Electrical versus Vestibular Stimulation in Erb's Palsied Children

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ABSTRACT

The main aim of the present study was to compare between the effects of electrical stimulation versus that of vestibular stimulation in accelerating motion recovery in patients suffering from Erb's palsy. From the Out-patient Clinic of the National Institute for Locomotor System – Imbaba, a sample of twenty infants, suffering from unilateral Erb's palsy was selected. Their age was ranging from one to three months. The sample was divided into two groups of equal number, each comprised 10 patients. Both groups received the traditional physical therapy program, in addition to electric muscle stimulation (ES) for one group and electrical vestibular stimulation (VS) for the other. The duration of treatment was two successive months and sessions conducted at three times per week-basis. The patients were evaluated before and after the treatment program, using electrodiagnostic measures and muscle tone assessment scale. At the end of the treatment period, the results showed significant improvement in all measured parameters in both groups, In favor of the ES group. Such Significant difference may be due to increasing the motor neuron pool excitability, which excites alpha motor neurons to increase their discharge to the extra-fusal muscle fibers. So it is preferable to add ES or VS to the physical therapy program for such cases.

Key words: *Erb's palsy - Electrical stimulation - Vestibular stimulation.*

INTRODUCTION

The main aim of physical therapy application in patients suffering from Erb's palsy is to gain motor control. This training should be as early as possible, as this serves to elicit activity in muscles which are temporarily denervated[29]. More stress should be made to activate shoulder flexors, abductors and external rotators, elbow flexors, forearm supinators and wrist-finger extensors if affected[17]. Different physical therapy techniques may be used to serve this purpose such as passive movement[31], therapeutic exercises and electrical stimulation[19]. Splinting has also been suggested but not advised as it may cause excessive gleno-humeral joint mobility[13].

Electro-motor stimulation (EMS) has been used for centuries for therapeutic and diagnostic purposes[1]. It was extensively utilized by physical therapists during the rehabilitation setting as an adjunctive tool in the restoration of function in innervated weak musculature and after partial denervation[11].

The vestibular stimulation is a viable and powerful modality for therapeutic intervention because it is a unique sensory system, critical for multi-sensory functioning[22]. The vestibular system plays a major role in the expression of

early motor behavior. Previous researchers cited extensive neural connections between the vestibular apparatus and the motor system. Accordingly, some therapists have implemented programs of supplemental vestibular stimulation to improve motor and cognitive abilities in children with delayed motor development[4].

Aim of the study

The purpose of the current study is to compare between the effects of faradic stimulation and trans-mastoid electrical vestibular stimulation on motion recovery in infants suffering from Erb's palsy.

MATERIALS AND PROCEDURES

Subjects

From the Out-patient Clinic of the National Institute for Locomotor System – Imbaba, twenty infants having unilateral (12 right and 8 left) Erb's palsy were selected. Their ages ranged from one to three months. They had difficult delivery, the type of nerve lesion was neuropraxia, according to EMG study and all of them had no joint contractures. They had neither previous physical therapy nor medications that might affect the program of treatment. The patients were randomly divided into two groups of equal number; group (A) and group (B), each comprised 10 infants.

Materials

- Medisana EMS dual-channel muscle stimulator: It was used in different therapeutic procedures.
- Phyaction (787): It was used to conduct electro-diagnostic study before and after the treatment program.
- Special scale: It was utilized for evaluation of muscle tone (Form 1).

Form (1): Special muscle tone scale[9].

Grade	Degree	Percentage
0	No tone	0 %
1	Moderate hypotonia	25 %
2	Slight hypotonia	50 %
3	Near to normal tone	75 %
4	Normal tone	100 %

Procedures

1- For evaluation

- ***Electro-diagnosis:***

The rheobase and chronaxie were evaluated in all selected patients. The factors that affect validity and reliability of the electro-diagnosis should be monitored carefully (suitable examination room, skin temperature, skin preparation, humidity of the environment, position of electrodes and adjustment of the apparatus).

