Significance of Electrical Stimulation in Conjunction with Ankle Foot Orthosis on Spasticity Control in Hemiplegic Children

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ABSTRACT

The present study was conducted to determine the effects of faradic stimulation on the anterior tibial muscle group while wearing ankle foot orthosis, in conjunction with traditional physical therapy program, on controlling lower limb spasticity in hemiplegic cerebral palsy. Subjects: Thirty hemiplegic cerebral palsied children (8 right side and 22 left side) ranging in age from six to eight years represented the sample of this study. They were selected from the out-patient clinic of the Faculty of Physical Therapy, Cairo University. The degree of spasticity ranged from mild to moderate grades according to the modified Ashworth scale. The lower limb was free from any structural deformities. Children were divided randomly into two groups of equal number A (control) and B (study). Procedures: Double blind evaluation was conducted to determine H/M ratio and degree of ankle excursion was conducted for each child of the two groups, before and after three months of treatment. Group A (control) received faradic stimulation on the anterior tibial group in addition to an exercise therapy program and wearing an ankle foot orthosis as a home routine, while group B (study) received faradic stimulation on the anterior tibial group while wearing the ankle foot orthosis in addition to the exercise program and home routine given to group A. Results: The results revealed, no significant differences when comparing the pre-treatment mean values of the two groups. Significant improvement was observed in all the measuring variables of the two groups (A and B), when comparing their pre and post-treatment mean values. Significant difference was also observed when comparing the post-treatment results of the two groups in favor of group B. Discussion and Conclusion: The significant difference recorded between the two groups in Hoffman reflex Myogenic response ratio and in ankle excursion may be attributed to the combined effects of faradic stimulation during wearing the ankle foot orthosis, in addition to the physical therapy program, in controlling spasticity of the affected lower limb and so, improving its functional

Key words: Faradic Stimulation, Ankle Foot Orthosis, Hemiplegic Cerebral Palsy.

INTRODUCTION

Hemiplegic cerebral palsy composes a large portion of the pediatric physical therapist's case load. Impairment in hemiplegia may include mal-alignments, contractures, deformities, insufficient force generation, abnormal muscle tone, abnormal tissue extensibility, exaggerated or hyperactive reflexes, poor selective control and regulation of activity in muscle groups and decreased ability to learn unique movement.

Loss of recruitment of agonist contraction or reduced output paresis play a major role in impairment of muscle function. Planter flexion deformity is a common finding in hemiplegic children, resulting from spasticity. In such cases, increased motor neuron excitability has postulated to be a contributing factor in causing spasticity. This
leads to excessive activity in muscle groups as wrist flexors and ankle planter flexors.

A general goal of physical therapy for children with hemiplegia is to decrease or inhibit the influence of abnormal muscle tone and reflex patterns, while simultaneously facilitate or stimulate the development of normal movement components.

A number of treatment modalities are used to improve function of cerebral palsied children.

Orthosis has been introduced as an effective method for correcting ankle planter flexion in those children. It is thought to be an effective approach because it may diminish hyper-reflexia and stretch connective tissues.

Various types of lower extremity orthosis have been used to correct equinus pattern in children with spastic cerebral palsy. A solid ankle foot orthosis (AFO) has been the most commonly prescribed brace for reducing excessive planter flexion. The rational for the design, purpose and use of the inhibitive AFO is proposed to be based on the inhibitive or reducing effect of casts.

It was established that the primary role of AFO is to change or enhance the biomechanics of the lower extremity. These biomechanical changes give an opportunity to enhance learning of motor skills which in turn result in functional improvement.

Application of orthosis in cerebral palsy has been indicated for preventing mal-alignment and contractures or correcting deformity, providing variable range of motion as needed and protecting weak muscles.

On the other hand electrical stimulation can be used increase muscle strength, motor control, range of motion, reduce abnormal muscle tone (spasticity) and improve function.

It has been reported that application of short width pulse stimulation in addition to neuro-developmental technique could help the hemiplegic children in deceasing spasticity and so, improving their functional abilities, compared to neuro-developmental technique alone.

This study is a trial conducted to investigate the effects of faradic stimulation on anterior tibial muscle group during wearing AFO in hemiplegic children.

