Institution: Queen Margaret University
Unit of Assessment: UoA 3 Allied Health Professions, Dentistry, Nursing and Pharmacy
Title of case study: Putting your worst foot forward: Orthotic interventions (including functional electrical stimulation) to enhance activity of daily living-related functional capacity and quality of life
1. Summary of the impact

Functional electrical stimulation (FES) to the ankle dorsi-flexors is an assistive technology that aims to counter foot drop, a common symptom in people with neurological impairment. Our research has facilitated a better understanding of the clinical potential of FES as a means to enhance walking capability and ultimately the quality of life of people with gait abnormalities associated with “dropped foot”. The production and dissemination of this research has directly had an impacted on local NHS clinical treatment practice and NHS clinical service evaluation/re-design in support of self-managed care of people with long-term conditions such as Cerebral Palsy, Stroke, and Multiple Sclerosis.

2. Underpinning research

Novel research, carried out with local clinicians specialising in the treatment of Cerebral Palsy, provided one of the first 3-dimensional kinematic evaluations of the effects of FES in patients eligible for neuro-rehabilitation services. This work by van der Linden, initially as a Research Assistant (2003) and latterly as a Research Fellow in Physiotherapy (2008) at Queen Margaret University, demonstrated that FES for selected children with cerebral palsy was a practical treatment option that improved their gait kinematics and was reflected in higher levels of parent-reported function.

Although evolving clinical guidelines recommended that FES for the management of dropped foot after stroke is delivered by a specialist team, little detailed guidance was provided about the structure and composition of any specialist team or model of service delivery. Consequently, Bulley and colleagues (2011, 2012) employed a combination of mixed-methods research and clinical practice reflection to investigate the viability and effectiveness of a novel multi-disciplinary FES tertiary outpatient service provided for the Lothian stroke population. This work, conducted initially as a Research Assistant and latterly as a Lecturer in Physiotherapy at QMU, observed clear improvement in the gait velocity and cadence of the FES service recipients. Qualitative findings revealed the emergence of one super-ordinate theme: 'The FES clinic met my needs' and four sub-themes:

1) 'Getting to grips with FES wasn't difficult';
2) 'It's great to know they're there';
3) 'Meeting up with others really helps'; and
4) 'The service is great but could be better'.

On reflection, minor modifications were made to the service delivery model but, overall, the service was considered to meet user needs.

Many people with Multiple Sclerosis (pwMS) also present with foot drop, which often results in the development of abnormal gait patterns resulting in disproportionately high levels of effort being needed to walk, contributing to an earlier onset of daily living-related fatigue. Ongoing research by van der Linden, Mercer and others (2012) has again used 3-dimensional kinematic analysis to explore how FES assists the gait in pwMS, whether in the longer term FES-assisted gait leads to decreased fatigue, and the relationships between FES-assisted gait characteristics, self-reported fatigue, activities of daily living and quality of life. The preliminary evidence from this research indicates that even prior to habitual use the acute application of FES in pwMS improved ankle and knee kinematics, resulting in a better foot clearance and thus potentially decreasing the risk of tripping (Scott et al, 2013).

The relevance and potential clinical impact of our FES research is also acknowledged, firstly in funding support received via local Allied Health Professional research capacity building initiatives:

- Stroke - Centre for Integrated Healthcare Research, Bulley et al £15K, and van der Linden and Bulley, £13.5K;
- Multiple Sclerosis - Edinburgh and Lothians Health Foundation (ELHF), van der Linden £7K;
- National symptom relief research awards (UK Multiple Sclerosis Society, £97K, Mercer, van der Linden).

Secondly, van der Linden's (2012) invitation to provide a research editorial on FES in children and adolescents with cerebral palsy.

3. References to the research

1. van der Linden M L, Hazlewood ME, Hillman SJ, Robb JE. (2008) Functional electrical stimulation to the dorsiflexors and quadriceps in children with cerebral palsy. *Pediatr Phys Ther*, Spring: 20(1): 23-9
2. Shiels, J and Wilkie, K and Bulley, Catherine and Smith, Stephen and Salisbury, Lisa (2011) A mixed methods service evaluation of a pilot functional electrical stimulation clinic for the correction of dropped foot in patients with chronic stroke. Primary Health Care Research Development, 12(3): 187-199. ISSN 1463-4236
3. Wilkie, Katie M and Shiels, Jane E and Bulley, Catherine and Salisbury, Lisa (2012) "Functional electrical stimulation (FES) impacted on important aspects of my life"—A qualitative exploration of chronic stroke patients' and carers' perceptions of FES in the management of dropped foot. *Physiotherapy Theory and Practice*, 28(1): 1-9. ISSN 0959-3985
4. Bulley, Catherine and Shiels, J and Wilkie, K and Salisbury, Lisa (2011) User experiences, preferences and choices relating to functional electrical stimulation and ankle foot orthoses for foot-drop after stroke. *Physiotherapy*, 97(3): 226-233. ISSN 00319406
5. Scott, S M and van der Linden, Marietta and Hooper, Julie and Cowan, P and Mercer, Tom (2013) *Quantification of gait kinematics and walking ability of people with multiple sclerosis who are new users of functional electrical stimulation.* *Journal of Rehabilitation Medicine*, 45(4): 364-369. ISSN 1650-1977. doi: 10.2340/16501977-1109
6. van der Linden, Marietta (2012) *Functional electrical stimulation in children and adolescents with cerebral palsy.* *Developmental Medicine and Child Neurology*, 54(11): 972. ISSN 0012-1622
7. Scott, S M and van der Linden, Marietta and Hooper, Julie and Cowan, P and Mercer, Tom (2013) Quantification of gait kinematics and walking ability of people with multiple sclerosis who are new users of functional electrical stimulation. *Journal of Rehabilitation Medicine*, 45(4): 364-369. ISSN 1650-1977. doi: 10.2340/16501977-1109