- ***Physical evaluation:***

The muscle tone was evaluated from supine position by passive movement of the baby's affected arm in different directions, to be compared by the sound one.

These parameters were done for all patients before and after the suggested period of treatment (2 months).

2- For treatment

The patients of both groups received the traditional physical therapy program for cases of Erb's palsy, in addition to electric muscle stimulation for one group (ES) and electrical vestibular stimulation (VS) for the other.

- ***Faradic stimulation:***

- The infant is in a comfortable supine lying position.
- The skin resistance was reduced by rubbing the skin a piece of cotton, soaked in alcohol.
- One electrode was placed on the motor point of the biceps brachii muscle.
- The other electrode was placed under the scapula on the same side.

- The stimulation period was for 20 minutes, with intensity of three times the motor threshold, frequency of 1: 80 Hz and a pulse rate of 300 msec. The contraction-rest time ratio was 1: 5[27].

- ***Electric vestibular stimulation:***

Trans–mastoid technique of electric vestibular stimulation was applied on the infant, while sitting on his mother's lap. The specifications were as follows:

- After cleaning the skin with a piece of cotton, two small stainless electrodes covered with soaked gauze with saline were applied bilaterally on both mastoid processes.
- The anode was placed on the sound side, while the cathode was placed on the mastoid process of the affected side.
- The stimulation period was for 2 minutes, with pulse duration around 100 msec and a current pulse of 1.6 ma[3].

Patients reactions and expressions as nausea, hyper-excitability, dilated pupils and flight reaction were carefully observed during the stimulation period.

- ***Physical therapy program used:***

- Medical massage by the thumb in the form of longitudinal, transverse and spiral movements.
- Passive movement of the affected arm was conducted regularly, emphasizing on shoulder external rotation, abduction and extension, elbow flexion, forearm supination and wrist extension.
- Passive stretching of shoulder internal rotators and adductors, forearm pronators, wrist and fingers flexors.
- Approximation and distraction techniques.
- Active exercises were encouraged from the start of the program[13].
- The parents were instructed to perform gentle exercises as a home routine.

Each session lasted for half an hour. The whole treatment was applied for a period of 2 successive months, on 3 times per week-basis.

RESULTS

Statistical analysis of the obtained results before starting the treatment program indicated no significant difference between both groups in any of the measured parameters ($t > 0.05$).

As represented in table (1) and fig. (1), the ES group mean values of rheobase of biceps brachii muscle decreased from 2.027 ± 0.1640 ma to 1.898 ± 0.1522 ma ($P < 0.01$). Concerning rheobase values of the VS group, it decreased after the suggested period of treatment from 2.050 ± 0.1561 ma to 1.982 ± 0.1008 ma ($P < 0.05$).

Table (1): Comparison of mean values of rheobase (in ma) pre and post treatment of the biceps brachii muscle for both groups.

Rheobase	ES		VS	
	Pre	Post	Pre	Post
Mean	2.027	1.898	2.050	1.982
SD	± 0.1640	± 0.1522	± 0.1561	± 0.1008
MD	0.123		0.068	
% of Improvement	6.36 %		3.32 %	
t	4.225		2.255	
P	< 0.01 (Sig.)		< 0.05 (Sig.)	

