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Characteristics of lateral electrical surface stimulation (LESS) and its effect on the degree of spinal deformity in idiopathic scoliosis

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Clinical studies were carried out in the period of 2003-2006 at the Provincial Children's Rehabilitation Hospital in Ameryka near Olsztyn (Poland). The study involved a group of children and youth exhibiting spinal deformity progression in idiopathic scoliosis (IS) of more than 5° per year according to the Cobb scale. Four hundred and fifty patients between 4 and 15 years of age were divided into three groups (n = 150). Group I and group II received 2-hour and 9-hour lateral electrical surface stimulation (LESS), respectively, whereas group III (control) was treated only with corrective exercises for 30 minutes twice a day. LESS was performed with the use of a battery-operated SCOL-2 stimulator manufactured by Elmech, Warsaw, Poland.

The effectiveness of this method was confirmed in the treatment of spinal IS in children and youth, especially when the initial spinal deformity did not exceed 20° according to the Cobb scale. A short-duration electrostimulation (2 hours daily) was found to produce results similar to those obtained after overnight (9 h) electrostimulation. Moreover, the analysis of the Harrington prognostic index F confirms the positive effect of LESS in both groups of patients (2 h and 9 h of LESS).

Key words: electrostimulation, LESS, rehabilitation, idiopathic scoliosis.

Introduction

Idiopathic scoliosis (IS) in children and adolescent youth is an important problem for treatment centres due to its quite high prevalence. It has been estimated that globally this problem concerns, depending on the method and the region analysed, from 0.3 to 15.3% of the population. In Poland, the occurrence of this condition ranges from 2 to 14%, while in Western Europe it involves 2 to 3% of the population. The majority (80-90%) of reported spinal deformities are those of idiopathic scoliosis (IS), i.e. arising from an unknown cause [1-3].

A wide variety of kinesitherapeutical methods applied in spinal lateral deformity (SLD) treatment have an undeniable effect on stopping the deformity progression, however, current procedures are influenced by the interpretation of the pathogenesis of this condition [1-3].

Based on electromyographic studies, a decreased activity at the concave side has been observed in the superficial muscles stabilizing the spine. Excessive activity of the convex side indicates a defensive response so as to maintain the spine in an upright position. This indicates an asymmetric activity of the muscles stabilising the spine [4, 5].

However, asymmetric exercises have long been shown to be ineffective because certain spinal muscles, especially the intervertebral muscles, are not amenable to exercises aimed at their selective strengthening or loosening [6].

In recent years, attention has been paid to the disorders of the nervous-muscular system and their secondary effect on lesions in the spinal osteoarticular-ligament system as one of the potential causes of IS [7-9]. Therefore, LESS was introduced into the conservative treatment of IS.

The aim of this study was to determine the effectiveness of LESS therapy in treating children and youth with IS.

Material and methods

Clinical studies were carried out in the years 2003-2006 in a research project financed by the State Committee for Scientific Research at the Provincial Children's Rehabilitation Hospital in Ameryka near Olsztyn. The study involved a group of children with the progression of the spinal deformity of more than 5° per year according to the Cobb method. In all the cases examined, scoliotic deformity was located within the thoracic segment of the spine between Th4 and L1. The Cobb deformity angle in the children examined ranged from 10° to 39°. The study involved 450 children and youth between 4 and 15 years of age divided into three groups (n = 150): group I and group II with 2-hour and 9-hour LESS, respectively, and group III – a control group.

Children in both groups stimulated (LESS) had additional corrective exercises at home, applied twice daily for 30 minutes, while children in group III were only treated with the same corrective exercises.

Electrical stimulation was performed with the use of a battery-operated SCOL-2 stimulator produced by Elmech, Warsaw [3, 7-9]. The stimulator's technical parameters were as follows: rectangular approx. 0.1 ms impulses and frequency of 20-55 Hz, duration of the impulse series of 3.5-4.5 s, impulse series intervals of 4-12 s, and the stimulation current amplitude range of 5-75 mA. The impulse waveforms during laboratory trials were recorded on a TEKTRONIX oscilloscope using a state-of-the-art technique for imaging electric signals.

