**Electrical stimulation in dysphagia treatment: a justified controversy?**

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**Key-words.** Dysphagia; electrical stimulation

**Abstract.** Electrical stimulation in dysphagia treatment: a justified controversy? Neuromuscular electrostimulation (NMES) is a method for stimulating muscles with short electrical pulses. Neuromuscular electrostimulation is frequently used in physiotherapy to strengthen healthy muscles (as in sports training) or to prevent muscle atrophy in patients. The first article on the use of NMES as a motor treatment in dysphagic patients was published in 2001. The study involved treating a group of stroke patients with NMES. The supralaryngeal muscles were stimulated using transcutaneous electrostimulation. On the basis of that study and additional reports from the same researcher, a commercial product was developed and marketed. The way in which this product was designed by its producers and evaluated in publications has rendered the use of NMES in the field of dysphagia treatment controversial.

Recent literature reports are rather mixed about the effects of NMES on swallowing physiology and possible treatment outcomes. However, critical appraisal of the literature on NMES in dysphagia treatment shows a diversity of treatment parameters, which may be a confounder for the different outcomes in these studies. NMES is used with a variety of different parameters for different types of treatment since muscle contraction is dependent on different electrical parameters. A standard operation protocol for the use of NMES in the treatment of dysphagia seems to be required in order to study the outcomes of this treatment modality in different populations. The current controversy seems to be a threat to the potential benefits of NMES in the treatment of dysphagia.

**An introduction to neuromuscular electrical stimulation**

Neuromuscular electrostimulation (NMES) is a method for stimulating muscles with short electrical pulses. Since the late 18th century, it has been well known that muscles contract when an electrical stimulus is applied to the muscle or its innervating nerve. The first author to publish about this phenomenon was Luis Galvani in 1791. Since Galvani’s time, electrical stimulation has acquired a position in physiotherapy and it is now a well-researched part of many rehabilitation programs.

Neuromuscular electrostimulation is frequently used in physiotherapy to strengthen healthy muscles (as in sports training) or to prevent muscle atrophy in patients. Good therapy outcomes have been reported in cases where electrostimulation is combined with active exercises. This combination of active exercising with electrostimulation has a distinct advantage over traditional physiotherapy without the use of NMES. In 2005, Umarova et al. published a study in which they showed that motor function in stroke patients recovers faster with the help of NMES than in a control group treated without NMES.

In the literature currently available, the effects of NMES on healthy muscle have been well described as an adjunct to traditional therapy for training muscles and muscle groups faster and better. The literature also supports the therapeutic application of NMES to enhance muscle strength, retard muscle atrophy, and reduce spasticity. The first PubMed citation on the use of NMES dates from almost two decades ago. Since that first study, more than 200 studies have been published about the use of NMES.

**Neuromuscular electrical stimulation in dysphagia treatment**

The first article about the use of NMES as a motor treatment in dysphagic patients was published by Freed et al. in 2001, and it described treatment of a group of stroke patients with NMES. In that study, the supralaryngeal muscles were stimulated using transcutaneous electrostimulation. The aim of the electrical stimulation was to stimulate the muscles responsible for laryngeal elevation during swallowing. Two muscle groups were therefore stimulated: the m. thyrohyoideus and the mouth floor muscles (m. digastricus). The m. thyrohyoideus runs
between the hyoid and the thyroid and contraction of this muscle during swallowing causes the vertical elevation of the larynx. The mouth floor muscles cause an anterior movement of the hyoid during swallowing, so that during swallowing the larynx also moves forward and causes the upper oesophagus sphincter to open.

According to the authors, the clinical results of this treatment were superior to those for a control group, although the data presented in this initial publication were unconvincing because of the poor description of the procedure itself, the mixed use of standard therapy with the electrical stimulation procedure, and the use of cricopharyngeal myotomy or cricopharyngeal dilatation in many patients without any clear description of how, why, and when these procedures were performed. In addition, the underlying neurophysiological basis for using the procedure that involves surface electrode placement on the external lateral neck was poorly defined.

