastic cerebral palsy children during walking with power spectrum analysis. The EMG signal of 16 cerebral palsy patients (CP) and 18 age matched control (Normal) were collected during several walking trial. It was found that our CP participants had significantly longer firing duration and higher median frequency within a gait cycle for all the muscle groups, these indicated of the EMG characteristics of in the spastic muscles. In addition, the CP produced significantly smaller root mean square value in tibialis anterior muscle than the normal; this indicated that the tibialis anterior muscle of CP was weakness or atrophy. Because of good objectivity and reproducibility, employing RMS and the MF could be suggested to be the parameters for further gait studies.

KEY WORDS: electromyography, spastic cerebral palsy, power spectrum analysis

INTRODUCTION: The gait of spastic cerebral palsy was much different from that of normal. Physician and scientist want to identify why they presented such abnormal walking pattern. It is, therefore, the EMG of the lower extremity has been studied. For gait study involved EMG, only phasic information was investigated (Rose J et al, 1999; Policy JF et al, 2001), but it seldom studied power spectrum analysis of EMG, including root mean square (RMS) and median frequency (MF). The root mean square value (RMS) and median frequency (MF) are the most frequently used parameters in functional assessment of skeletal muscles (spinal muscles, upper limb muscles), because of their good objectivity and reproducibility. Therefore, in this study, the RMS and MF values were tried to adopt in the interpretation of gait EMG: Root mean square represents the square root of the average power of the EMG signal for a given time while median frequency reflects the number of motion unit recruitment. The purpose of this study is to identify and intrepet the alternations of gait EMG of spastic cerebral palsy using the power spectrum analysis method.

METHODS: 16 CP with dynamic equinus deformity (Ashworth Scale 1 to 3) and 18 healthy normal participants were recruited. All participants came to gait laboratory for data collection by Vicon System and surface electromyography. All subjects performed a minimum of three barefoot walking trial.

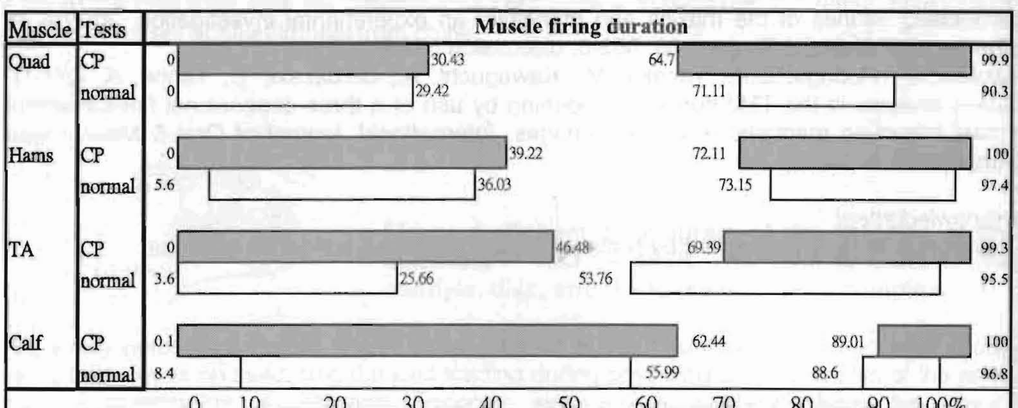

Figure 1. The start point and end point of muscle firing duration in the gait cycle. The Quadriceps, hamstrings, tibialis anterior and calf muscles were studied, with different type of conditions.

Surface EMG electrodes were applied to 4 muscle groups (quadriceps, hamstring, tibialis anterior and calf muscles) after an alcohol swab. After synchronization the Vicon and EMG system and averaged of trials, starting point and end point of each muscle channel were found in Figure 1. Our testing parameters were defined as below: 1) firing duration was end point of muscle firing minus start point of muscle firing, 2) Root mean square (RMS) measured the magnitude of the muscle firing signal normalized by their corresponding standing EMG, and 3) median power frequency (MF) measured the density during muscle firing period. If a muscle group had two contracting durations within gait cycle, the RMS and MF were averaged, and the total contraction duration was summated to a single value. Independent t-test was used to assess the EMG difference between the CP and control group.

RESULTS: For contracting duration, it was found that the CP had significantly longer firing duration within a gait cycle for all the muscle groups. For median frequency, all the muscle groups in the CP had significantly higher median frequency than the normal control. For root mean square value, the CP produced significantly smaller amplitude in tibialis anterior muscle than the normal.

