Tonic Vibration Reflex Versus Cryotherapy on Biceps Brachii Recovery in Erb's Palsied Infants

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ABSTRACT

The present study is a trial conducted to differentiate between the effects of tonic vibratory reflex and cryotherapy on facilitating recovery of the biceps muscle in Erb's palsied infants. Thirty Erb's palsied infants from both sexes, ranging in age from two to four weeks, represented the sample for the study. They were selected from the Out-patient Clinic of the National Institute for Locomotor System - Imbaba. They were suffering from unilateral paralysis, with no other associated disorders. They were divided randomly into tow groups of equal number, each comprised fifteen subjects. The type of nerve lesion in all patients was axonotemesis, as referred from the physician. Patients of both groups received a physical therapy exercise program. In addition, patients of group I (TVR group) received high frequency vibratory stimulation for the biceps brachii muscle. Patients belonging to group II (cold group) received brief quick ice application to the same muscle. Strength duration curve study was conducted to each patient of both groups before and after treatment, which continued for twelve successive weeks, on three-time per week basis. The post-treatment results revealed significant improvement in both groups, when compared to the pre-treatment results. Furthermore, significant difference was also observed on comparing the post-treatment results of both groups in favour of the group I. Such significant improvement in TVR group may be explained by the fact that the motor neuron pool excitability may be increased through the facilitatory impulses of the TVR, via increasing the afferent input through the poly-synaptic stretch reflex, which leads to contraction of the extra-fusal muscle fibres. Gradually throughout the period of treatment, the patients acquired relative active control over the target muscle.

Key words: *TVR, Cryotherapy, Erb's palsy.*

INTRODUCTION

Injury to the brachial plexus of an infant may occur when traction is exerted to separate between the neck and the shoulder or on out-stretched arm during difficult birth. The commonest variety seen in 99 % of cases is Erb's palsy or upper brachial plexus type. It is usually associated with difficult breech delivery, forceps delivery or misapplication of the vacuum extractor. This type is due to lesion at the point of junction between the 5^{th} and 6^{th} cervical roots. Immediately after birth, the baby is noticed to lie asymmetrical, with the affected arm limply at his side, instead of being maintained in the flexed posture of the neonate[25].

Incidence of brachial plexus injury has declined because of improved obstetric management of difficult labor. Approximately, 1 to 2 per 1000 babies is born with brachial plexus palsy. The treatment of peripheral nerve injuries has always constituted an important medical problem because it is a very slow process and frequently incomplete, although clinical recovery eventually occurs[19].

Specific motor responses may be facilitated or inhibited by application of sensory stimuli. Peripheral nerve stimulation can increase the excitability level of the alpha and gamma motor neurons of the spinal cord. The patient is unable to initiate a muscle contraction voluntarily although being capable of achieving it with addition of facilitatory peripheral stimulation[10].

Tonic vibration reflex (TVR) is a sustained muscle contraction induced by a high frequency vibrator (80 – 120 Hz) and amplitude of 1-2 ma, which is enough to produce muscle contraction[11]. It is widely used with patients suffering from motor disorders. Although it is initiated immediately on application of the vibratory stimulus, the tension level increases progressively and slowly until it reaches a plateau within 30 to 60 seconds. As long as the vibration continues, the contraction will remain and as soon as the vibration ceases, the contraction fades away within few seconds[2]. The TVR is most effectively elicited when applied on the musculo-tendenous junction[20].

The skin contains primary thermal receptors. Cold receptors are several times greater in number than warm receptors. The cold receptors respond to cooling by a sustained discharge of impulses. When cold stimulation is applied in an appropriate way (quick, brief), there will be an increase in the excitatory bias around the anterior horn alpha and gamma motor cells. Combined with other forms of excitation, this can produce contraction in extra-fusal muscle fibres[13].

It has been stated that the plotting of strength duration carve (SDC), which indicates the strength of impulses of various durations required to produce contraction in a muscle, is the most satisfactory method for the routine non-invasive testing of electrical reactions in peripheral nerve lesion. Measurement of rheobase and chronaxie can be taken from the curve[12].