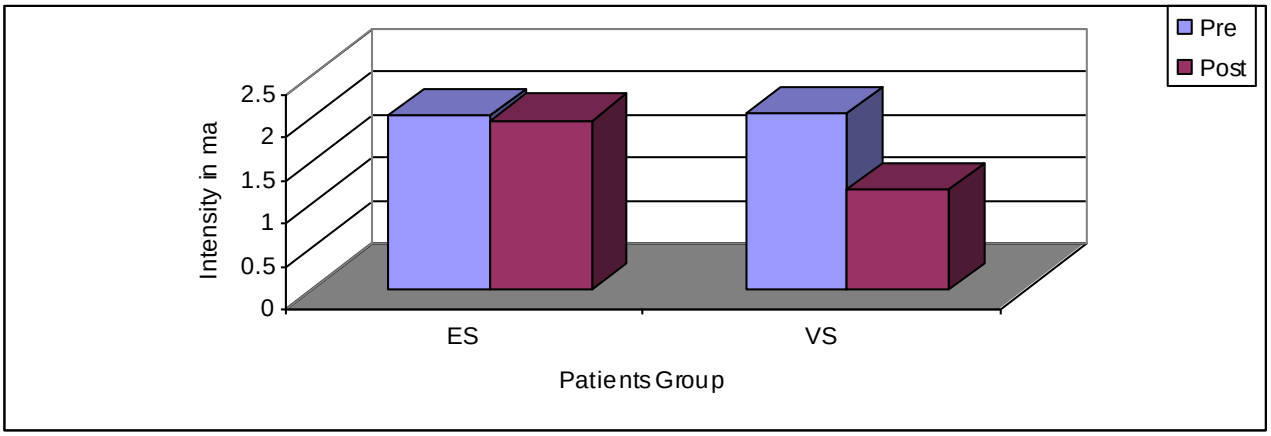

Fig. (1): Comparison of mean values of rheobase (in ma) pre and post treatment of the biceps brachii muscle for both groups.

As for the results of the chronaxie, the mean value of chronaxie of the biceps brachii muscle of the ES group was 2.017 ± 0.0998 msec before starting the treatment program. It was decreased after the suggested period of treatment (2 months) to 1.892 ± 0.1014 msec ($P < 0.01$), while in the VS group it decreased from 1.991 ± 0.1249 msec to 1.975 msec ± 0.1148 msec after treatment ($P < 0.05$) (Table 2 and Fig. 2). The percentage of change in rheobase and chronaxie after treatment of both groups was presented in fig. 3.

Table (2): Comparison of mean values of chronaxie (in msec) pre and post treatment of the biceps brachii muscle for both groups.

Chronaxie	**ES**		**VS**	
	Pre	**Post**	**Pre**	**Post**
Mean	2.017	1.892	1.991	1.975
SD	± 0.0998	± 0.1014	± 0.1249	± 0.1148
MD	0.125		0.016	
% of Improvement	6.20 %		0.80 %	
t	4.931		2.449	
P	< 0.01 (Sig.)		< 0.05 (Sig.)	

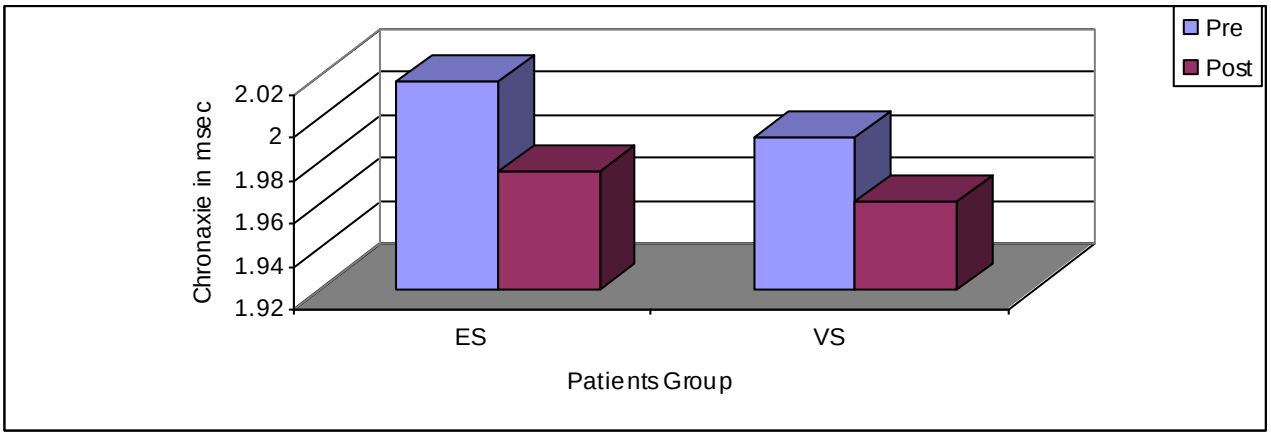

Fig. (2): Comparison of mean values of chronaxie (in msec) pre and post treatment of the biceps brachii muscle for both groups.