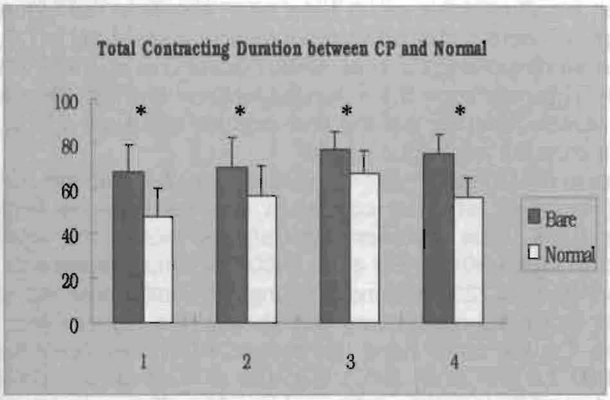

Figure 2 Firing Duration between CP and normal at 1) Quadriceps, 2) Hamstrings, 3) Tibialis Anterior and 4) Calf Muscle

*meant significant difference

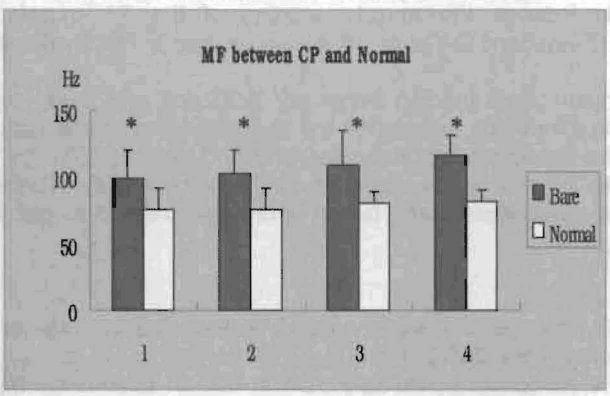

Figure 3 Median Frequency between CP and normal at 1) Quadriceps, 2) Hamstrings, 3) Tibialis Anterior and 4) Calf Muscle

*meant significant difference

DISSCUSSIONS AND CONCLUSIONS: Spasticity is a common presentation in the patient with cerebral palsy (CP) and it can be defined as a condition in which there is a velocity-dependent increase in resistance of a muscle group to passive stretch with a "clasp-knife" type component associated with hyperactive tendon reflexes (Smyth MD et al, 2000). This always alters the electromyography pattern, including phasic and amplitude.

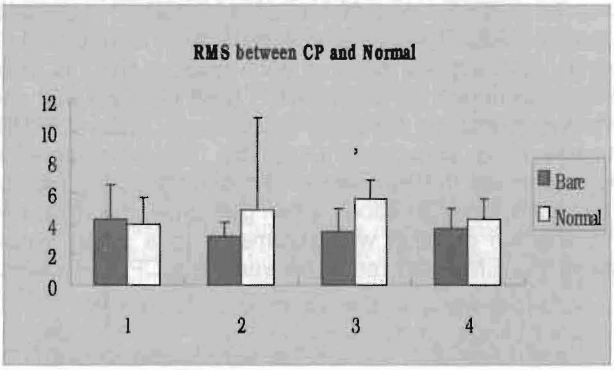

Figure 4 Root Mean Square between CP and normal at 1) Quadriceps, 2) Hamstrings, 3) Tibialis Anterior and 4) Calf Muscle

*meant significant difference

CP showed a significant higher median frequency (MF) and longer total contracting duration when compared to the normal (Figure 2 and 3). The higher muscle median frequency reflects more motor units were recruited for a certain action or a certain period of time. The duration of muscle contraction reflects the period of muscle firing in each gait cycle: the start and the end point of muscle firing duration for all muscles group have been shown in the Figure 1. Long contracting duration and high MF were a characteristic of muscular spasticity in CP, as indicated by the results of previous studies (Feng CJ et al, 1998; Gamet D et al, 1993; Policy JF et al, 2001; Rose J et al, 1999). This may imply the muscular function was not effective, it takes much more non-functional muscle firing for walking than normal, and such a high MF could further indicate that the CP's muscles will fatigue easily.

On the contrary, the root mean value (RMS) in CP was significantly smaller than the normal in tibialis anterior (TA) muscle (Figure 4), which is consistent with the previous findings (Sutherland DH et al, 1996).The RMS value represents the square root of the average variance or power of the myoelectric signal (Kleine BU et al, 2000), or simply represents the averaged EMG amplitude. Karlsson S et al (2001) found a strong correlation between RMS and force in the quadriceps under isokinetic contraction, and showed the higher RMS, the more effort done by the muscles. On the other hand, decreased RMS was indicative of muscle atrophy (Riley DA et al, 1990; Lu WW et al, 2002). Because of the muscle imbalance (spasticity) between the calf muscle and their antagonist muscles, with calf muscles stronger than tibialis anterior (TA), this induces the muscle wasting of the TA muscle and development of muscle atrophy (Sutherland DA et al, 1996), and a drop in RMS value in the TA muscle.

In addition to muscle firing duration, both median frequency (MF) and root mean square (RMS) value are also an objective methods to interpret the characteristics of EMG and are recognized as a useful tool for the assessment of muscular function (Josef F, 2001; Lu WW, 2002; Wk Lam, 2005), because of their good objectivity and reproducibility. Therefore, employing RMS and the MF as parameters could be an alternative method in gait EMG studies in the future.

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