Nevertheless, this study by Freed et al. and additional reports by the same researcher led to the development and marketing of the commercial product “VitalStim”. In their advertisements and on their website the manufacturers of VitalStim claim to have obtained “better and faster results than any traditional therapy”. Careful review, however, of the current literature on the effectiveness of treatment using VitalStim results in an interesting observation. Generally, studies using non-blinded subjective outcome measures based on non-validated rating scales reported potential success with the VitalStim treatment. If, however, blinded and more objective measures such as myoelectric activity, hyoid movement or biomechanics were defined as outcome measures, then no positive effect was reported.

The design of VitalStim by its producers and the way it has been evaluated in publications has also made many clinical investigators and clinicians think carefully about how a new procedure should be designed, evaluated, and introduced for commercial gain. Generally, there should be a strong neurophysiological rationale for the procedure’s application to a particular patient group or groups, followed by studies that define the efficacy of the procedure in a small group of patients, preferably a homogeneous group, before moving on to a study of a larger group of patients, preferably several groups representing different diagnoses. A clinical trial should then be developed if the procedure is found to be effective in studies of smaller groups. The producers of VitalStim skipped all of the steps described here.

Nowadays, it would seem that the brand name “VitalStim” is more widely known among speech therapists and in the medical field than the actual name of this application: neuromuscular stimulation. Given the situation described above, NMES in the field of dysphagia treatment has become controversial. This controversy could be the result of the failure of the producers of VitalStim to assume their responsibility to the clinical research world and patients with dysphagia, who are desperate for additional treatment procedures. Much more research is needed to determine whether methods of neuromuscular electrical stimulation have any role to play in the management of oropharyngeal swallowing difficulties in any specific patient group.

Recent literature about the use of NMES in dysphagia treatment

In 2003, Leelamanit et al. published a study of the positive clinical effects of a treatment programme with NMES on patients with chronic dysphagia. Unfortunately, this study was flawed methodologically. Consequently, in 2003, Burnett et al. published a study in which the muscles in the floor of the mouth in 15 healthy persons were stimulated with hooked-wire electrodes. This study showed that stimulation with a 30 Hz frequency and a phase duration of 200 μsec of the submental muscles would result in a laryngeal elevation of about 50% of the laryngeal elevation accomplished during swallowing. Researchers concluded that NMES could possibly contribute to swallowing rehabilitation in patients with swallowing disorders.

In 2006, two studies were published on the outcomes of NMES in dysphagia therapy with opposing conclusions. Blumenfeld et al. concluded that, in a cohort of 40 patients, treatment of dysphagia with NMES is superior to conventional treatment, whereas Kiger et al. published a small randomised trial with 22 patients in which they concluded that the use of NMES in dysphagia treatment did not lead to significant differences in treatment outcome.

In a recent study, we evaluated the efficacy of NMES in patients with severe multiple sclerosis and dysphagia. Twenty-five patients with multiple sclerosis and
Swallowing problems were treated for three weeks with two sessions of neuromuscular electrostimulation (NMES) per week. For the electrical stimulation we used the Myomed-134 (ENRAF-NONIUS, Rotterdam, Netherlands). A 30 Hz, 200 μs current with a surge pattern was used. Patients were stimulated for 10 seconds and were then given a break of 20 seconds. During the 10-second stimulation period, the patients were asked to swallow. After treatment, a significant decrease in the pooling of saliva in the piriform sinuses was seen in six patients (p = 0.03) and significantly less aspiration during the swallowing of thin liquids (p < 0.01) was seen in nine patients. Overall, patients reported that their swallowing had improved (p < 0.01) and 20% of all patients found it had become less strenuous. No adverse effects of the treatment were reported [Bogaardt H, et al. Personal communication].

Researchers have suggested that, in addition to effects on motor function, some types of electrical stimulation might have a sensory (corticobulbar) effect. In 1998, Hamdy et al. showed that 30 minutes of pharyngeal stimulation in humans would lead to increased motor cortex excitability. Following this study, Fraser et al. published a study in which they found an increase in corticobulbar excitability with a concomitant improvement of swallowing function in small group of dysphagic stroke patients. A similar outcome was recently found by Oh et al. in eight dysphagic patients.

