Observational Gait Analysis for Evaluating the Effectiveness of Functional Electrical Stimulation Enhanced Gait

JP Hasler¹, M Molin², K Lentz², V Gerkens², S Oestergaard², E Scott³, SL Vazquez⁴, I Nunez del Rio⁴, JThMM Cloostermans⁵

¹ Queen Elizabeth National Spinal Injuries Unit, South Glasgow University Hospitals, Glasgow, Scotland.
² Clinic for Para and Tetraplegia, Rigshospitalet, Copenhagen University Hospital, Denmark.
³ Princess Royal Spinal Injury Unit, Northern General Hospital, Sheffield, England.
⁴ Unidad de Lesionados Medulares, Hospital Juan Canalejo, Coruna, Spain.
⁵ Rehabilitation Centre Het Roessingh, Enschede, The Netherlands.

Abstract

Purpose: To use Observational Gait Analysis (OGA) to evaluate the effects of FES for improving the gait of Incomplete Spinal Lesioned subjects.

Participants: OGA was performed on 35 subjects by nine physiotherapists at five centres. Methods: Following a period of FES use the gait of each subject was assessed twice, once without FES (1) and once with FES (2). Video recorded lateral views and anterior/posterior views were used and gait deviations, as defined by the Rancho Los Amigos OGA system, were scored. This system categorises 169 gait deviations (83 major and 86 minor). Gait improvements are demonstrated by comparing the major and minor deviations between assessments 1 and 2. Results: Considering all subjects, major deviations without FES averaged 27, this reduced by 9 with FES use. Minor deviations without FES averaged 5. This reduced by 11 with FES use. 34 subjects showed a decrease in major deviations and 31 subjects also showed a decrease in minor deviations. 34 subjects showed an increase in major deviations but 1 subject had an increase in minor deviations. Although all the subjects showed an overall reduction in deviations, 24 showed new deviations with FES. Conclusions: It was observed that FES improved the quality of gait in all of the subjects. OGA was found to be a useful clinical outcome measure for evaluating the effects of FES walking systems.

1. Introduction.

In Europe there are many thousands of new spinal cord lesion cases every year, most of these individuals being young men. It has been shown that in patients with an incomplete spinal cord lesion (ISCL) FES can improve the marginal gait into a gait that is useful in the community. Unfortunately the necessary expertise to apply this technique is held in a relatively small number of centres whereas the end users are widely distributed. The main aim of the CREST (Clinical Rehabilitation using Electrical Stimulation via Telematics) project was to demonstrate that FES systems can be applied locally by a professional ‘non-expert’ clinical user aided by interactive teleconsultation with remote ‘expert’ centres.

An essential and central theme of the project was to enable assessment of patients to be undertaken in a normal clinical setting. To this end one of the assessment tools used was the observational gait analysis (OGA) as pioneered by Rancho Los Amigos [1]. The advantage of the OGA in the clinical setting is its speed, simplicity and low cost compared instrumented gait analysis systems. OGA combines observation of the temporal parameters of gait with kinematics (joint angles). The Rancho Los Amigos OGA system is the most comprehensive OGA system which has been widely reported. It is one of the few OGA systems which is not pathology specific.

The aim of this study was to evaluate the use of the OGA to quantify the effects of FES for improving the gait of ISCL subjects.

Participants

This work was carried out by nine physiotherapists working in the following five rehabilitation units:
1. The Queen Elizabeth National Spinal Injuries Unit, Glasgow, Scotland.
2. The Clinic for Para and Tetraplegia, Copenhagen, Denmark.
4. The Unidades de Lesionados Medulares, Coruna, Spain.
5. The Rehabilitation Centre Het Roessingh, Enschede, The Netherlands.

Each of the centres specialise in the management of the ISCL individuals, and each of the physiotherapists was highly experienced in the assessment and treatment of these patients.

For details of the patients in this study please refer to the paper of Biering-Sørensen at al. [2].
2. Method

Study Design

This study had the main aim of testing if the use of individualised FES, in a clinical setting, enhances the gait of individuals with an incomplete spinal cord injury. A Single Case (N=1; A,B,A) Experimental Design (SCED) as described (Barlow and Herson 1984) repeated on all subjects was used.