### SUBJECTS, INSTRUMENTATION AND PROCEDURES

#### Subjects

Thirty hemiplegic cerebral palsied children (8 right side and 22 left side), ranging in age from 6 to 8 years represented the sample of the study. They were selected from both sexes from the out patient clinic of the Faculty of Physical Therapy, Cairo University. They were free from any associated disorders other than spasticity, with minimal non significant perceptual defects, but they were able to follow instruction given to them. The degree of spasticity ranged from mild to moderate grade according to the modified Ashwroth scale. The involved lower limb was free from any structural deformities; however children demonstrated variable degrees of tightness of hip adductors, hamstrings and tendo-Achillis muscles. Children were divided randomly into two groups of equal number (A and B). Double-blind evaluation to determine H/M and ankle excursion was conducted for each child individually before and after three months of treatment.

Group A (control) received faradic stimulation on the anterior tibial group in addition to an exercise therapy program and wearing an ankle foot orthosis as a home routine. Group B (study) received faradic stimulation on the anterior tibial group while...
wearing the ankle foot orthosis in addition to the exercise therapy program and home routine given to group A.

**Instrumentation**

**I- For evaluation**

1- A computerized electromyographic apparatus (Diza 2380) was used to determine the Hoffman reflex Myogenic response (H/M) ratio.

2- Electrogeniometer was used to determine the degree of ankle excursion.

**II- For treatment**

1- Ankle foot orthosis (AFO) made of polypropylene that covers the entire calf and medio-lateral borders and sole of the foot, with straps across the anterior aspect of upper part of tibia and front of the ankle was used. The ankle foot orthosis is flexible, light weight and easily worn with regular shoes.

2- Faradic stimulator was used for anterior tibial group stimulation, (Phyaction 787) manufactured in Netherlands by Uniphy BV.

3- Tumble forms (mat, wedges, rollers and balls) from Preston for the application of the exercise program.

**Procedures**

**I- For evaluation**

Double blind evaluation for each child in the two groups was conducted in a warm, well lighted and quiet room, before and after three months of treatment using electromyography to measure H/M ratio, and electrogeniometer to measure the degree of ankle excursion.

**1- H/M ratio**

Surface electrodes were used for recording electromyographic signals from soleus muscle. Tibial nerve in poplitial fossa was used for stimulation. The active electrode was placed two centimeters distal to the insertion of the gastrocnemius muscle, and the reference electrode was placed three centimeters distal to the active electrode. Maximum Hoffman reflex and maximum gynogenic responses were recorded and H/M ratio was calculated to measure the motor neuron pool excitability which reflects the level of spasticity as an indication of central nervous system excitability.

**2- Ankle excursion**

From supine lying position with the foot outside the plinth and the knee slightly flexed, the fixed arm of the electrogeniometer was placed on the lateral aspect of the leg and the movable arm parallel to the lateral aspect of the foot. These arms were fastened in position via straps. Each child was then asked to move the ankle from full planter flexion to full dorsi-flexion (ankle excursion) and the range of motion was determined.

**II-For treatment**

Group A (control) received faradic stimulation on the anterior tibial group in addition to an exercise therapy program and wearing an ankle foot orthosis as a home routine for 8 hours daily.

**1- Faradic stimulation**

From supine lying position two small electrodes covered with gel were placed and fastened with straps as follows: One electrode was at the fibular head and the other at the anterior surface of the lower third of the lower leg. The apparatus was adjusted and the intensity was increased gradually until visible contraction was observed. Stimulation continued for thirty minutes with ratio 1: 2 (10 seconds stimulation and 20 seconds relaxation).
2- Exercise therapy program

It include neuro-developmental technique, proprioceptive training, facilitation of righting and equilibrium reactions, stretching exercises for the muscles liable to be tight, namely hip flexors, adductors, hamstrings and tendo-Achillis muscles. Strengthening exercises to the antagonistic groups of the spastic muscles and gait training in a close and open environment. Special attention was also given to the effected upper limb and uninvolved side.

Group B (study) received faradic stimulation on the anterior tibial group with the same technique used for control group, but while wearing the ankle foot orthosis to keep the ankle joint at right angle, in addition to the same exercises therapy program and home routine give to group A.

RESULTS

The raw data of the H/M ratio and degree of ankle excursion of the affected lower limb were statically treated to determine the mean and standard deviation of each measuring variable, for the two groups A and B, before and after three months of treatment. Student's t-test was then applied to examine the significance of treatment conducted for each group.

The obtained results in this study revealed no significant differences when comparing the pre- treatment mean values of the two groups. Significant improvement was observed in all the measuring variables of the two groups A and B, when comparing their pre and post treatment mean values. High significant improvement was observed in group B, when comparing its post treatment mean values with the post treatment mean values of group A.

