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Electrostimulation to Increase Peroneal Muscle Strength in Pediatric Patients With Postsurgical Clubfoot

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Abstract

Background: Idiopathic congenital clubfoot is a deformity with various components. Its treatment can be conservative and or surgical in order to eliminate the deformity and to obtain a pain-free foot allowing for adequate mobility.
Objectives: Our objective was to evaluate whether neuromuscular electrostimulation is useful for improving peroneal muscle strength in post-operative congenital clubfoot in children.
Patients and Methods: An experimental, prospective, longitudinal, and comparative study was carried out on 10 patients with congenital clubfoot in the experimental group, and on 10 for historical controls. Initial and post-treatment clinical evaluations were conducted on patients in both groups. Surface electromyography (SEMG) was used for the experimental group; each patient received 30 sessions of treatment with neuromuscular electrostimulation in order to obtain muscular contraction.
Results: In both groups, there were more males with the average age or 5.5 years (ranging from 3 to 8 years of age). Peroneal muscular strength evaluated through the Daniels and Worthingham's test increased post-treatment only in the experimental group, and comparing these results to those of the historical group, a significance level of $P = 0.001$ was obtained. The motor unit potential amplitude in the SEMG increased in the experimental group with a significance level of $P < 0.05$.
Conclusions: Neuromuscular electrostimulation can be used to increase muscle strength, and it is a safe and painless treatment.

Keywords: Congenital Clubfoot, Electrostimulation, Peroneal Muscles.

1. Background

Congenital clubfoot (CC) is a complex deformity which is difficult to correct. The global incidence rate is reported as 1 per 700/1000 (1, 2). More specifically, Arroyo and Urbalejo report that it constitutes 6.0% of all congenital deformities in Mexico (3).

This deformity is more common in males than females. Possible causal factors include genetics, infection (1), arrest in fetal development of the foot (2), and histological abnormalities in different foot structures (including bone, tendon, muscle, nerve, and cartilage defects), germinal tissue changes and their related bone structures, and degradation of the contractile proteins of fibroblasts and miofibroblasts (4-6). CC is considered secondary to polygenic type inheritance, and genetic polymorphisms have been identified which seem to confer with more susceptibility to acquiring it (3, 6-8).

As CC is very evident, it is diagnosed at birth. This deformity has various components: equinus, varus, aductus and cavus of the foot, and internal tibial torsion (2). The objective of treatment is to eliminate these malformations and obtain a foot with normal mobility so that the patient can walk without pain in a functional way. Treatment can be conservative and or surgical. In the latter case, the patient remains immobilized for a long period of time, anywhere from a few weeks to several months. Immobilization for extended periods causes atrophy of unused muscles, leading to loss of mass in type II muscular fibers, thus leading to an imbalance between the inverter and evertor muscles (4, 8, 9).

Neuromuscular electrostimulation (NMES) is used to strengthen muscles in healthy people, including athletes. It is also administered to those who are in the process of recovery from surgery or a muscular-skeleton type lesion (10-13). Dynamic intervention with NMES on evertor muscles as well as peroneus muscles may help to improve the balance between type I and type II muscle fibers. The aim of the present study was to evaluate whether or not NMES can be effectively used to increase peroneal muscle strength in children that undergo operations for CC.

2. Objectives

Our objective was to evaluate whether neuromuscular electrostimulation is useful for improving peroneal muscle strength in post-operative congenital clubfoot in children.

3. Patients and Methods

An experimental, prospective, longitudinal, and comparative study was conducted. Two groups were selected, each with 10 children. Experimental and control groups both had the following inclusion criteria for patients: 3 - 8 years of age, with previous surgery for CC (a maximum of two operations), and a minimum range of movement of 5 degrees for dorsiflexion and eversion. None of the patients have had peroneal nerve disorder. The control group was historical. The sample was defined by convenience sampling, and because the control group was historical, we looked in the clinical files for patients who satisfied the inclusion criteria.

With small variations, surgery consisted of posteromedial release with tenotomies from the Achilles tendon, posterior tibial, and deep flexor of the toes, capsulotomies of the subtalar and tibiostragalina joints, and Achilles tendon enlargement. Patients were previously treated with the Ponseti method.

The patients were treated with surgery at different ages, but the majority were treated at around 3 years (± 6 months) of age. We had one patient who was treated at 5 years, one at 3 months, and 2 at about one year of age.

Pre- and post-treatment evaluations were conducted by testing muscular strength (Daniels and Worthingham's scale) and applying an electromyography (SEMG). We asked each patient to engage in voluntary activity involving eversion movement, first without any weight and later with 250 and 500 g. The activity was registered during a duration of 2 seconds, and this was done 5 times for each evaluation. We measured the peak to peak amplitude from the motor unit action potentials (MUAP). Each value represents an average of the 5 tests. In the control patients, based on clinical records, only the Daniels and Worthingham's scale results were analyzed because of the lack of regular MUAP results in the patients' histories (this latter test was not routinely applied). The data of the first evaluation in both the experimental and control group were compared with a Student's t test (P = 0.44). This way we were sure that the results could also be compared with the second evaluation.