A baseline measure was established prior to intervention. This was followed by a period of application of an individualised FES strategy which was iteratively improved. During this phase the two ‘non-expert’ centres were supported by teleconsultation with the three ‘expert’ centres.

At the end of the intervention period subjects were reassessed. At this point reassessment of their gait was performed both using their final prescribed FES system and without FES. A comparison between the gait with and without FES was made.

Observational Gait Analysis (OGA)

In the Rancho Los Amigos OGA gait pathology is defined in terms of deviation from normal function. In this system the gait cycle is divided into 8 phases. The definitions used for these phases are slightly idiosyncratic when compared to the standard classifications used in biomechanics. The form appended to the end of this paper shows the Gait Analysis: Full Body Form used by the system to record gait deviations. On the form the rows represent gait deviations and the columns gait phases. The scoring is constrained by blanking out those phases where certain deviations are not possible and by indicating the severity (grey boxes for minor deviations) of the deviation in each phase. A score for total limb function is obtained by summing the gait deviations that occur in each phase.

The system then identifies thirty five possible deviations in the trunk, pelvis, hip, knee, ankle and toes in each of the eight phases of the gait. The choice is then given of having either a major or minor deviation or no possibility of a deviation at all. This gives a total of eighty-three major and eighty six minor deviations making a total of one hundred and sixty nine in all, per leg. These are represented on a form known as the “Full Body Gait Assessment form”.

<table>
<thead>
<tr>
<th>Weight acceptance</th>
<th>IC</th>
<th>Initial contact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LR</td>
<td>Loading response</td>
</tr>
<tr>
<td>Single limb support</td>
<td>MS</td>
<td>Mid stance</td>
</tr>
<tr>
<td></td>
<td>TS</td>
<td>Terminal stance</td>
</tr>
<tr>
<td>swing limb</td>
<td>PSw</td>
<td>Pre swing</td>
</tr>
<tr>
<td>advancement</td>
<td>ISw</td>
<td>Initial swing</td>
</tr>
<tr>
<td></td>
<td>MSw</td>
<td>Mid swing</td>
</tr>
<tr>
<td></td>
<td>TSw</td>
<td>Terminal swing</td>
</tr>
</tbody>
</table>

Table 1 Gait cycle divisions used in the Rancho Los Amigos OGA system

To subjects’ gait was videod, and saved to hard disk, whilst they walked along an eight-metre walkway. Both sagital plane and frontal plane views were recorded. This video was analysed in slow motion to record any gait deviations.

OGA Analysis

A score for combined total limb function was obtained by summing the gait deviations that occured in each phase. This was performed separately for the major and minor deviations and also for the total of both major and minor deviations. A comparison was made between these number of deviations in the two assessment conditions of FES walking and non-FES walking.

3. Results

In figure 2 comparing the change in the sum of total deviations for FES against sum of total deviations without FES it can be seen that all patients exhibit a reduction in the deviations scored when using the FES system. Whilst all patients exhibited a net fall in deviations some patients expressed new deviations as a result of the FES system.

In all the subjects’ OGAs the number of gait deviations was seen to have been reduced with the introduction of FES. However in a number of the subjects it was seen that, when using the FES, there were a number of newly acquired deviations.
4. Discussion

All nine physiotherapists found that the Rancho Los Amigos OGA was effective in identifying gait deviations in ISCL individuals and identifying changes to these gait patterns produced by the use of FES. The greatest changes seen were in the most disabled subjects.

All nine Physiotherapists were in agreement that the Rancho Los Amigos OGA was an excellent tool in assessing and formalising changes to a subject’s gait pattern. It was also found to be relatively fast and worked well in a clinical physiotherapy setting.

The authors recommend its use in the assessment of gait in this group of individuals and also in assessing the effects of FES.

Acknowledgement: The project was supported by the European Commission through the Fourth R & D framework programme. Telematics application programme. Telematics for the integration of the disabled and elderly (DE3204).

References