Aim of the study

To differentiate between the effects of tonic vibratory reflex and cryotherapy on facilitating the biceps brachii muscle recovery in Erb's palsied infants.

SUBJECTS, MATERIALS AND PROCEDURES

Subjects

Thirty Erb's palsied infants from both sexes (13 males and 17 females), ranging in age from two to four weeks represented the sample for this work. They were having unilateral paralysis (ten of them were right-side affected, while twenty were left-side affected), with no other disorders. All of them had a history of difficult labour, with an average birth weight between 3 to 4 kg. They were selected from the Out-patient Clinic of the National Institute for Locomotor System - Imbaba. They were divided randomly into 2 groups of equal number, each comprised 15 subjects. Each group of patients received a specific treatment protocol.

Materials

- ***For evaluation***

- Neurotone electrical stimulator: (Model no. 726S), a universally applicable instrument for modern electro stimulation, diagnosis and therapy, by which the measurement of the strength duration curve were conducted.

- ***For treatment***

- Electric Vibratory stimulating unit: (EV 225, China production). It is composed of a head having two surfaces: soft and hard. The unit produces high

frequency vibration of 117 cycles / second and an amplitude of 2 ma, through a speed control knob.

- Solid ice cubes: They were made by putting a tongue depressor upright in a small cup of water in the freezer.

Procedures

- ***For evaluation***

- Electrophysiological test

The skin over the biceps brachii muscle was rubbed by alcohol to decrease the skin resistance. Two electrodes (active pin-point and indifferent) were used. The indifferent positive electrode was placed on the anterior aspect of the forearm and the pin-point electrode was positioned on the anterior aspect of the upper arm, just above the elbow joint, at the belly of the biceps brachii muscle. The least possible intensity required to produce contraction of the muscle was recorded as the rheobase. By utilizing intensity equals double the rheobase, the least possible time needed to produce muscle contraction was recorded as the chronaxie. A relation was made between the two readings and a strength duration curve was plotted.

- ***For treatment***

Patients of both groups received a physical therapy exercise program including range of motion exercises, stretching exercises, activation of the upper limb muscles from different positions and via different extroceptive and proprioceptive stimulation as tactile stimulation, pressure, tapping, brushing and approximation for the upper limb joints.

- Group I (TVR group): In addition to the exercise program, these patients received high-frequency vibratory stimulation for the biceps brachii muscle. This muscle was chosen because of its importance in ADL and its wide action in shoulder and elbow joints. Vibratory stimulation was performed by placing the infant in a comfortable supine lying position. Several quick stretches were applied to the elbow flexors to facilitate the appearance of the tonic vibratory reflex; the elbow was then held in slight extension, to allow isometric contraction. The vibrator was then applied perpendicularly to the musculo-tendinous junction of the biceps brachii muscle (on the distal end of the anterior surface of the arm above the ante-cubital space). Vibration was delivered at 117 Hz, because this frequency is known to activate muscle spindle primary endings preferentially. It continued until the appearance of the tonic vibratory reflex, with a maximum time of one minute and a rest period for 15 seconds between trials [15]. This was repeated for 5 successive times. The vibrator was always moved to avoid friction which may cause skin trauma[22].
- Group II (Cold group): In addition to the exercise program, patients belonging to this group were exposed to stimulation by brief quick ice application, given in the form of circular movements along the biceps brachii muscle for about 5 seconds, followed by rest period for 1 minute. The procedure was repeated 5 times.

For all patients' groups, treatment was conducted for 12 successive weeks, on 3-times per week basis.

RESULTS

The data collected were statistically treated to show the mean and standard deviation of the strength duration curve of the thirty infants, before and after 12 weeks of

treatment. Intensities were determined at the following durations: 0.05, 0.1, 0.2, 0.3, 0.4 and 0.5 msec. Comparing between the two groups using t-test revealed non-significant difference before treatment for the rheobase and chronaxie (P > 0.05).

