USING FUNCTIONAL ELECTRICAL STIMULATION (FES) IN PARKINSON'S DISEASE

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SUMMARY

Parkinson's disease (PD) is a neurological impairment resulting in motor and functional problems including reduced stride length (shuffling) and akinesia (freezing). The deprivation in function of the basal ganglia in the brain results in diminished internal cueing associated with the planning of complex movements. There is evidence that external cues – visual, auditory, cognitive or sensory, may be able to compensate for the defective internal 'cueing system', improving step initiation and quality of walking in PD patients.
It is hypothesised that FES may act as a sensory cue to help maintain stride length and reduce akinesia in PD. 2 subjects diagnosed with PD were set up with FES devices. Foot switch triggered stimulation was applied via surface electrodes to the common peroneal nerve and the motor point of tibialis anterior. Although 1 subject could achieve active dorsiflexion, bilateral FES was effective in producing improved heel strike and reduced shuffling. Video footage from the subjects home showed an average increase in stride length of 19% and more importantly, appeared to have a safer gait. Subject 2 who has a dropped foot gained a beneficial effect from the dorsiflexion as well as the sensory cue provided by FES. By using a single channel FES device an increase in stride length of 24% was achieved.
This new application of FES has increased the mobility, stability and confidence of walking in the two subjects.

STATE OF THE ART

Introduction

PD is a progressive neurological condition resulting in motor and functional disability. It affects 1% of people over 50 years of age and is a leading cause of disability in those over 60 years of age /1/. The progressive nature of the gait disturbance in PD can lead to an eventual loss of mobility, an increased incidence of falls, and a loss of independence /2/. It is associated with reduced production of the neurotransmitter, dopamine, through degeneration of the basal ganglia and the substantia nigra. Characteristic neurological impairments in PD include resting tremor, rigidity, slowness of movement (bradykinesia) and postural instability. Walking becomes slower, with reduced stride length and cadence giving rise to a shuffling gait. As the disease progresses there are difficulties in initiating and maintaining movement resulting in freezing episodes, which occurs particularly in confined spaces. An increasingly flexed posture often develops over time. Symptoms may be relieved by levodopa - based drugs, which increase the amount of dopamine in the body. These drugs become less effective as the disease progresses and maximum dosage is reached /3/.

Functions of the basal ganglia

The basal ganglia are thought to have two main functions in movement. Firstly, the provision of internal motor 'cues' to the supplementary motor area of the cerebral cortex, to enable the release of each sub movement of a movement sequence to be correctly timed. Secondly, they contribute to the cortical 'motor set', which maintains movement sequences ready for execution /4/.

External Cueing

The effect of basal ganglia dysfunction in PD leads to defective cueing, which is manifested in early fatigue and reduction in speed and amplitude of movement. There is evidence that external cues – visual, auditory, cognitive or sensory, may be able to compensate for the defective internal 'cueing /5/. Bagley et al., /1/ showed that visual cues in the form of lines at regular intervals on the floor or as a target above eye level, improved the step length, velocity and heel strike of gait. Cutaneous cueing has also been shown to improve step initiation, force production and walking speed in Parkinson's Disease patients /6/. The concept of using FES to aid walking in PD is that stimulation of the common peroneal nerve produces dorsiflexion, providing a cutaneous and proprioceptive sensory cue and assisting the patient to step, thus avoiding shuffling and helping to overcome freezing.

MATERIALS AND METHODS

Devices Used

Two clinically used, CE marked devices were used. The Odstock 2-Channel Stimulator (02CHS) is a dual channel, foot switch triggered stimulator designed to elicit dorsiflexion of the foot by stimulation of the common peroneal nerve, (maximum amplitude 80mA, 300μs pulses, 40Hz). Surface electrodes are placed over the head of the fibula bone and the motor point of tibialis anterior.

The Odstock Dropped Foot Stimulator (ODFS) is a single channel device, currently being used by well over 1000 stroke and multiple sclerosis victims suffering from dropped foot. A randomised-controlled trial with hemiplegic patients showed a statistically significant increase in walking speed of 16% and a reduction in the Physiological Cost Index (PCI) of 29% /7/.

Subject 1

This is a 68-year-old man with a 14-year history of PD. He is currently prescribed levodopa – based medication, which is effective in relieving most of his symptoms. His main problems are initiating and maintaining movement, which cause him to adopt a shuffling gait, with reduced heel strike and to 'freeze' in confined spaces, especially in doorways and when turning. He often falls, having a detrimental effect on his confidence and therefore, mobility.

He was issued with the 02CHS in order to provide a bilateral sensory and motor cue. A footswitch placed in the right shoe triggers the stimulation to the right side on heel-rise and delivers stimulation to the left side on heel-strike. The stimulation envelope is ramped for comfort. The patient was video recorded walking with and without stimulation. The "Get-up" and go test /8/ that measures balance on a 5-point scale was conducted. This requires the patient to stand up from a chair, walk a short distance, turn around, return, and sit down again. This test was used to assess the risk of falling.

Subject 2

This is a 55-year-old woman with a 5-year history of PD. She is currently prescribed levodopa – based medication, which is effective in relieving most of her symptoms. Her main problem is an associated dropped foot. This results in a reduced stride length, tripping, hip 'hitching', large energy expenditure and again, loss in confidence when walking.

She was issued with the single channel ODFS for her affected (left) side. The foot switch was placed in the affected side's shoe so that the stimulation adapts to the speed of walking. The stimulation current was delivered on heel-rise, with ramping for comfort and to prevent 'foot-flap' on heel strike.

RESULTS

The "Get-up" and go test carried out for subject 1 suggests that by using FES as a sensory cue a more 'normal' (therefor safer) gait could be achieved in PD victims with substantial gait problems. Videos were taken of the subject performing a typical task at home with and without FES. An average increase in stride length of 19% was achieved using FES. This increase in stride length led to a safer gait pattern, agreeing with the findings of Morris et al. /2/, who states "regulation of stride length is the key deficit in gait hypokinesia".

Subject 2 achieved an increase in stride length of 24% over a 10m walkway. This large increase is probably due to the orthotic effect of FES (ankle dorsiflexion) as well as providing a sensory cue.

Both patients felt more confident when walking using FES.

DISCUSSION

From the preliminary work described above, both PD subjects appeared to benefit from the use of FES. This may be due to the sensation of stimulation acting as a triggering external sensory cue, to increased proprioceptive input from the contraction of the anterior tibial muscles, or a combination of the two. There is also probably some placebo effect in the knowledge that the stimulator will reliably lift the foot. It is hoped that there may be an application for FES for patients with PD in overcoming akinesia and maintaining their gait pattern, particularly when their drug treatment is becoming less effective after a number of years. We attempted to improve the quality and safety of PD walking so parameters such as walking speed and cadence were not measured. We also found it necessary to take measurements in the patient's home as the doorways and corridors are generally large and spacious in hospital clinic areas, and are not typical of the more confined spaces in the everyday environment of most patients.

The advantage of using FES over other cueing systems is the adaptability to the environment. The system will work around the home and outside – in any lighting conditions. It also adapts to the walking speed of the user as it is triggered on heel rise – overcoming audio cue systems with a metronome or music, where the user has to maintain a pre-set speed.

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