4. Details of the impact

Cerebral palsy (Van der Linden):
The original work with FES (NMES) conducted in children with CP by van der Linden has been identified as having an important influence in the clinical treatment of this group. Jan Herman, Senior Physiotherapist at the Anderson Gait Analysis Lab at the Astley Anslie Hospital, is willing to provide a testimonial indicating that the study by van der Linden et al (2008) on the effects of FES in children with Cerebral Palsy has directly influenced their clinical practice to such an extent that they now routinely consider prescribing FES as an alternative to an ankle foot orthosis (AFO), especially in the older child.

Mixed-methods FES Stroke Research Work (Bulley et al):
A dedicated FES service has a positive impact on functional ability and quality of life after stroke. Following this research-led service review, a Lothian-based clinic assessing twenty four patients per annum has now been established. The key beneficiaries of this impact were, in priority order:

1) The group of stroke patients with dropped foot who were observed in this research study to significantly improve their walking capability and, potentially their capacity for sustained independent living;
2) Subsequent groups of potential service recipients, who because of the research were able to continue accessing the service at its original level of access (24, instead of the reduction to 12, patients fitted with FES per year;
3) the Local NHS clinicians who as a result of the qualitative research and clinical practice reflection were able to utilise their expertise more effectively and in a more integrated fashion;
4) The local NHS Service provider who as a consequence of this research was able to offer a clinical service that better met the needs of the users.

FES units were initially funded by the Stroke Managed Clinical Network, then NHS Lothian agreed to fund 24 units a year. When the new, more expensive, PACE units were introduced this number was reduced to 12 because of increased cost. However, as a result of good practice in the clinic, as described in the article written by Shiels et al (2011), follow-up and refurbishment of old FES units (ODFS) meant that 24 patients per year could still be fitted.

The qualitative studies of the patient and carer views (Wilkie et al 2012), alongside a service evaluation, were particularly useful as these provided evidence supporting the continuation of the service. At a time when the cost of equipment is continuously reviewed, the findings of this research allowed a case to be made to support the continuation of the provision of FES to stroke patients in NHS Lothian. The equipment is now funded through the Neurological Out-patient Physiotherapy Service at Astley Ainslie Hospital, Edinburgh.

FES and Multiple Sclerosis (van der Linden, Mercer et al)

Although there is evidence to support the use of FES for people with stroke, there has been little research into its potential for people with MS. Moreover, previous investigations in people with MS did not comprehensively examine gait characteristics and so offered limited insight into how FES may facilitate walking ability or improve fatigue. The impact of this research is rooted in the provision of a better understanding of how FES assists gait in people with MS, for example whether in the longer term FES-assisted gait leads to decreased fatigue and ultimately how this may assist clinical service providers to more effectively deliver the required clinical service.

A related approach is evident in recently funded research (ELHF) which offers promise as a means to assist clinical service providers to more effectively deliver FES provision for people with MS. In people with MS, foot drop is often exacerbated as the result of fatigue. When a patient is assessed for suitability for FES during a clinical appointment, the patient's walking may only be visually assessed over several metres. Our pilot research study has recorded the amount of foot drop through using flexible ankle electrogoniometry over a period of extending walking (a maximum of six minutes) with a view to assessing the amount of foot drop over time.

Both the information provided by detailed 3D gait analysis, as provided by clinical gait analysis services in the UK, and the possibility of recording the degree of foot drop during a walking test, which can be carried out during a clinical appointment, have the potential to augment the information content of clinical assessments and have an impact on the clinical service provided at Slateford Medical Centre, Edinburgh.

As a result of this research, local clinicians will now consider referring patients with MS for clinical gait analysis to assess the need for FES and the impact of FES on gait kinematics. In addition, consideration is being given to the recording of the ankle kinematics during a prolonged walking assessment as part of routine FES fitting or follow-up appointment.

5. Sources to corroborate the impact

Confidential testimonial data from NHS Lothian and NHS Lothian FES service available on request.

Research by Bulley et all cited in:
Horsley W (2012) *Orthotic functional electrical stimulation for drop foot of neurological origin.NHS North East Treatment Advisory Group.*
http://www.netag.nhs.uk/files/appraisal-reports/NETAG%20appraisal%20report%20-%20FES%20for%20drop%20foot%20-%20web%20version%20-Jan%202012.pdf

NHS Scotland Evidence note 25:
http://www.knowledge.scot.nhs.uk/media/CLT/ResourceUploads/4003796/TheUseOfFunctionalElectricalStimulation(FES)inAdultsWithDroppedFoot_OCT08.pdf

MS FES research activity is included in, and cited by, The Foundation for Assistive Technology (http://www.fastuk.org/about/)
http://www.fastuk.org/research/projview.php?trm=mercer&id=1607

This is a highly influential body that "works" directly with academic researchers, industry, service providers, policy makers and voluntary sector organisations to raise awareness of the crucial importance of equipment to achieve independence by (1) providing expert analysis of research and development trends and service provision challenges and (2) providing a central hub for the sector to review and provide action plans on promoting good practice and to address cross-sector barriers to delivering good services.

MS Trust magazine – Article on impact of the study and the walking experience of MS sufferers.
MS Connect Vol 5 Issue 3 June/July 2010