As shown in tables (1-6) and fig. (1 and 2), the mean values of SDC of biceps muscle of both groups before and after treatment program were presented. Significant differences were recorded in both groups at the different intensities. The highest significance difference was recorded at 0.3 msec in the TVR group, while it was at 0.5 msec in the cold group.

Table (1): Comparison of mean values of SDC at 0.05 msec in ma, pre and post treatment of the biceps brachii muscle for both groups.

Statistical Analysis	TVR		Cryo	
	Pre	**Post**	**Pre**	**Post**
Mean	3.27	2.65	3.07	2.84
SD	±0.684	±0.719	±0.578	±0.487
MD	0.62		0.23	
% of Change	18.96%		7.49%	
t	8.630		3.607	
P	< 0.001 (Sig.)		< 0.01 (Sig.)	

Table (2): Comparison of mean values of SDC at 0.1 msec in ma, pre and post treatment of the biceps brachii muscle for both groups.

Statistical Analysis	TVR		Cryo	
	Pre	**Post**	**Pre**	**Post**
Mean	3.22	1.98	3.00	2.57
SD	±1.089	±0.860	±0.805	±0.771
MD	1.24		0.43	
% of Change	38.51%		14.33%	
t	5.236		5.609	
P	< 0.001 (Sig.)		< 0.001 (Sig.)	

Table (3): Comparison of mean values of SDC at 0.2 msec in ma, pre and post treatment of the biceps brachii muscle for both groups.

Statistical Analysis	TVR		Cryo	
	Pre	**Post**	**Pre**	**Post**
Mean	3.13	2.34	2.98	2.51
SD	±1.166	±1.125	±1.126	±0.952
MD	0.79		0.47	
% of Change	21.01%		17.45%	
t	9.509		4.768	
P	< 0.001 (Sig.)		< 0.01 (Sig.)	

Table (4): Comparison of mean values of SDC at 0.3 msec in ma, pre and post treatment of the biceps brachii muscle for both groups.

Statistical Analysis	TVR		Cryo	
	Pre	**Post**	**Pre**	**Post**
Mean	2.92	1.56	2.74	2.14
SD	±1.102	±0.766	±1.074	±1.115
MD	1.36		0.60	
% of Change	46.57%		21.90%	
t	11.348		5.071	
P	< 0.0001 (Sig.)		< 0.001 (Sig.)	

Table (5): Comparison of mean values of SDC at 0.4 msec in ma, pre and post treatment of the biceps brachii muscle for both groups.

Statistical Analysis	TVR		Cryo	
	Pre	**Post**	**Pre**	**Post**
Mean	2.72	2.09	2.66	2.23
SD	±0.898	±0.880	±0.687	±0.810
MD	0.63		0.43	
% of Change	23.16%		16.17%	
t	7.296		4.522	
P	< 0.001 (Sig.)		< 0.01 (Sig.)	

Table (6): Comparison of mean values of SDC at 0.5 msec in ma, pre and post treatment of the biceps brachii muscle for both groups.

Statistical Analysis	TVR		Cryo	
	Pre	**Post**	**Pre**	**Post**
Mean	2.24	1.19	2.15	1.65
SD	±0.678	±0.773	±0.888	±0.757
MD	1.05		0.51	
% of Change	46.88%		23.72%	
t	9.340		5.683	
P	< 0.001 (Sig.)		< 0.01 (Sig.)	

