



Salisbury FES User Day Friday, 22nd February 2013

RCP Guidelines

The fourth addition of the Royal College of Physicians “National Clinical Guideline for Stroke” has been published. The guidelines have been brought into line with NICE and now recommend FES for correction of dropped foot:

Section 6.13.1: Functional electrical stimulation can be used for drop foot of central neurological origin provided normal arrangements are in place for clinical governance and audit.

Further, the guidelines now include a recommendation for the use of electrical stimulation for shoulder subluxation:

Section 6.19.2.1: Any patient who has developed, or is developing shoulder subluxation should be considered for functional electrical stimulation of the supraspinatus and deltoid muscles.

Intercollegiate Stroke Working Party. National Clinical Guideline for Stroke, 4th edition London: Royal College of Physicians 2012. ISBN 978-1-86016-492-7

<http://www.rcplondon.ac.uk/resources/stroke-guidelines>



The Effects of Functional Electrical Stimulation on Walking in Hereditary and Spontaneous Spastic Paraparesis

Jonathan Marsden, Valerie Stevenson, Carol McFadden, Ian Swain, Paul Taylor

Objectives: To investigate in people with spastic paraparesis (SP): 1) the factors contributing to foot drop and reduced toe clearance while walking; 2) short-term effects of bilateral functional electrical stimulation (FES) of the common peroneal nerve.

Materials and Methods: Long term (>0.5 years) users of FES with SP were compared to matched controls ($N = 11$ per group). Ankle strength and plantarflexor stiffness and walking kinematics were objectively recorded. The effects of FES on: 1) perceived efficacy; 2) muscle torque and ankle motion; 3) clinical outcome measures and walking kinematics were assessed. Results were compared using an analysis of covariance.

Results: Ankle weakness and stiffness is higher among people with SP. Higher plantarflexor stiffness is associated with reduced swing phase dorsiflexion; higher toe clearance while walking is associated with increased hip flexion. FES increases dorsiflexor torque, improves toe clearance and dorsiflexion in swing phase, and significantly improves walking speed ($p < 0.05$).

Conclusions: There are multiple causes of tripping in people with SP; FES reduces foot drop and improves walking speed.

Marsden J., Stevenson V., McFadden C., Swain I., Taylor P. 2012. The Effects of Functional Electrical Stimulation on Walking in Hereditary and Spontaneous Spastic Paraparesis. *Neuromodulation* 2012; E-pub ahead of print. DOI: 10.1111/j.1525-1403.201



A Feasibility Study to Investigate the Effect of Functional Electrical Stimulation and Physiotherapy Exercise on the Quality of Gait of People With Multiple Sclerosis

Paul Taylor, Catherine Barrett, Geraldine Mann, Wendy Wareham, Ian Swain.

Objective: To examine the effect of functional electrical stimulation (FES) for dropped foot and hip instability in combination with physiotherapy core stability exercises.

Methods: Twenty-eight people with secondary progressive multiple sclerosis and unilateral dropped foot participated in a randomized crossover trial. Group 1 received FES for correction of dropped foot for six weeks with the addition of hip extension for a further six weeks. In weeks 12–18, FES was continued with the addition of eight sessions of core stability physiotherapy with home-based exercise. FES and home-based exercise were continued until weeks 19–24. Group 2 received the same physiotherapy intervention over the first 12 weeks, adding FES in the second 12 weeks.

Results: FES improved walking speed and Rivermead Observational Gait Analysis (ROGA) score, whereas physiotherapy did not. Adding gluteal stimulation further improved ROGA score. Both interventions reduced falls, but adding FES to physiotherapy reduced them further. FES had greater impact on Multiple Sclerosis Impact Scale, MSIS-29.

Conclusion: The intervention was feasible. FES for dropped foot may improve mobility and quality of life and may reduce falls. Adding gluteal stimulation further improved gait quality. Adding physiotherapy may have enhanced the effect of FES, but FES had the dominant effect.

Taylor P., Barrett C., Mann G., Wareham W., Swain I. 2013. A Feasibility Study to Investigate the Effect of Functional Electrical Stimulation and Physiotherapy Exercise on the Quality of Gait of People With Multiple Sclerosis. *Neuromodulation* 2013; e-pub ahead of print. DOI: 10.1111/ner.12048



The long-term cost-effectiveness of the use of functional electrical stimulation for the correction of dropped foot due to upper motor neuron lesion

Paul Taylor, Laura Humphreys and Ian Swain

Objective: Functional Electrical Stimulation (FES) for correction of dropped foot has been shown to increase mobility, reduce the incidence of falls and to improve quality of life. This study aimed to determine how long the intervention is of benefit, and the total cost of its provision.

