An investigation of the effect of functional electrical stimulation to assist the gait of children with cerebral palsy

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Abstract

The gait of children with hemiplegic cerebral palsy is often characterised by toe walking and asymmetry in temporal spatial parameters. Persistent toe walking impairs balance, resulting in shortening of the musculo-tendinous unit and reduced function. Current interventions to maintain range of movement at the ankle and improve walking patterns show mixed results. An alternative may be functional electrical stimulation (FES), which is effective in assisting walking in adults, however there is limited research assessing its effectiveness or acceptability in children. The aim of this work is to investigate the efficacy of using stimulation to support the gait of ambulant children with cerebral palsy.

Following a review of the literature, two stimulation approaches are being investigated; stimulation to dorsiflexors (tibialis anterior) in swing, and stimulation to plantarflexors (calf) in stance. For each study a repeated measures, ABA based approach has been adopted. The calf project is in progress and preliminary results will be presented at the conference. The tibialis anterior project has been completed and the analysis so far suggests an improvement in gait when stimulation is being applied. In both cases stimulation is tolerated well by the children, but there is a need to improve the overall design of the stimulator.

1 Introduction

Persistent toe walking in children with cerebral palsy (CP) leads to poor balance and frequent falls, increased asymmetry and likely development of fixed deformity resulting in reduced function.

Current practice to reduce toe walking includes orthotics, botulinum toxin, physiotherapy and surgery. An alternative approach is that of electrical stimulation, in which (for this work) electrical pulses are applied to surface electrodes from a small, lightweight, external battery powered unit. This has been used successfully in rehabilitation following neurological damage, e.g. spinal cord injury and stroke [1,2]. In comparison, less work has been reported in assisting gait in children with CP with electrical stimulation. However, the general view is that although requiring further work it does offer therapeutic and possibly functional benefits [3-5].

There is conflict in the literature regarding the use of electrical stimulation in children with CP. Some evidence supports the use of stimulation to the tibialis anterior (TA) muscle, others support stimulation of the calf muscles. However, due to a variety of stimulation approaches reported in the literature, there is a lack of information to inform selection criteria, treatment regimes and outcome measures [6]. This work aims to resolve some of these issues through controlled clinical studies in which the stimulation is used during walking.

1.1 Aim of the project

To establish whether FES can be used successfully with children to control toe walking and if so to determine the key selection criteria that need to be met.

2 Methods

Two ABA pilot studies are being undertaken with children who present with a toe-walk gait, with ten children being recruited to each study.

Selection Criteria: Diagnosis of cerebral palsy; walks with toe gait; has 90 degrees dorsiflexion passively with knee extended; co-operative, with parents/carers suitably motivated; tolerant of machine and sensation of stimulation; and
able to walk independently of aids or assistance.

**Exclusion Criteria:** Surgery or botulinum toxin injection within 18 months of commencing FES; concurrent use of fixed AFO; insufficient parental/carer support to use equipment; a need for more than single channel stimulation, and contractures and/or fixed deformities at the ankle.

Each phase lasts for three months with electrical stimulation being applied during phase B. Each child continues to receive their normal therapy input throughout. Data is collected at the beginning and end of each phase. Kinetic and kinematic data is collected in the gait laboratory, and range of movement, height, weight and physiological cost index (TA study only) are also recorded. In addition, for the calf muscle project, surface emg data from tibialis anterior and gastrocnemius is being collected.

The acceptability/effectiveness of the stimulation is also being assessed by a questionnaire, developed in conjunction with the Clinical Audit Department at Queen Mary’s Hospital, completed by the child and their parent or carer.

Stimulation is applied to either the tibialis anterior muscle (directly through the motor nerve or through stimulating the flexor withdrawal reflex action), or to the calf muscle, using the Salisbury Hospital single channel ODFSIII stimulator. A heel or toe switch is used to start/end stimulation. The stimulation envelope timings are adjusted to optimise improvements in the presenting problem of "toe walking". A follow up takes place the next day to ensure that electrical stimulation is being applied correctly. The electrical orthosis is then used as a gait assist device, for the three months of this phase. For the TA study, stimulation was encouraged throughout the day, however, because of the practical difficulties, this has been reduced to approximately 30 minutes a day during walking for the Calf study. For both studies telephone contact (was) is made to check on use of the stimulator fortnightly through phase B.

Processing of the data from the Calf study has only just begun, so the following Results and Conclusions refer to the TA study only. Further details of the analysis are available in Durham et al. [7].

### 3 Results

Seventeen children were screened. Five children were not enrolled onto the study either because they had complex pathology unlikely to benefit from a single channel of stimulation, disliked the sensation, or were too young to cooperate. Of the twelve accepted onto the study, two did not complete, due to non-compliance in one case and family circumstances in the other.

The greatest asymmetries were in the pattern of foot contact (measured by the heel-toe interval), and duration of pre-swing double stance. Heel-toe contact pattern and symmetry were both improved with stimulation. There was a clear trend toward reduction in affected side pre-swing double stance time and a move toward symmetry. Mean swing and stance times were close to symmetry with and without stimulation. At the end of the intervention phase the pattern of asymmetry of all parameters was the same as at pre-intervention, although absolute values changed.

Nine out of ten questionnaires were returned after three months of using the stimulator. Three respondents reported problems with compliance, however all reported that they would like to continue using the system after completion of the trial. General comments were that the stimulator was large and the electrodes/wires could be difficult for the child to manage, especially if the system was to be worn all day in school.

### 4 Discussion and Conclusions

Current physiotherapy practice attempts to correct the foot contact pattern and asymmetries of gait in children with cerebral palsy who toe-walk. The electrical stimulation improved foot contact pattern on the affected side and symmetry of the most asymmetrical temporal spatial parameters of walking in this group of hemiplegic children. The sensation of the electrical stimulation was generally well tolerated and therefore FES could represent a useful alternative to a conventional orthosis. Further work is needed to refine selection criteria and optimize use of stimulation.

The children and their parents/carers have reported the equipment to be reliable, but large, heavy and lacking cosmesis, particularly with summer clothes. Work is in progress at the University to develop more cosmetic and lightweight equipment [8].
References


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