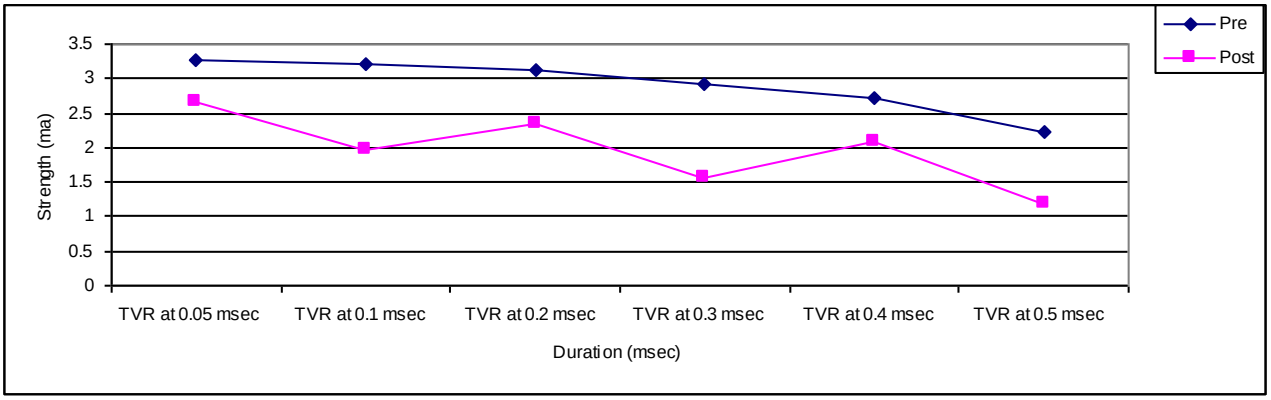

Fig. (1): Comparison of mean values of SDC at different durations in ma, pre and post treatment of the biceps brachii muscle for TVR group.

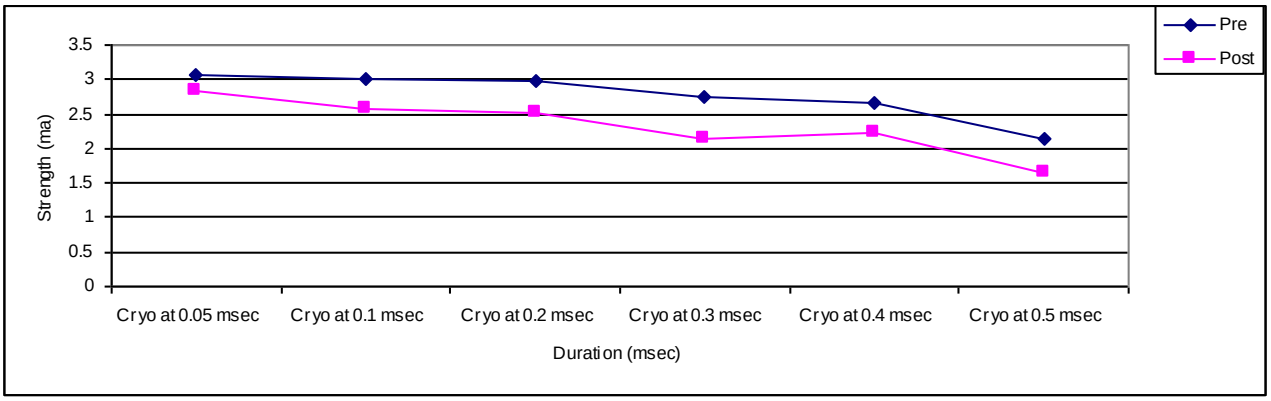

Fig. (2): Comparison of mean values of SDC at different durations in ma, pre and post treatment of the biceps brachii muscle for Cold group.

On comparing the post-treatment results of both groups at different intensities, significant difference has been revealed in 0.1, 0.3 and 0.5 msec. On the contrary, the change at 0.05, 0.2 and 0.4 msec proved to be not significant (table 7 and fig. 3). The mean percentage of change in SDC, when comparing the post-treatment results of both groups, is plotted in fig. 4. It also revealed significant difference between both groups in favor of the TVR group (32.52 % difference) in relation to the cold group (16.84 % difference).

Table (7): Comparison of mean difference values of SDC in ma at different durations in ma, pre and post treatment of the biceps brachii muscle for both groups.

	0.05 msec		**0.1 msec**		**0.2 msec**		**0.3 msec**		**0.4 msec**		**0.5 msec**	
	TVR	**Cryo**	**TVR**	**Cryo**	**TVR**	**Cryo**	**TVR**	**Cryo**	**TVR**	**Cryo**	**TVR**	**Cryo**
Mean	2.65	2.84	1.98	2.57	2.34	2.51	1.56	2.14	2.09	2.23	1.19	1.65
SD	±0.719	±0.487	±0.860	±0.761	±1.125	±0.952	±0.766	±1.115	±0.880	±0.810	±0.773	±0.757
MD	0.19		0.59		0.17		0.58		0.14		0.46	
t	0.989		1.939		0.482		2.269		0.427		2.614	
P	> 0.05 (N.S.)		< 0.05 (S.)		> 0.05 (N.S.)		< 0.05 (S.)		> 0.05 (N.S.)		< 0.05 (S.)	