As revealed from table (1) and figure (1), significant reduction was observed in the mean value of H/M ratio in the control group (A) at the end of treatment as compared with the corresponding mean value before treatment (P<0.01).

Also, table (1) and figure (1), showed a significant reduction in the mean value of H/M ratio in the study group (B) at the end of treatment as compared with the corresponding mean value before treatment (P<0.001).

| Table (1): Pre and post-treatment mean values of H/M ratio (mV.) for groups A and B |
|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
|                                   | Group A (control)                  | Group B (study)                     |
|                                   | Pre        | Post        | Pre       | Post       |
| X'                                  | 0.715      | 0.614      | 0.737     | 0.471      |
| ± SD                                | ± 0.012    | ± 0.035    | ± 0.013   | ± 0.014    |
| t-test                              | 2.937      |            | 3.246     |            |
| P-value                             | < 0.01     |            | < 0.001   |            |
| Sig.                                | Significant|            | Significant|            |

X': Mean SD: Standard deviation  
P-value: Level of significance  
Sig.: Significance

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Significant improvement was also observed when comparing the post-treatment mean values of H/M ratio of the two groups in favor of group B (P<0.0001), Fig. (2).

**II- Degree of ankle excursion**

As shown in table (2) and figure (3), significant increase was observed in the mean value of ankle excursion in the control group (A) at the end of treatment as compared with the corresponding mean value before treatment (P<0.01).

Also, table (2) and figure (3), revealed a significant increase in the mean value of ankle excursion in the study group (B) at the end of treatment as compared with the corresponding mean value before treatment (P<0.0001).

<table>
<thead>
<tr>
<th></th>
<th>Group A (control)</th>
<th>Group B (study)</th>
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<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
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<tr>
<td>X̄± SD</td>
<td>21.73± 1.437</td>
<td>30.47± 1.125</td>
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<tr>
<td>t-test</td>
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Table (2): Pre and post-treatment mean values of ankle excursion (degrees) for the two groups (A and B)
Fig. (3): Representing the pre and post-treatment mean values of ankle excursion (degree) for groups A and B.

Significant improvement was also observed when comparing the post-treatment mean values of ankle excursion of the two groups in favor of group B (P<0.001), Fig.(4).

DISCUSSION

Functional limitations of the cerebral palsied children are mainly in mobility, balance and delay in acquiring motor milestones.$^{14}$

Walker and Stranger$^{21}$ emphasized that, the ability to maintain proper joint alignment of the lower extremity, and control the position of the foot in standing, is a critical treatment objective for the hemiplegic patients. For that reason AFO are frequently prescribed for hemiplegic children to provide appropriate biomechanical alignment for practice of a motor skill.

Statistical analysis of the post treatment results revealed significant improvement in H/M ratio and ankle excursion for the two groups A and B when comparing their pre and post treatment mean values. Highly significant improvement was noticed in favor of group B receiving electrical stimulation during wearing of AFO, in addition to the exercise therapy program, when comparing its post treatment results with the post treatment results of group A.

These results revealed the evidence of using electrical stimulation in conjunction with AFO in children with spastic cerebral palsy who demonstrate ankle planter flexion.

In the present study, faradic stimulation was applied on the anterior tibial group. This agrees with Garrett et al.,$^{22}$ who reported that electrical stimulation produced better result than an exercise regimen alone. They revealed this to be due to recruitment of more motor units within stimulated muscle than by voluntary contraction alone.

Currier and Mann$^{23}$ established that electrical stimulation may influence cellular mechanism of the muscle, similar to the volitional contractile process, to produce adaptation of increased force.

Neuromuscular electrical stimulation has been well established as an effective adjunct to range of motion and stretching exercises, facilitation of muscle contraction and spasticity management programs used by the physical therapists.$^{24}$

Using faradic stimulation also agree with Powell et al.,$^{25}$ who reported an increase in
the strength of wrist extensors after eight weeks of application of neuromuscular electrical stimulation in hemiplegic cerebral palsied children.

Fathi et al., 26 concluded that neuromuscular electrical stimulation for the quadriceps and anterior tibial muscles is beneficial in controlling spasticity and improving gait pattern in hemiplegic cerebral palsy.

On the other hand, applying AFO as a home routine agree with Ohsawa et al., 27 who developed a plastic ankle foot orthosis which can deal with severe spastic foot during walking. They revealed that electro-myogram studies showed that AFO reduced the spasticity in gastrocnemius and hamstrings and activated the quadriceps muscles.

Burtner et al., 28 found decreased activation of gastrocnemius muscle and increased joint angular velocities at the knee when used AFO to correct skeletal mal-alignment in diplegic children.

