The Effect of Walking with Electrical Stimulation of Ankle Musculature on Lower Limb Coordination of a Child with Diplegic Cerebral Palsy

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Introduction: Children with cerebral palsy often lack the ability to produce appropriate muscle activation patterns for effective joint coordination and efficient ambulation. Consequently, compensatory gait patterns are produced which may place additional strain on joints, decrease movement efficiency and limit mobility. We used a within-subjects changing criterion single-subject design to determine if the effects of functional electrical stimulation (FES) applied to the ankle musculature while walking can improve lower limb coordination in a child with diplegic cerebral palsy (CP). Moreover, we were interested in whether walking with stimulation over an at home training period can produce long-term improvements in walking ability after the stimulation is turned off.

Statement of Clinical Significance: Walking with FES has been used therapeutically[2, 3,6] and may produce long-term changes in walking ability[2,3]. Assessing the effect of physical practice and the dynamic function of the knee and ankle during ambulation enables the clinician to evaluate improvements in walking ability resulting from interventions such as dynamic FES.

Methodology: Intramuscular electrodes were implanted into the gastrocnemius (GAS) and tibialis anterior (TA) muscles of a 12 year old male with spastic diplegic CP. Several foot switches implanted into the insoles of both shoes determined the foot strike, mid-stance, toe-off and swing phase of each step. The TA was stimulated during the swing phase and the GAS was stimulated during the push-off phase of the gait cycle (Stim ON) just prior to the period when the foot leaves the ground during gait testing and at-home practice sessions. Knee and ankle motion during ambulation were recorded with a six-camera Vicon motion analysis system (Oxford Metrics Ltd, Oxford, England) and gait spatial temporal factors, kinematics, and kinetics were calculated with Vicon Clinical Manager software. Prior to testing, the subject with CP underwent a training period of 90 minutes daily for five days with a physical therapist for each of the conditions in which walking with the stimulation would occur. Following the laboratory training period, walking with the FES system was practiced at home for twice a day across four weeks with 5-6 hours rest[4] between practice sessions (see Table 1). Phase plane portraits and angle-angle plots[1] of the ankle and knee joints were calculated and compared to that of a typically developing (TD) age-matched child.

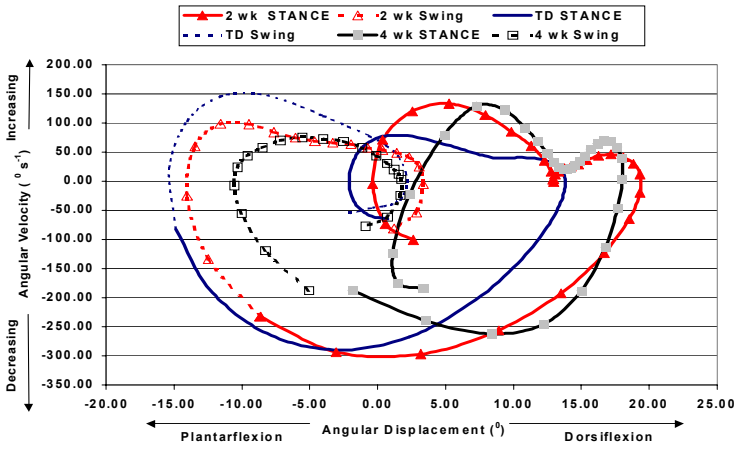
Results: Comparing the angle-angle plots and phase-plane portraits of the subject with CP and the TD norms resulted in an improvement in the swing phase of gait function for the subject with CP after 2 weeks of practice (see Figure 1). After 4 weeks of practice, the coordination dynamics changed to a more tightly coupled swing phase(i.e., dorsiflexion range of motion was 5^0 smaller and velocity range was $100°s^{-1}$ less than the 2 week findings).

Table 1. Summary of experimental design, gait practice schedule and stimulation status.

Phase	Pre-test	Practice	2 wk-test	Practice	4 wk-test	Practice	2 wk Posttest (withdrawal)
Location	LAB	HOME	LAB	HOME	LAB	HOME	LAB
Practice Schedule	Gait Analysis	2 X / d 40 min. 5 d / wk	Gait Analysis	2 X / d 60 min. 5 d / wk	Gait Analysis	2 X / d 60 min. 5 d / wk	Gait Analysis
Stimulation	ON & Off	ON	ON & Off	ON	ON & Off	OFF	ON & Off

Results: (cont'd): The change in coordination dynamics may be due to an increased stride length and increased average velocity while having a reduced average cadence.

Figure 1. Right side ankle phase-plane portrait of gait phases in a subject with typical development (TD) and a subject with diplegic cerebral palsy with stimulation on after the 2 weeks and 4 weeks of gait practice. All plots are the average of three trials.



Discussion: Previous research employing FES and gait training had stimulation treatment applied from three weeks[2] through six months[3]. Although our at-home practice protocol was within the range of other studies, our results suggest that additional at-home practice is necessary. Our results also showed variability in the subjects' gait coordination patterns. This outcome is expected since children demonstrate changes in their movement patterns as a function of practice[5]. More participants are needed before any final conclusions can be drawn

References:

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