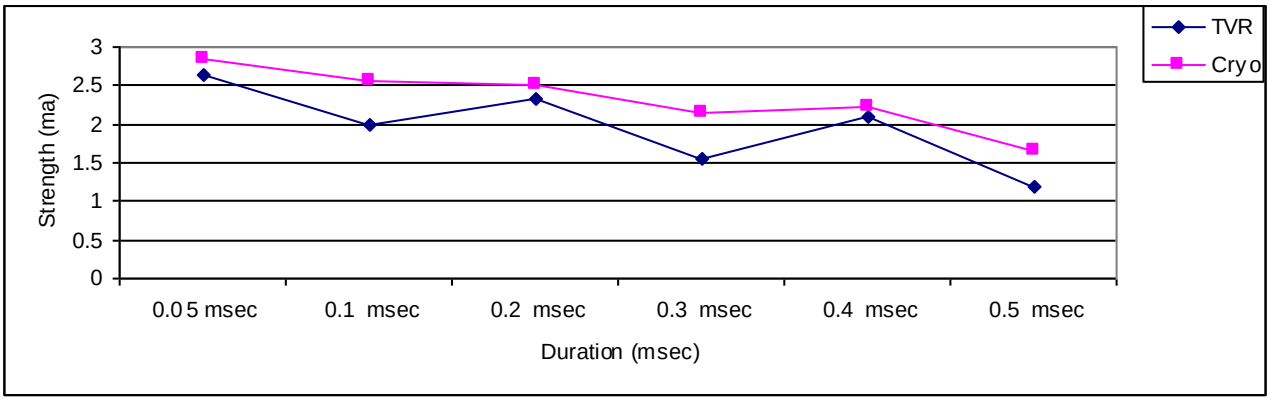

Fig (3): Comparison of mean difference values of SDC in ma at different durations in ma, post treatment of the biceps brachii muscle for both groups.

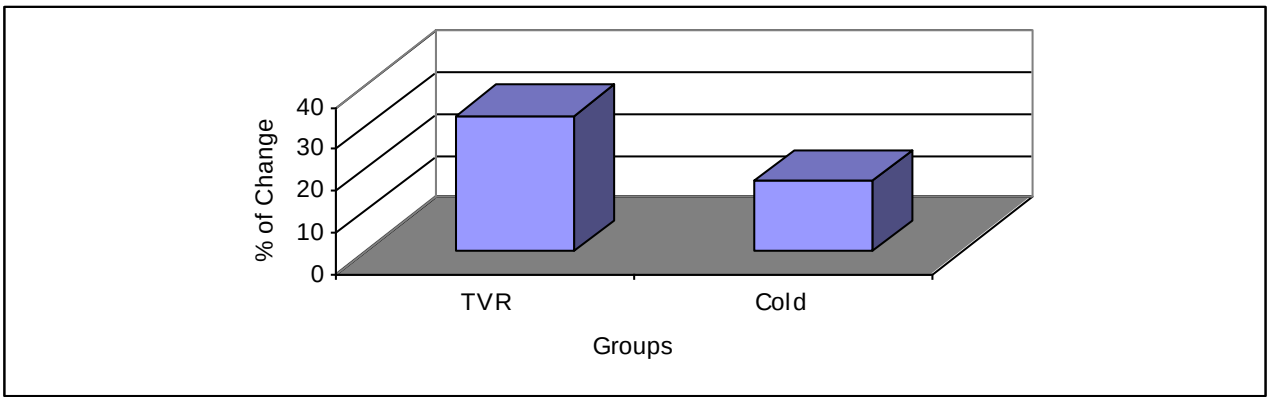

Fig (4): Comparison of mean percentage of change SDC in ma at different durations in ma, post treatment of the biceps brachii muscle for both groups.