Impulses generated by the stimulator have the form of slightly differentiated rectangles, registered in a stimulator using a substitute resistance of 5.1 kΩ, similar to human tissue resistance (Figures 1a and b).

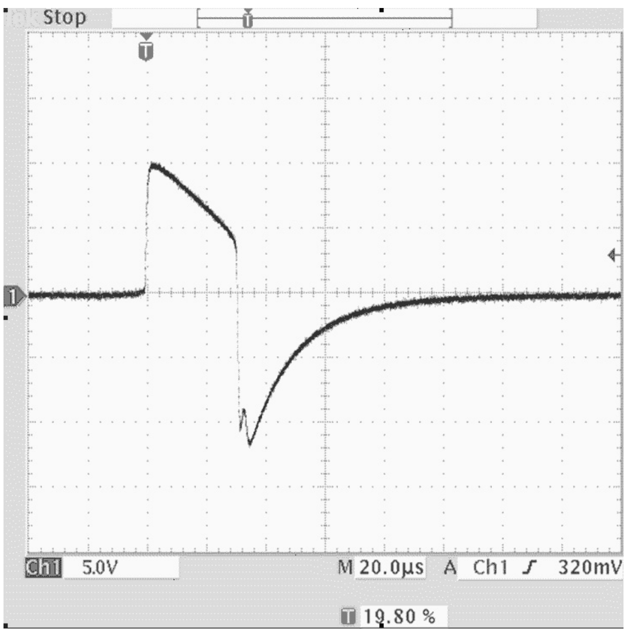


Figure 1a. Plot of minimum impulse amplitude set to 5 of scale

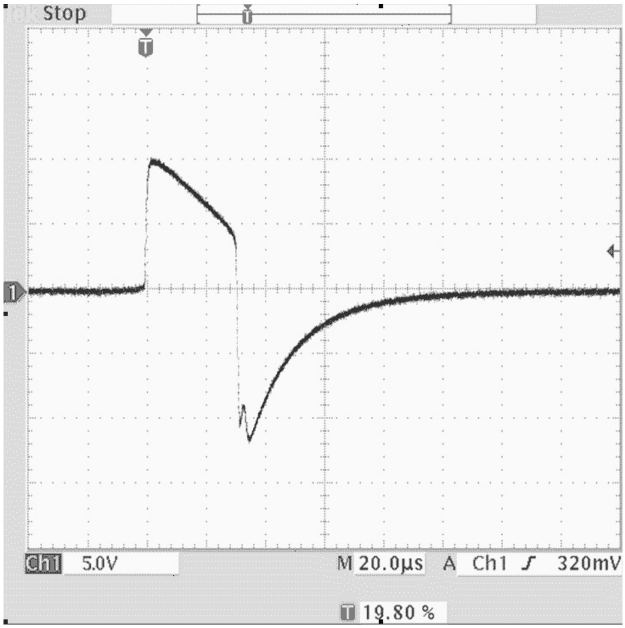


Figure 1b. Plot of maximum impulse amplitude set to 30 of scale

Electrical stimulation of trunk muscles was performed with superficial disc-shaped electrodes approximately 20 mm in diameter. The conductive rubber electrodes were placed along the scoliotic deformity every 6-12 cm, depending on its length, which is on average 10 cm.

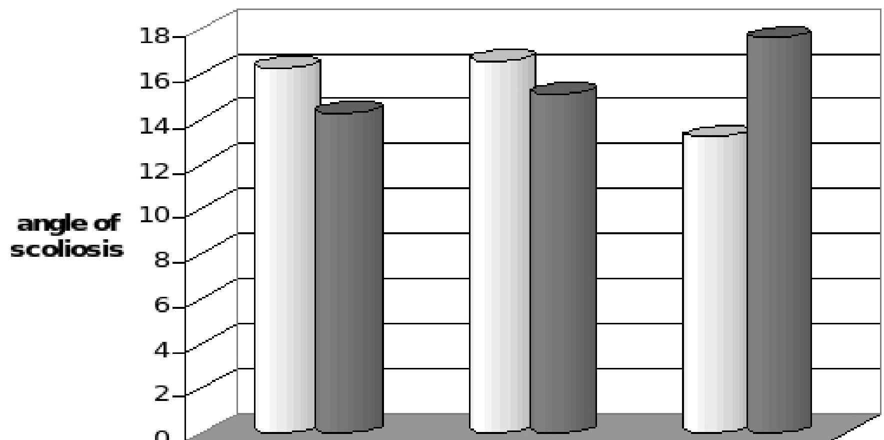
It is recommended that the electrode be located below the blade of the shoulder blade alongside the spinal line at the convex side of the scoliotic deformity. There are three possible locations of the electrodes: medial, intermediate and lateral. Based on preliminary studies, the intermediate location ensures the best conditions of stimulation. In this location, the effect of LESS, both after a long-duration (9 h) and a short-duration (2 h) electrostimulation, was analysed in all cases.