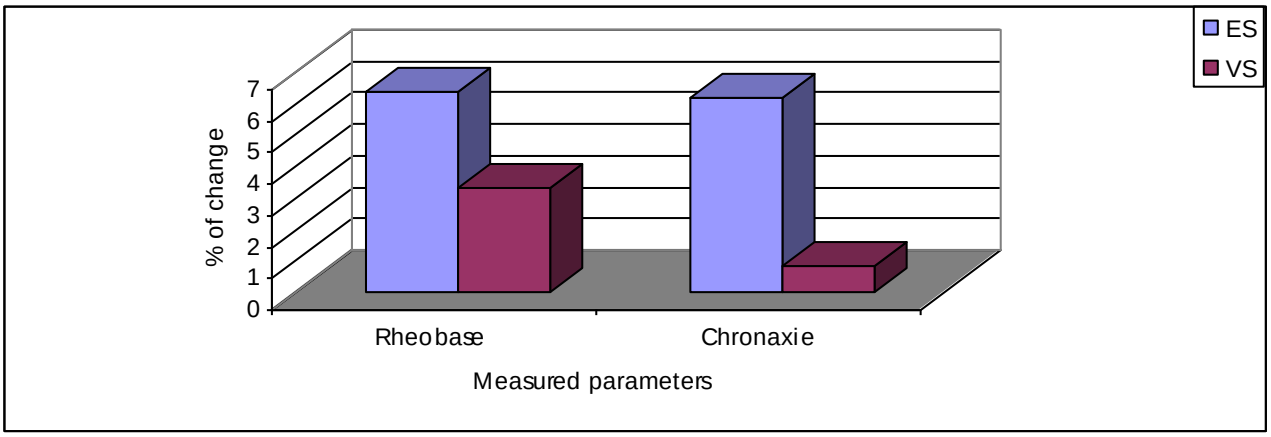

Fig. (3): Comparison between percentage of change in rheobase and chronaxie in both groups.

From table (3) and Fig. (4), the mean value of muscle tone percentage of the ES group increased from 30.0 ± 10.541 % before treatment to 45.0 ± 19.720 % after treatment ($P < 0.05$). Meantime, the muscle tone of VS group patients increased from 32.50 ± 12.076 % to 40.00 ± 12.910 % after treatment ($P < 0.05$).

Table (3): Comparison of mean values of muscle tone percentage pre and post treatment for both groups.

Muscle tone	ES		VS	
	Pre	Post	Pre	Post
Mean	30.0	45.0	32.5	40.0
SD	± 10.541	± 19.720	± 12.076	± 12.910
MD	10.0		7.5	
% of Improvement	33.33 %		23.01 %	
t	2.449		1.964	
P	< 0.05 (Sig.)		< 0.05 (Sig.)	