DISCUSSION

This study was conducted to compare between the effects of tonic vibration reflex (TVR) and cryotherapy on motor recovery of the biceps brachii muscle in Erb's palsied infants. The results obtained from both patients' groups clearly demonstrated the evidence of significant recovery in both groups, when comparing the pre- and post-treatment results of each group separately. Moreover, significant improvement has been recorded in TVR group, when comparing the post-treatment results.

The results of this study came in agreement with De Domenico[8], who suggested continued vibration until the appearance of the tonic vibratory reflex, with a period of time not more than one minute. He also recommended a great care, as some skin trauma may result from prolonged application of the vibrator with high frequency. The post treatment results of the TVR group came in agreement also with those of Bell et al.,[1] who emphasised several stretches before application of the tonic vibratory reflex to facilitate its neural effects.

It is well known that vibration of a muscle tendon at rest gives rise to a tonic contraction of the parent muscle when the subjects look at their arm[14]. Elicitation of TVR is due to the high-frequency activation of muscle spindle primary endings which, in turn, drive the alpha motoneurons through polysynaptic spinal pathways, as well as supra-spinal pathways[23].

Muscle tendon vibration excites muscle spindle primary endings, which in turn, induce reflex contractions in healthy muscles at rest. Vibration may evoke a tonic vibratory reflex (TVR) in the parent muscle when the subject looks at his or her arm, a response that can involve mono- and poly-synaptic spinal pathways, as well as supra-spinal processes[5].

Earlier studies have shown that tendon vibration generally induces either no TVR or a weak response in the parent muscle[4,9]. The various factors that contribute to this weakness during voluntary contractions may include disruption of descending inputs from higher centers to the spinal cord, death of motoneurons near the injury site, poor central drive, co-activation of biceps and triceps brachii muscles, and disuse atrophy. In order to compensate for this muscle weakness,

activation of additional motor units maximally by external inputs should be encouraged. An alternative way to activate the muscle may be by vibrating the muscle tendon mechanically. Sometimes, only electromyographic (EMG) signals were recorded[26].

It has been hypothesized that the maximal voluntary elbow extensor force could be increased by exciting the motoneuron pool with tendon vibration[18]. For tendon vibration to improve maximum voluntary elbow extensor force, it was necessary that the vibration-induced inputs excited the triceps brachii motoneurons. If a reflex response was induced by vibration before or during the voluntary triceps contraction, vibration may facilitate the initiation, maintenance, and/or strength of the voluntary contraction. Without tendon vibration, the maximum voluntary elbow extensor force developed, but this force was doubled during triceps tendon vibration. Vibration of the triceps brachii tendon (squares) gave rise to a large increase in both the extension force and the triceps surface EMG[27].

It is postulated that excitation of the paralyzed or poorly activated fraction of muscle could at least double the force that the subjects could generate by voluntary effort. The differences in the magnitude of these responses may be explained by the following: 1) more or less overlap between the populations of motor units that were still influenced by muscle spindle inputs and descending voluntary control; 2) variations in voluntary drive as opposed to disruption of the inputs to the spinal cord; 3) activation of neighboring muscles, like shoulder extensors with vibration, influencing elbow extensor force production[17].

Subjects with lower motoneuron damage may have denervated portions of muscle, but reinnervation is expected to occur from neighboring axons. If reinnervation from intact axons fails, the muscle fibers that remain denervated will not be activated either by volition or reflexly by vibration or electrical stimulation[21].

The significant improvement results obtained from the TVR group may be attributed to the enormous value of the tonic vibratory reflex as an effective facilitatory technique to augment the active contraction. Utilization of vibratory stimulation on the musculo-tendinous junction of the affected muscles excites the primary endings in the muscle spindle of the vibrated muscle, which through its connection with motor neuron pools will elicit contraction of the extra-fusal muscle fibres[6].