The effectiveness of the LESS treatment was evaluated from the measurements of the initial spinal deformity angle prior to the treatment and that after 24-month treatment (including corrective exercises in combination with stimulation or only corrective exercises in a control group). The deformity angle was measured in an upright position in a a-p projection according to the Cobb method in three subranges of angle value: 10-19°, 20-29° and 30-39°. The mean value of the deformity angle before treatment and the mean deformity decrease or scoliosis progression after treatment were determined for each experimental group. Moreover, the Harrington prognostic co-efficient F, defined [in 17] as equal to the Cobb deformity angle divided by the number of vertebrae within the deformity, was determined.

All clinical results were statistically analysed with a t-Student test.

Results

The clinical results obtained after therapy with LESS (Figures 2 and 3) depended on the deformity angle range to which the patients were qualified before treatment. In the 10-19° range, some improvement after treatment was observed: on average 2° decrease in deformity angle size. This value is statistically significant at p = 0.01. The LESS treatment proved to have a significantly positive effect in 75.5% of all cases of small deformities. In the 20-29° range, only a slight (0.3°) improvement in the scoliosis angle was observed after treatment. Stabilisation was observed in almost half of the patients, whereas in the 30-39° range a mean 1.4° scoliosis progression (not statistically



	LESS 2 h	LESS 9 h	control group
□ before treatment	16,3	16,6	13,2
■ after treatment	14,3	15,1	17,6

Figure 2. Mean values of the deformity angle before and after treatment

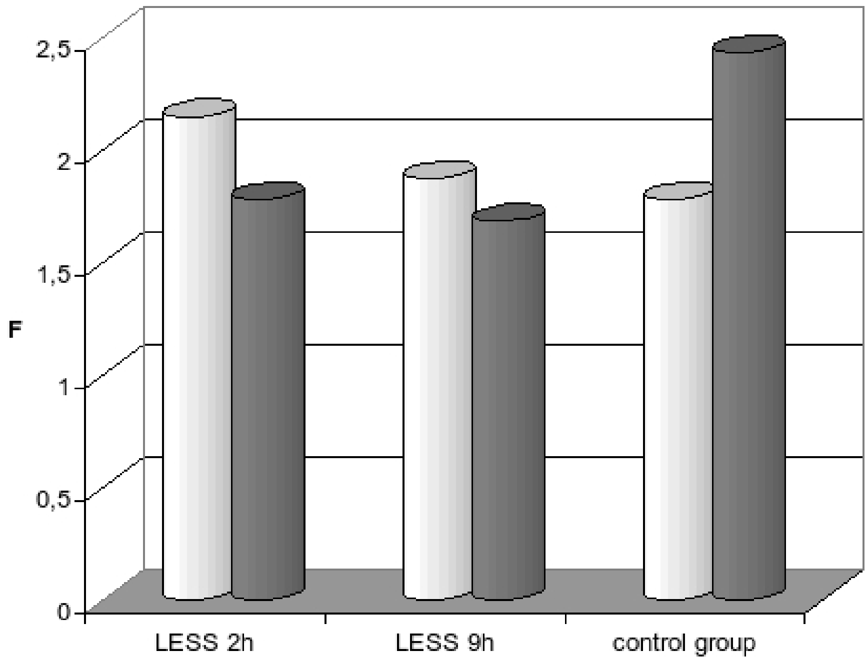


Figure 3. Mean values of the F co-efficient before and after treatment

significant) was recorded after treatment. Therefore, the therapeutic effect in this group of patients was small.

