

A Pilot Study to investigate the effects of Functional Electrical Stimulation on gait in Parkinson's Disease

Mann GE¹, Finn SM¹, Taylor PN¹

¹ Department of Medical Physics & Biomedical Engineering, Salisbury District Hospital, Salisbury, Wiltshire SP2 8BJ.

Email: g.mann@mpbe-sdh.demon.co.uk

Website: www.salisburyfes.com

Abstract

Parkinson's Disease (PD) is a progressive neurological condition resulting in motor and functional disability. Walking becomes slower, and frequently a shuffling gait develops with reduced stride length and cadence. There are difficulties initiating and maintaining movement and an increased incidence of falls. Ten subjects with idiopathic PD were recruited to the 16 week study. Following a 4 week baseline period each subject received Functional Electrical Stimulation (FES) for 8 weeks to the common peroneal nerve of the more severely affected side. Stimulation was withdrawn for the following 4 weeks. Assessments were made of stride length, time and number of steps to complete a 20 metre walk with a turn and walking distance over 3 minutes.

Episodes of 'freezing' and quality of life measures were also recorded. Each subject kept a falls diary.

Results indicate that there is no immediate orthotic effect of electrical stimulation on gait but that there is a significant learning effect on unstimulated walking at the end of the treatment period which is maintained for at least a month after stimulation has been withdrawn.

1 Introduction

Parkinson's Disease (PD) is a progressive neurological condition which gives rise to motor and functional disability as a result of reduced production of the neurotransmitter, dopamine, through degeneration of the basal ganglia and substantia nigra. Parkinson's Disease is characterised by slowness and poverty of movement. Walking becomes slower, with reduced stride length and cadence giving rise to a shuffling gait. As the disease progresses there are difficulties initiating and maintaining movement resulting in motor blocks (freezing), which occur particularly in confined spaces. 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.

1.1 Effect of External Cues

There is evidence that external 'cues' – visual, auditory, cognitive or sensory, may be able to compensate for the defective internal 'cueing system' for initiating and maintaining movement, usually facilitated by dopamine [1][2][3][4].

1.2 The Odstock Dropped Foot Stimulator

The Odstock Dropped Foot Stimulator (ODFS) is a single channel footswitch controlled neuromuscular device used to correct dropped foot during walking. Stimulation is applied to the common peroneal nerve to elicit dorsiflexion and eversion during the swing phase of walking.

Study hypothesis

It is hypothesised that use of electrical stimulation of the common peroneal nerve in patients with PD may act to provide an appropriate external sensory cue to maintain or improve the normal gait pattern and reduce episodes of 'freezing' during gait.

2 Methods

2.1 Subjects

10 subjects with Parkinson's Disease who were stable on their current medication were recruited to the study. Each subject exhibited reduced stride length and heel strike during gait and most experienced both motor blocks and episodes of falling.

2.2 Stimulation treatment

Subjects received single channel FES of the common peroneal nerve of the lower limb of the more severely affected side. Stimulation was delivered by the Odstock Dropped Foot Stimulator (ODFS), a neuromuscular stimulator powered by a 9 volt battery, producing a train of pulses of 300 microseconds duration at a frequency of 40Hz. Stimulation was applied through PALS adhesive electrodes and triggered by a pressure sensitive switch placed in the shoe.

2.3 Assessments

The 16 week study period comprised a 4 week baseline period without stimulation, 8 weeks with stimulation and a 4 week follow up period without stimulation. Assessments were conducted at weeks 0, 2, 4, 8, 12, 14 and 16. Subjects completed a 20 metre walk which included walking through a doorway, turning and walking back to the start. Two high backed chairs were placed in the walkway as obstacles to be negotiated. Subjects also completed a timed 3 minute walk over the same walkway. A video recording was made of each walk for each subject.

Assessments included the motor examination of the Unified Parkinson's Disease Rating Scale (UPDRS), the Mini-Mental State Examination (MMSE), and the PDQ 39 quality of life questionnaire. Subjects completed a falls diary for the duration of the study.

The number and length of steps and time to complete the 20 metre and 3 minute walks were recorded with and without stimulation from the videotape. The number of clear steps was distinguished from the number of shuffling step movements in which the foot moved forward but did not clear the floor. This is referred to as the 'shuffle ratio'.

The average stride length is referred to as the 'step index'. This is the number of steps taken over the distance covered in 3 minutes.

3 Results

10 subjects, 6 male and 4 female, aged 41 to 80 years (mean = 66.7) and PD of 2 to 25 years (mean = 8.7) duration were recruited to the study. Three were excluded as their primary problem was a dropped foot rather than more commonly recognised symptoms of idiopathic PD.

Subjects required significantly fewer steps and less time to complete the 20 metre walk at the end of the treatment period than during the 4 week baseline period both with and without stimulation. This effect was maintained at the end of the follow up period (Tables 1&2). A similar pattern was seen in the shuffle ratio and step index for the 3 minute walk (Tables 3&4).