Despite all the publications referred to here, the use of NMES as an adjunct to standard treatment in dysphagic patients is still quite controversial. Although there is still an academic debate about the efficacy of NMES in the treatment of dysphagia, the number of speech therapists using this adjunct to swallowing rehabilitation seems to be growing.8

**Issues to be addressed in NMES in dysphagia treatment**

NMES is used with a variety of different parameters for different types of treatment since muscle contraction depends on different electrical parameters. An increase in frequency (Hz) will result in an increased tension of the stimulated muscle, whereas increased intensity spreads current over a larger area, stimulating more motor units. Lastly, increasing the current duration causes more motor unit activation. NMES can be used for either muscle strengthening, retardation of atrophy or muscle re-education, and different stimulation parameters have to be chosen for each of these three applications of NMES.

The most effective parameter for enhancing muscle strength, in terms of the control of the parameters within the clinical therapeutic range, might be the stimulus intensity. However, when sufficient intensity is already being applied in NMES, and when it is necessary to modulate an additional parameter, increasing the frequency might be the best option if the takes the issue of muscle fatigue into consideration.17

An optimal NMES system for muscle re-education (which is normally used in the treatment of dysphagia) utilises the minimal stimulus frequency that produces a fused response. Ideal stimulation frequencies range from 12 to 25 Hz. Greater muscle force generation is accomplished by either increasing the pulse duration (typically 200 μs) or stimulus amplitude to activate neurons at a greater distance from the activating electrode. These parameters have been established for limb muscles which are histologically different from the head and neck muscles. So far, no attempts have been made to define the optimal stimulation parameters for the use of NMES in dysphagia. In 1956 Doty and Bosma published a rare study in which they found that the fire frequency of the laryngeal muscles is around 30 Hz. This publication suggests that a low-frequency stimulation is appropriate for NMES in dysphagia treatment.

Unfortunately, in studies published recently on the effects of NMES on dysphagia and swallowing physiology, no standard stimulation parameters are used by the different researchers.

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**Table 1**

<table>
<thead>
<tr>
<th>Study</th>
<th>Frequency</th>
<th>Pulse duration</th>
<th>Treatment intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freed et al. (2001)</td>
<td>80 Hz</td>
<td>300 μs</td>
<td>1 hr daily</td>
</tr>
<tr>
<td>Leelamani et al. (2002)</td>
<td>60 Hz</td>
<td>not described</td>
<td>4 hrs daily</td>
</tr>
<tr>
<td>Burnett et al. (2003)</td>
<td>30 Hz</td>
<td>200 μs</td>
<td>n/a*</td>
</tr>
<tr>
<td>Langmore et al. (2006)</td>
<td>50 Hz</td>
<td>200 μs</td>
<td>Not described</td>
</tr>
<tr>
<td>Ludlow et al. (2007)</td>
<td>80 Hz</td>
<td>300 μs</td>
<td>n/a*</td>
</tr>
<tr>
<td>Bogaardt et al.</td>
<td>30 Hz</td>
<td>200 μs</td>
<td>20 min / twice weekly</td>
</tr>
</tbody>
</table>

* = not applicable.
Table 1 shows a short overview of different stimulation parameters used by various researchers in recent history. As different outcomes can be expected with different stimulation parameters, these studies report different findings for NMES in dysphagia treatment.

Interestingly, Table 1 also addresses the subject of treatment intensity. The literature contains several studies conducted to establish the optimal treatment intensity for NMES: the number of treatment sessions and the length of the sessions required for optimal outcome with this treatment. Findings by McCarthy et al. in 2002 provide a physiological basis as support for several performance studies that consistently indicate that concurrent training of three times weekly is optimal. For muscle re-education, stimulation at a level of comfortable contraction with surge current and patients attempting to contract muscles along with the stimulation for 15-20 minutes each treatment session is also advised.

Nevertheless, a recent published meta-analysis of existing literature revealed a small but significant summary effect size for transcutaneous NMES for swallowing. The small number of studies and low methodological grading for these studies mean that caution is advisable when interpreting this finding. The authors believe that these results support the need for more rigorous research in this area.

**Conclusion**

NMES is frequently used in physiotherapy and has been well described for several decades. The use of NMES in dysphagia treatment is relatively new; the first study of the use of this modality was published in 2001. Since then NMES has been marketed intensively, although questions persist about the physiological rationale underlying this treatment modality. This has made the use of NMES in the treatment of dysphagia rather controversial. Recent literature reports about the effects of NMES on swallowing physiology and possible treatment outcomes are quite mixed. These findings have fuelled the controversy still further.

**References**

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