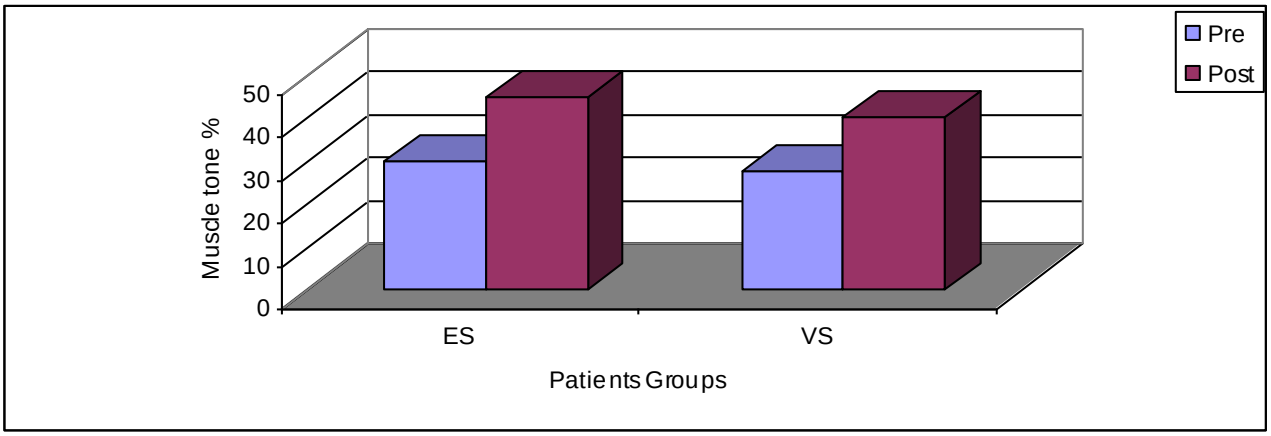

Fig. (4): Comparison of mean values of muscle tone percentage pre and post treatment for both groups.

DISCUSSION

The current study was made to compare between the effects of electrical muscle stimulation (MS) and electric vestibular stimulation (VS) on rate of motion recovery and modulation of muscle tone in case of Erb's palsy infants. All patients received the traditional physical therapy program, in addition to electro-motor stimulation for biceps muscle of patients of one group and electric trans-mastoid vestibular stimulation for the second group. The results showed that the patients of both groups had significant improvement in mean values of rheobase, chronaxie and muscle tone percentage.

The results of this study agreed with those of Ottenbacher[24], who showed that VS can increase arousal level, motor development, visual exploratory behavior and reflex integration in infants with developmental delay disorders. It was also found vestibular stimulation can lead to significant improvement in gross motor skills[10], which may be due to activation of synapses[7]. Moreover, Cauquil and Day[8] mentioned that VS can result in either a decrease or increase in muscle tone and movements of the trunk, extremities and head, due to the relation of the vestibular system with many other structures in the CNS.

Tokita et al.,[29] observed an increase in EMG activities of the soleus muscle by galvanic-stimulation of the labyrinth on the side ipsi-lateral to the cathode and a decrease on the contra-lateral side. More recently, Baldissera et al.,[6] studied the effect of mastoid electrical stimulation on the triceps brachii muscle electromyography (EMG). After applying trans-mastoid galvanic stimulation on five subjects, they found an increase of EMG activities of triceps brachii muscle on the side ipsi-lateral to the cathode and a decrease on that of the contra-lateral side.

Muscle tone may be increased by VS as its effect on the intra-fusal fiber to the muscle spindle prepares the nervous system for easier activation of the alpha motoneuron supply in the skeletal muscles[5]. The effect of electric VS on muscle tone may be shown by the stimulation of the vestibulo-spinal tract, which ends on inter-neurons in lamina VII, VIII, which in turn synapse on alpha and gamma motoneurons[26]. The vestibulo-spinal tract re-enforces the tone of the extensor muscles of the trunk and limbs, enhances the local

myotatic reflexes and supports body against gravity[2].

The post-treatment results of the study group also agreed with Hon et al.,[16] and Walker et al.,[30] who reported that ES produces an increase in muscle strength of the weak muscles more than an exercise regimen dose. The treatment results of the present study confirmed the findings of other earlier studies, which reported that application of electric muscle stimulation increases the range of motion of the treated body parts[18].

The results of this work also coincide with the findings of Ouzounian et al.,[25] who emphasized the importance of the ES to facilitate weak muscles and maintain healthy state. When the electrical current is applied to the tissues, the effect is upon the nerves first. There is stimulation of the sensory nerves in the skin, followed by stimulation of the motor nerves, which convey impulses through the myo-neural junction to the muscles to respond by contraction[23].