Design: Retrospective review of medical records. *Participants:* One hundred and twenty-six people with spastic dropped foot (62 stroke, 39 multiple sclerosis, 7 spinal cord injury, 3 cerebral palsy, 15 others) who began treatment in the year 1999.

Method: All received common peroneal nerve stimulation, producing dorsiflexion and eversion time to the swing phase of gait using a heel switch. Device usage, 10 m walking speed and Functional Walking Category (FWC) were recorded.

Results: The median time of FES use was 3.6 years (mean 4.9, standard deviation 4.1, 95% confidence interval 4.2–5.6) with 33 people still using FES after a mean of 11.1 years. People with stroke walked a mean of 45% faster overall, including a 24% training effect with 52% improving their FWC. People with multiple sclerosis did not receive a consistent training effect but walked 29% faster when FES was used with 40% increasing their FWC. The average treatment cost was £3,095 per patient resulting in a mean cost per Quality Adjusted Life Years of £15,406.

Conclusion: FES is a practical, long-term and cost-effective treatment for correction of dropped foot.

Taylor P, Humphreys L, and Swain I, The long-term cost-effectiveness of the use of functional Electrical stimulation for the correction of dropped foot Due to upper motor neuron lesion. *J Rehabil Med* 2013; 45: 154–160

FES used to affect bowel function in MS. A case Study

Christine Singleton
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Bowel dysfunction is a common problem for people with Multiple Sclerosis - 50% are prone to constipation with a major impact on quality of life and social engagement. There is little research into simple measures likely to improve bowel dysfunction. The use of electrical stimulation to the abdominal muscles was considered as a treatment option for one patient with chronic constipation. This case study reports on promising early results in the management of constipation over the last 6 months.



Shocking to the core: The initial findings of a service evaluation study of the use of gait-triggered functional electrical stimulation of nerves supplying core muscles

Emily Goodchild

Abstract

Background: Core muscle weakness is a common cause of gait disturbance in patients who have Multiple Sclerosis (MS). Gait-triggered functional electrical stimulation (FES) is a widely used, efficacious and cost effective treatment for dropped-foot in patients with MS, however, it is not yet clear whether stimulation of the nerves supplying core muscles is useful in improving gait.

Objective: To elucidate the use of gait-triggered FES of nerves supplying core muscles to improve walking in patients who have stable MS.

Method: The results of tests carried out on five healthy subjects were used to inform the electrode position placement, and stimulation parameters, used in six patients affected by stable MS. Baseline muscle power, tone and range of movement in the lower limbs, in addition to MSIS-29, 10 metre walk speeds, Borg Rating of Perceived Exertion (RPE), Rivermead Observational Gait Analysis and two-plane electrical goniometry were recorded prior to intervention in all patients. Electrical stimulation was delivered via two channels to electrode positions found to produce useful hip flexion, hip extension, knee flexion and/or spine ad- and abduction and the initial assessments immediately repeated. Patients will be reassessed immediately prior to the cessation of treatment at six weeks and two weeks after.

Results: Five of the six volunteers perceived their effort of walking to be less with core FES, compared to their foot-drop stimulation alone, over 10 metres, rated on the Borg scale (mean reduction 1.4) and their walking speed was increased (mean 27.14%). One patient did not perceive his effort of walking over 10 metres to change with the addition of core stimulation and his walking speed was reduced by 1.3%, however a three minute walk revealed a 19.6% walking speed increase. Rivermead observational analysis demonstrated improvement in gait in all six patients (mean reduction 5.3 units). One patient withdrew from the study at the first appointment one due to the inconvenience of applying additional electrodes daily.

Conclusion: Gait-triggered core muscle FES incurs an immediate improvement in gait, walking speed and perceived level of exertion compared to dropped-foot stimulation alone in all tested patients. The results of assessments after the use of core muscle stimulation over a six week period are awaited.



The role of FES in improving motor performance in Parkinson's disease. A feasibility study

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Background: Parkinsonian gait is characterized by bradykinesia (slowness of movement), hypokinesia (reduced movement size) and akinesia (difficulty in initiation of movement leading to freezing in gait). FES has been proposed as means of overcoming akinesia and it has also been observed that to increase walking speed and upper limb function.