B=mean-baseline, S=stim, NS=no-stim,
w=week

assessments	median values	Wilcoxon p-value
B - w12 NS	56 - 42	0.028
w12 NS - w16 NS	42 - 42	0.917
B - w12 S	56 - 42	0.028
w4 NS - w4 S	53 - 54	0.237
w8 NS - w8 S	42 - 42	0.109
w12 NS - w12 S	42 - 42	0.046
w16 NS - w16 S	42 - 41	0.917

Table 1: Number of steps to complete 20m Walk With Turn.

assessments	median values	Wilcoxon p-value
B - w12 NS	35.59 - 29.08	0.043
w12 NS-w16 NS	29.08 - 28.08	1.000
B - w12 S	35.59 - 27.74	0.028
w4 NS - w4 S	30.89 - 33.56	0.779
w8 NS - w8 S	28.27 - 28.27	0.753
w12 NS - w12 S	29.08 - 27.74	0.327
w16 NS - w16 S	28.88 - 29.61	0.866

Table 2: Time taken to complete 20m Walk With Turn.

assessments	median values	Wilcoxon p-value
B - w12 NS	8.97 - 4.17	0.017
w12 NS - w16 NS	4.17 - 4.00	0.499
B - w12 S	4.17 - 1.75	0.012
w4 NS - w4 S	5.88 - 2.27	0.063
w8 NS - w8 S	2.44 - 1.64	0.295
w12 NS - w12 S	4.17 - 1.75	0.225
w16 NS - w16 S	4.17 - 4.48	1.000

Table 3: Shuffle ratio – 3 minute walk.

assessments	median values	Wilcoxon p-value
B - w12 NS	0.36 - 0.42	0.420.028
w12 NS - w16 NS	0.42 - 0.40	1.000
B - w12 S	0.36 - 0.40	0.460.018
w4 NS - w4 S	0.37 - 0.40	0.400.028
w8 NS - w8 S	0.40 - 0.44	0.440.176
w12 NS - w12 S	0.42 - 0.44	0.460.018
w16 NS - w16 S	0.40 - 0.44	0.046

Table 4: Step index – 3 minute walk

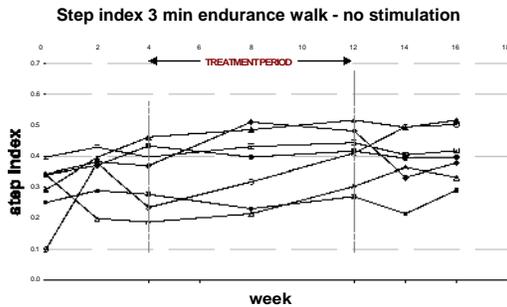


Figure 1: Step index – 3 minute walk, no stimulation.

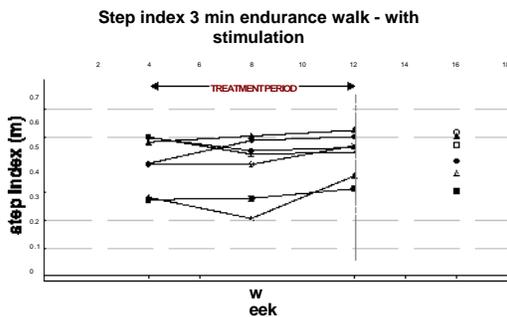


Figure 2: Step index – 3 minute walk, with stimulation.

4 Discussion and Conclusions

For the results presented in this paper there was found to be a significant carry over effect at the end of the treatment period which was maintained 4 weeks after stimulation was withdrawn. This agrees with anecdotal evidence from study participants who reported that the stimulator acted as a training device. This suggests an improvement in stride length and consistent heel strike which reflects an improvement in gait pattern. Interestingly there was no immediate orthotic effect for most of the 20m Walk With Turn tests at any stage of the study. However, the step index for the 3 minute walk did reveal an immediate orthotic

effect at all but one stage of the study. It may be that a greater distance was necessary for the effect of the stimulation to be shown with such small number of subjects. This training effect is reinforced by results showing the benefits to be maintained to the end of the follow up period (see Tables 1-4).

The training effect may have implication for the way in which stimulation is used in this patient group. Most subjects reported that the device trained them to improve gait features such as heel strike and stride length. One user reported that the improvement in his unassisted walking was maintained through periodic use of the stimulator.

Subjects may have benefited from the gait re-education as an adjunct to the study. Further work is necessary to establish the mechanisms of the effects of stimulation in patients with PD and to identify which patients are likely to derive the most benefit from FES.

Conclusion-There does appear to be an immediate training effect that has been maintained for the period of this trial. A trial with a control group is needed to verify this conclusion.

References

- [1] Bagley S, Kelly B, Tunnicliffe N, Turnbull G.I., Walker G.M. The effect of visual cues on the gait of independently mobile Parkinson's disease. *Physiotherapy*. 77(6). 415-420, 1991.
- [2] McIntosh G.C., Brown S.H., Rice R.R., Thaut M.H. Rhythmic auditory – motor facilitation of gait patterns in patient's with Parkinson's Disease. *Journal of Neurology, Neurosurgery and Psychiatry*. 62(1). 22–26, 1997.
- [3] Morris M.E., Ianseck R, Matyas T.A, Summers J.J.. Ability to modulate walking cadence remains intact in Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry*. 57. 1532-1534, 1994.
- [4] Jacobs A.B., Horak F.B., Nutt J.G., Obeso J.A. Step initiation in Parkinson's Disease: Influence of Levodopa and External Sensory Triggers. *Movement Disorders*. 12(2). 206–215, 1997.

Acknowledgements

The authors acknowledge the Parkinson's Disease Society UK for funding this study.