The significant improvement that occurred in the ES group may be attributed to the effect of ES in recruiting more motor units within the stimulated muscle than by voluntary contraction alone. Gramick[15] mentioned that ES might influence cellular mechanisms of the muscle, similar to the volitional contractile process to produce adaptation of increased force. They also found a lower incidence of muscular soreness in group receiving electrical stimulation than the group receiving exercises only.

Electrical stimulation of a muscle via its motor nerve has both immediate and long-term effects. Volitional muscle contraction is the immediate effect, while muscle strengthening and structural changes in muscle fibers may result from long-term stimulation[20]. The maximum muscle contraction obtained by ES may be due to increasing muscle pumping effect, which may lead to further stimulation of type III and IV afferents in and around muscles[21]. The improvement of muscular strength by using EMS may be through increasing the motor neuron pool excitability. This can be achieved via increasing the afferent input through the afferent Ia fibers. As a result, the alpha motor neurons become excited, increasing their discharge to the extra-fusal muscle fibers, leading to their contraction[28].

Similarly, Eng and Smoking[12] reported that the improvement of muscular strength by using ES may be attributed to an increase of the motor neuron pool excitability through the facilitatory impulses via increasing the afferent input through Ia afferent fibers. As a result, the alpha motor neurons become excited, increasing its discharge. Impulses then reach the extrafusal muscle fibers, causing muscle contraction.

Moreover, EMS produces significant strength gains in weakened musculature and in muscle functioning at normal strength levels. Significant increase in muscle tone and in turn in muscle strength has been found using EMS alone or in conjunction with voluntary exercises[14].

Conclusion

According to the results of this study, supported by the relevant previous literature, it may be concluded that it is preferable to use electric muscle stimulation (ES) or electrical vestibular stimulation (VS) in addition to the traditional physical therapy program to enhance the recovery of Erb's palsy patients. It may also be added that ES has greater role on muscle recovery than VS, when applied as early as possible after injury.

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الملخص العربي

مقارنة بين تأثير التنبيه الكهربائي للعضلات والتنبيه الكهربائي لجهاز التوازن في حالات الشلل الإربي لدي الأطفال

أجرى هذا البحث بهدف مقارنة بين تأثير التنبيه الكهربائي للعضلات وتأثير التنبيه الكهربائي لجهاز التوازن على تحسين الأداء الحركي في حالات الشلل الإربي ، تم إجراء هذه الدراسة على عشرين طفلاً من الأطفال المصابين بالشلل الإربى الذين تراوحت أعمارهم ما بين شهر وثلاثة أشهر ، تم اختيارهم من العيادة الخارجية للمعهد القومي للجهاز العصبي والحركي – إمبابة ، ثم تم تقسيمهم عشوائياً إلى مجموعتين متساويتين ضمت كل مجموعة عشرة أطفال ، وقد تم علاج مرضي المجموعة الأولي باستخدام التنبيه الكهربائي للعضلات، أما مرضي المجموعة الثانية فتم تعريضهم للتنبيه الكهربائي لجهاز التوازن ، بالإضافة إلى تطبيق برنامج تدريبات علاجية لمرضى المجموعتين . تم تقييم مستوى النشاط الكهربي في العصب المصاب والنغمة العضلية قبل وبعد شهرين متواصلين من تطبيق العلاج، بالإضافة إلى تقييم النغم العضلي باستخدام مقياس خاص .

وقد أظهرت النتائج وجود فروق ذات دلالة إحصائية عند مقارنة النتائج قبل وبعد العلاج في المجموعتين ، وكانت النتائج أفضل في المجموعة التي عولجت بالتنبيه الكهربائي للعضلات بالإضافة إلى برنامج التدريبات العلاجية ، وعليه وفقاً للنتائج يوصى بإضافة التنبيه الكهربائي للعضلات أو التنبيه الكهربائي لجهاز التوازن إلى النوعيات المختلفة من العلاج التقليدي لحالات الشلل الإربى عند الأطفال ، مع التوصية ببدء العلاج لمثل هذه الحالات فورا عند اكتشاف حدوث الإصابة لتلافي المضاعفات الناتجة من إهمالها .