In a group of scolioses treated with LESS, the best therapeutic effect was obtained in patients with an initial spinal scoliosis angle below 20° according to Cobb method.

In the control group, scoliosis progression of approximately 4° according to Cobb method (statistically significant at p = 0.01) was observed despite 24-month rehabilitation.

Discussion

Currently, functional electrostimulation of the nervous-muscular system (FES) brings about positive effects. The ever-growing number of applications of electrostimulation as a supportive factor in other treatment methods has been observed. Results of studies carried out at different centres justify the application of LESS in the treatment of IS [9-12]. Electrostimulation of spinal muscles is the only method which can protect asymmetric activity of spinal muscles including intervertebral muscles. Therefore, the non-invasive LESS method will hopefully be used in the treatment of children with IS [9-12]. It can, however, only be used in grade I° scoliosis, where there are no profound morphological lesions and no degenerative changes in concave side muscles [10-12].

Bobechko [12] was first (1974) to introduce electrostimulation for treating IS using superficial electrodes and then electrodes implanted into perispinal muscles. By implanting electrodes he wanted to reach deep layers of segmental muscles. Stimulation was performed in a horizontal position while sleeping, and lasted from 8 to 10 h. In 1983, Axelgaard [11] showed that percutaneous electrostimulation with electrodes placed on the patient's back also produced advantageous results compared with those obtained with implanted electrodes. An increase in muscle tension can be obtained by direct stimulation of a muscle or by a reflex arc as well as by excitation causing facilitation of or decrease in inhibiting excitation [5].

The results obtained by Bobechko [12] were encouraging enough for many authors to introduce electrostimulation among the methods used in treating spinal lateral scolioses. The main goal of LESS is to replace the non-existing or reinforce the defective bioelectrical activity with adequately formed series of electrical impulses acting directly on the affected nervous-muscular structures. An advantage of electrostimulation is the excitation of afferent nervous fibres through which the spinal cord structures are excited. Thus a substitute excitation model is initiated or a new stereotype of muscle activity control system is created [5, 12].

Over the period of the last twenty years there have been many reports on the effects of LESS functional electrostimulation on the reduction or stopping progression of the disease, or even a decrease in the initial spinal scoliosis. The results concerning the effectiveness of LESS are unequivocal, especially as regards the range of the angular deformity for which this type of therapy could be used without causing side effects [9-13].

Weiss and Pasniczek were first in Poland to apply electrostimulation [14, 15]. At the Konstancin Rehabilitation Centre (1979-80) they used electrostimulation to excite the perispinal muscles at the convex side of grade IIo scoliosis in children between 11 and 14 years of age during scoliosis progression. The stimulations were performed according to an empirically established programme which included 3-month cyclic stimulations lasting 8 to 10 hours carried out during sleep. The results were positive: spinal scoliosis diminished after treatment, which was confirmed by radiological examinations. However, long-term results of the improvement have not been analysed [14-16].

In this paper an attempt has been made to prove that the LESS method of treating IS [3, 7-9] produces similar or even better results than traditional procedures. The results of the research which has been carried out by Kowalski since 1986 (partly presented in this paper) on a large group of children with IS prove that LESS has a good effect on the reduction or stabilisation of scoliosis. Based on these studies, the best treatment can be obtained when the initial scoliosis is less than 20°, measured according to the Cobb method. Kowalski also found that the inconvenience of overnight therapy could be reduced by proposing a 2-h evening therapy with LESS, which is equally effective as the all-night 8-h stimulation [7, 9].

Conclusion

1. The analysed LESS method has a good effect on the nervous-muscular system in the therapy of children and youth with IS.
2. LESS has been found to be an effective method in treating IS, especially in cases where the initial spinal scoliosis is less than 20° according to the Cobb method.
3. Short-duration electrostimulation (2 h daily) produces similar positive effects as those obtained after all night electrostimulation (9 h) and eliminates undesirable symptoms of all-night LESS therapy.
4. The analysis of the Harrington prognostic co-efficient F confirms the positive effect of LESS in both groups of patients (2 h and 9 h of LESS).

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