Purpose: This trial investigated the feasibility of combining upper and lower limb FES

Design: Case series

Research volunteers: Mild to moderate PD, Hoehn and Yahr score 2 or 3 with effected gait and upper limb function.

Intervention: Volunteers received common peroneal stimulation on the most effected side using an ODFS Pace. They also received either radial nerve stimulation for long finger, thumb and wrist extensors or hand intrinsic muscles via the ulna and median nerves using the same device in its exercise mode. The duration of FES use was increased over the 2 week intervention period.

Outcome measures: 9 hole peg test, box and block test, 10m walking speed, cadence and step length, Tinetti balance scale, Modified Parkinson's Disease Quality of Life questionnaire (PDQL) and SPES/SCOPA scale. All tests were carried out without FES.

Results: 11 volunteers were recruited and 9 completed the protocol. 2 dropped out due to their difficulty in using the equipment. Mean walking speed increased by 0.29ms^{-1} ($p = 0.002$), step length by 0.09 m ($p = 0.007$) and cadence by $19.8\text{ steps min}^{-1}$ ($p = 0.045$). Improvement in balance was indicated by a change of 2.9 ($p = 0.006$) in the Tinetti score. There was no statically significant change in 9 hole peg test but there was an increase in the number of blocks moved in the box and block test of 5.1 blocks ($p = 0.025$). There was a significant change in the PD Symptoms score of the PDQL of 4.9 ($p = 0.013$) and also a reduction in the SPES/SCOPA score of -5.7 ($p = 0.005$) indicating a reduction in the impact of PD.

Conclusion: FES produced significant improvements in gait and to a lesser extent in upper limb function. Some volunteers found using both interventions challenging and we would recommend that their introduction be staggered over time.

Skin irritation audit at Oak Tree Lane Rehab Centre.

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Oak Tree Lane Rehab Centre.

In 2012 an audit on skin irritation experienced by patients currently using FES in the Birmingham UK clinic was undertaken. Of the 653 patients using FES, 114 (17%) now use hypoallergenic electrodes successfully following reported/nonreported skin irritation. The results will be presented informing on diagnosis, time to and reasons for irritation.

Recommendations on clinical procedures are made though the risk of irritation has not increased significantly since the last audit in 2005.



Case study demonstrating clinically important changes in function and sensation associated with constraint induced movement therapy and electrical stimulation

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Introduction

Constraint Induced Movement Therapy (CIMT) improves arm function post-stroke but little research focuses on sensation. There is some research suggesting electrical stimulation (ES) may improve sensation post-stroke.

Aims

To document changes in sensation and function pre/post outpatient CIMT incorporating ES.

Methods

David (pseudonym) aged 65 has hemiplegia affecting his right (dominant) hand (stroke 2002). He had activity in wrist/fingers/thumb but minimal functional use (12/06/12). CIMT consisted of 12 intensive goal orientated, task specific physiotherapy sessions over five weeks with pre/post assessments. A mitt worn for 60% of the day limited left hand use. He completed independent arm exercises focussed on sensorimotor function (two hours/day) and used cyclical ES of wrist/finger extensors for 30mins per day.

Results

Sensory: Pre-CIMT sensed touch but could not distinguish between hot/cold over hand. Post-CIMT distinguished hot/cold correctly on all tests. Pre-CIMT could feel stiffest Von Frey monofilament (6.65) over the extensor aspect of forearm but not elsewhere on forearm/hand. Post-CIMT registered the 4.93 filament over whole forearm/hand. David can now do up 'out of sight' shirt buttons for the first time post-stroke. His improved hot/cold sensation has important safety implications.

Motor: Nine Hole Peg Test: pre-CIMT=122 seconds(s), post-CIMT=83s. ARMA Caring for your arm: pre-CIMT=6/32, post-CIMT=1/32. ARMA Independence with tasks: pre-CIMT=20/32, post-CIMT=7/52. Writing Address: pre-CIMT 'gave in' after two lines (120s), post-CIMT completed all five lines in 97s (two months later 66s). Amount of use: pre-CIMT=34/65, post-CIMT=51/65; Quality of movement: pre-CIMT=30/65, post-CIMT=57/65.

Pre-CIMT David wouldn't have considered using his right hand for the demanding tasks he now routinely expects it to perform. He achieved his goal of writing greetings cards with his right hand.