Both groups received physical therapy, including local heat administered for 20 minutes, passive mobilizations to improve articulation of the arch, gentle posterior tibial elongation, abductor of the first toe, plantar fascia and gastrocnemius. Gait training (in different phases and variants) was also employed. The NMES was conducted on the experimental group, being applied 5 days a week for 6 weeks with the proper intensity to obtain a peroneal muscle contraction without contracting the neighboring muscles. After placing the electrodes longitudinally over the peroneal muscles, a pulse was given every 14 seconds at a frequency of about 2.5 KHz (depending on muscle tolerance to fatigue).

None of the patients suffered pain before or after treatment. Patients were treated in compliance with the Nuremberg code, the ethical principles for protection of human beings in investigation (from the Belmont report), the ethical principles for medical research on human beings (from the Helsinki declaration), and the Mexican general health Laws. Patients' parents were asked to allow their children to participate in the study after the treatment was explained to them in detail. All parents of participating children signed the appropriate informed consent forms.

A descriptive analysis of the results was performed. Because of the normal distribution of the data, the Student's t-test was used to compare the first and second evaluations in both groups of patients, as well as for the intergroup analysis and the evaluation of SEMG.

4. Results

The descriptive characteristics were similar between the two groups (Table 1).

The measurement of the muscular strength of the peroneal, evaluated according to the Daniels and Worthingham's scale, showed an increase between pre- and post-treatment for the electrostimulation group (P = 0.002). In the control group, there was no increase during the evaluation period (P = 0.1). The data we show are from both the first evaluation and three months after the treatment (Table 2).

It should be noted all patients retained the strength gained for 6 or more months after treatment with NMES (data not shown).

The means of the values from the SEMG of the peroneal muscles, pre- and post-treatment, show an improvement in amplitude in all patients (movements with and without resistance) who received electrostimulation treatment (P < 0.05). Table 3 shows the changes during the treatment process of the study group in the amplitude of the SEMG.

Table 1. Distribution by Age, Sex and Affected Side of the Foot

Group	Control (Historical)	Study (Electrostimulation)
Gender		
Male	9	8
Female	1	2
Affected foot		
Right	5	5
Left	5	5
Age (average)	5.7	5.3

Table 2. Comparison Between the First and Final Evaluations (Daniels and Worthingham's scale) for Both Groups

Group	First Evaluation	Final Evaluation	P Value
Control (historical)	2.4	2.2	> 0.5
Study (electrostimulation)	2.2	3.2	0.0001

Table 3. Changes in the Study Group in the Amplitude of the SEMG After Electrostimulation

SEMG	Average of First MUAP Amplitude	Average of Final MUAP Amplitude	Percentage of Amplitude Increase
Without extra weight	919	1190	30
250, g	814	1436	76
500, g	799	1185	48

MUAP = motor unit action potentials.

5. Discussion

Congenital clubfoot is very frequent in a variety of populations, including in Mexico, where there is a prevalence rate of about 6% (3). We think it should be considered a malformation more than a deformation because pathological studies have shown abnormal structures (8).

In the present study CC was more prevalent in males than in females, which is in agreement with the reports in the literature. This type of gender difference occurs in a variety of multifactorial hereditary diseases, as is the case with CC (4).

The disease is commonly treated conservatively by the Ponseti and Campos method, or surgically (7). In either case, the foot is immobilized for long periods of time and the muscles lose strength. Conducting alignment rehabilitation maneuvers with passive movements is important, but the abductor muscles (such as the peroneal) must also be strengthened. This study demonstrates that administering NMES in conjunction with physical therapy has better results than physical therapy alone for strengthening muscles.

NMES has not been used very often in the treatment of clubfoot, but it has been used as part of the treatment for many other diseases and in otherwise healthy people, especially athletes, and all of the studies have shown, as ours did, that there is an increase in strength of different muscles after treatment (13, 15-19). However, for the CC treatment, there is only one report to date, and its sample was small (n = 8) compared to the current contribution (n = 20) (20). We believe that NMES is a good option for treatment because it improves muscle strength and is not an invasive method, thus causing no pain or discomfort.

In the present study the Daniels and Worthingham's scale was employed to evaluate muscle strength; although it is a subjective scale, it is widely used and is deemed to be reliable. Of course, the results may vary depending on the action of the assessor (i.e., intra-observer variability). We could not employ an objective method because of the historical controls. The statistical analysis showed no improvement in the control group. Contrarily, with the SEMG, increased electrical activity of the muscles was observed in the electrostimulation group, with the highest improvement being 76%.

It is easy to activate muscle fibers in a selective way due to the difference in diameter between the larger group II fibers and the smaller group I fibers. The group II fibers suffer greater immobilization, and also respond better to the NMES, resulting in a notable improvement in strength (21). Hence, the NMES can be used as a kind of adjuvant in the treatment of the CC patients, being well tolerated and offering positive results. Furthermore, the fact that it can stimulate the muscles in a selective way allows for the restoration of muscular balance, which is abnormal in CC patients as it is in patients with many other diseases.

It is very important to follow-up on the patients of the present study in order to determine whether or not the strength obtained will remain, and whether it will maintain or improve the foot alignment corrected by the surgical treatment. At the moment, all of the patients have conserved the strength they gained more than 6 months after treatment concluded.

5.1. Conclusion

In conclusion, neuromuscular electrostimulation can be used to increase muscle strength in those treated for clubfoot, as demonstrated in this study. It is a safe and painless treatment. However, a limitation of this study is the small sample size and the short follow-up period, but we believe that the results are still reliable enough to reveal the beneficial possibilities of using this method of treatment in this type of patients.

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