Yankowitz 29 believed that foot orthosis are designed to provide an external correction for structural imbalance in the foot that may cause abnormal gait mechanics, affecting musculo-tendinous and ligamentous structures in the lower extremities, pelvis and lower back.

The results of the present study agree with Dursun et al., 30 who evaluated the effectiveness of AFO on gait of spastic cerebral palsied children for whom orthosis were indicated to control dynamic equinus deformity. Their obtained results revealed that, the use of AFO during gait produced a statistically significant improvement in velocity and stride length.

Simultaneous use of faradic stimulation while wearing AFO, in group B, in addition to the physical therapy program demonstrated highly significant improvement. This combination gave a better chance to improve muscle tone, increase active range of ankle joint and strengthened the anterior tibial group via stimulating type II muscle fibers, so, improved the functional activities of the spastic lower limb muscles.

This improvement may be due to the effect of AFO which controlled spasticity via placing the ankle in a prolonged stretched position leading to inhibition or decrease of abnormal reflexes in the affected lower extremity by protecting the foot from tactile induced reflexes.

Inhibition caused by prolonged stretch via using AFO is thought to be a result of activation of Golgi tendon organs and joint receptors leading to autogenic inhibition of the stretched muscle groups. Spindle secondary endings may also be activated as they are more sensitive to absolute length changes.

It has been reported that AFO broke the extensor pattern of the lower limb by preventing excessive plantar flexion, producing inhibition or dampening of muscle response and normalizing movements of the lower extremities, in addition, stimulating the anterior tibial group via faradic stimulation, facilitated its contraction which in turn reciprocally inhibited the posterior calf.

Keeping the ankle in stretched position via wearing ankle foot orthosis while application of faradic foot orthosis produce concentration of the stimulating current on the anti-spastic group of muscles and preventing its diffusion to the neighboring antagonistic group of muscles which may cause an undesired action.

Conclusion

From the results of the present study, it can be concluded that applying faradic stimulation while wearing AFO is an effective
method for controlling lower limb spasticity and in turn improving functional abilities.

REFERENCES


الدلالة الإحصائية لتطبيق التنبؤ الكهربائي أثناء ارتداء جبيرة مفصل القدم على التحكم

في النغمة الفعلية لدى الأطفال المصابين بالتشتت الشعبي

أجريت هذه الدراسة لتحلئ المثير والتوبة الكهربائي باستخدام البارود الفرادي أثناء ارتداء جبيرة مفصل القدم، بالإضافة إلى برنامج علاج طبيعي، وذلك للإبتكار على تحسين الطرف السفلي لدى الأطفال المصابين بالتشتت الشعبي. شمل البحث، إنشاء العنوان على ثلاثين طفلا مصاباً بالتشتت الشعبي (تمدّدات جداً أينم و أينم و استثناء جامع آيي) من تراوح أجراهم من ستة إلى ثمان سنوات. وقد تمّت درجة التحسين من السبعة إلى متوسط طفلاٍ مع sizeof A لأدوار ارتقاء المفصل. تم تتبثم الأطفال بشكل عشوائي إلى مجموعتين: مجموعة الضابطة (A) و مجموعة أي وهو، وهذا كلي الطرف، في الطرف، بناءً على الرسالة أو المجموعة (ب) (التشتت الكهربائي أثناء ارتداء جبيرة مفصل القدم، بالإضافة إلى برنامج العلاج الطبيعي). أنتج Result من المجموعة (أ) (التشتت الكهربائي) إضافة إلى وفقت المجموعة (ب) (التشتت الكهربائي) أثناء ارتداء جبيرة مفصل القدم، بالإضافة إلى برنامج العلاج الطبيعي. كشفت النتائج أنه لا يوجد اختلافات ذات دالة إحصائية عالية عن مقارنة في المتوسط الحسابي قبل العلاج. أما النتائج فقد لوحظ في جميع متغّرات مساوية المجموعة (أ) (وب)، عندما قام رؤى في المجموعة (ب) (وب)، لوحظ التحسين أيضاً عند E ملاحظات من بعد العلاج لمجموعة إجراء مواد البيوت الكهربائية لعلاج الفرادي أثناء ارتداء جبيرة مفصل القدم، بالإضافة إلى برنامج العلاج الطبيعي. في النتيجة على التبنين للطرف السفلي المصاب و هذا

الكلمات الدالة: التنبؤ الكهربائي، جبيرة مفصل القدم، العلاج الشعبي لدى الأطفال