Discussion

This case study demonstrates clinically important changes in function and sensation associated with CIMT incorporating ES. Further research is required to fully assess the effects of combining CIMT and ES.



Case study report: mobility improvements using bilateral Functional Electrical Stimulation in a patient with bilateral lower limb 'fixed dystonia' (medically unexplained)

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Introduction

Medically unexplained conditions are common and challenging to treat. Most previous research has reported benefits of FES for people with MS, stroke or spinal cord injury.

Aims

To describe improvements in gait in a patient with medically unexplained dystonia using Functional Electrical Stimulation (FES).

Methods

Clinical case study: John (pseudonym) is a 46 year old married businessman with a young family. John was diagnosed with ankylosing spondylitis in 2007 and presented with bilateral leg weakness (2010). Multiple clinical assessments yielded a diagnosis of unexplained 'fixed dystonia' and non-epileptic seizures. John walked slowly with a rollator using bilateral Toe-off orthoses which reduced the marked bilateral plantar-flexion and inversion but did not eliminate scuffing. His gait abnormalities were stable prior to FES. At rest passive dorsiflexion was restricted; he was unable to achieve plantargrade. John was open to the explanation that a medical cause was not found and that a psychological etiology was present. Psychological intervention was accessed initially but there was no active psychology input during the period described in this case study when we offered FES bilaterally as a pragmatic physical approach to help gait. NHS funding was secured for Common Peroneal Nerve stimulation using two ODFS Paces.

Results

FES improved clearance and speed and after 2 months using FES John could walk with crutches. Despite the fixed dystonia and lack of passive range he achieved bilateral consistent heel strike with FES. Rivermead Mobility Index: pre-FES=6/15, with FES=10/15. EQ5D-5L: change 0.60. Falls Efficacy Scale-International pre-FES=56/64, with FES=46/64. BORG pre-FES (orthoses off)=10/10, pre-FES (orthoses on)=8/10, with FES=4/10.

Discussion

This case illustrates improvements associated with FES in a patient with fixed dystonia including very restricted passive ankle dorsiflexion. FES has helped John manage his symptoms and achieve functional goals despite his complex history.



IMPROVING BALANCE WITH AN ELECTROCUTANEOUS FEEDBACK SYSTEM

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Keywords: electrotactile feedback, balance improvement

Abstract

Individuals with reduced sensation in their legs often suffer from balance problems and a high risk of fall. A device which gives information about balance can help a wearer to improve his balance. Electrocutaneous stimulation can be used to give feedback based on the data received from external force sensors. A device was developed that uses the input from force sensors integrated into a shoe insole to detect the change of the centre of pressure and uses electrical stimulation for feedback. The device is designed to help individuals with balance problems to compensate for their disability by redirecting the sensation from the affected areas of reduced sensation on the feet to sensing skin, e.g. in the upper limb. The wearer can interpret the feedback and correct the body position accordingly.

A clinical trial was conducted with 13 patients in Bournemouth Royal Hospital and the device was tested towards balance improvement with the test participants. The analysis is not finished yet, but preliminary results show that some patients could use the information from the feedback device to correct their balance.



STIMuSTEP **The first 56 cases**

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Abstract

A mixed population of 46 people have received the STIMuSTEP implanted dropped foot stimulator. The most common reason (44%) for receiving the implant was persistent skin irritation from external electrodes. 42 use the device successfully while 2 are unable due to device failure and 2 have been explanted. The performance of the device was evaluated using 10m walking speed, physiological cost index, distance walked in 3 minutes, the psychosocial impact of assistive devices scale (PIADS) and the SF36 quality of life scale. Comparisons were made with the response to an external FES device used before implantation. An 18% increase in walking speed, a 9% reduction in PCI and a 23% increase in distance walked in 3 minutes was recorded when the device was used. There was also a positive impact on quality of life. There was no significant difference between the external FES device and the implant in any functional outcome measures. However, device usage was higher in the implant group and the time taken to don and doff the equipment was significantly lower 11.7 to 2.3 minutes $p < 0.0001$. User satisfaction with the implant was high.

Initial versions of the implant were subject to cable fracture but this has been eliminated by design modifications. There is a risk of short term neuropraxia which resolves after a few weeks or months. The STIMuSTEP is a viable alternative to external FES for the correction of dropped foot where difficulties in placing electrodes, skin irritation or skin sensation prevent its successful use.