On the other hand, improvement that occurred in the cold group receiving cryotherapy in addition to the physiotherapeutic exercise program agreed with Bishop[3], who stated that there is evidence that ice can be used as an aid to neuromuscular facilitation.

The results obtained in the cold group after 12 weeks of treatment confirmed the findings of Goodwin et al.,[13] who recommended the use of superficial quick ice application to obtain motor facilitation. They referred this effect to be based on fusi-motor fibres facilitation. The post treatment results also agreed with those obtained by Darcy[7], who recommended a few seconds of ice stimulation, to ensure effective muscle response.

The treatment results also coincide with the results of Forster and Palastange[12], who used quick ice therapy to provide excitatory stimulus when the muscles are inhibited.

The effect of applying a cold pack on the passive range of knee flexion in subjects with restricted knee motion has been tried. The results revealed a marked increase in the

passive range of knee flexion in the study group. The range of knee flexion following the treatment with the application of a cold pack significantly exceeded that after treatment without a cold pack. Cold pack application had a limited but significant effect during mechanical stretching for restricted knee motion[24].

To investigate the influences of cryotherapy on antero-posterior laxity and joint position sense of the knee, twenty healthy volunteers were analyzed. A cooling pad was applied to the knee for 15 minutes under the circulating medium at 4°C. The subject's skin temperature over the antero-medial aspect of the knee was measured during the 15 minutes of cooling and again 15 minutes later. All parameters had normalized at 15 minutes post-cooling. Cooling for 15 minutes makes the knee joint stiffer and lessens the sensitivity of the position sense. These findings may be significant and should be taken into account for therapeutic programs that involve exercise immediately after a period of cooling[28].

The results obtained in the cold group may be attributed to the effect of application of intense short-period cold, which produces a short latency response of vaso-constriction of the superficial skin vessels by the axon reflex. Thus, through the spinal segmental reflex, this leads to subsequent vasoconstriction of adjacent areas i.e muscles or joints. Stimulation of the extroceptors of the skin causes reflex facilitation of the alpha motor neurons in addition to the direct effect on the spindle and gamma afferents. This may be the basis of ice massage, used in neuromuscular facilitation for muscle re-education[16].

Any disruption or reduction in the influence of afferent inputs at spinal or supra-spinal levels may result in the vibration stimulus being ineffective or inadequate to bring all the motoneurons to threshold, especially in reinnervated muscles, in which an absence of stretch reflexes has been shown[6]. The significant improvement recorded in the post-treatment results in favour of the TVR group may be attributed to the sensitivity of other afferents, such as Golgi tendon organs, muscle spindle secondary endings and cutaneous afferents to vibration, particularly if muscle reinnervation has occurred, altering the magnitude of the TVR[27].

Conclusion

From the previously discussed results, supported by many research works, it can be concluded that either TVR or cryotherapy is beneficial when added to the traditional methods of treatment in cases of Erb's palsy in children. It can be also concluded that TVR may be preferable to cryotherapy due to the more intense activation of motor neuron pool by TVR.

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الملخص العربي

دراسة مقارنة بين الانعكاس النغمي الاهتزازي والعلاج بالثلج على عضلة العضد ذات الرأسين في حالات شلل ارب عند الأطفال

تهدف الدراسة إلى المقارنة بين تأثير التنبيه بالانعكاس النغمي الاهتزازي والعلاج بالثلج علي تحسن عضلة العضد ذات الرأسين في حالات شلل ارب عند الأطفال .

اشتملت عينة البحث علي ثلاثين طفلا من الجنسين من المترددين علي العيادة الخارجية للمعهد القومي للجهاز العصبي والحركي - إمبابة ، تراوحت أعمارهم بين أسبوعين وأربعة أسابيع ، وكانت عينة البحث تعاني من ضغط على العصب ، قسمت العينة عشوائيا إلى مجموعتين متساويتين ضمت كل واحدة خمسة عشر طفلا ، تلقت المجموعتين برنامجا للعلاج الطبيعي مع إضافة التنبيه بالاهتزاز الكهربائي علي عضلة العضد ذات الرأسين لمرضي المجموعة الأولي ، وإضافة العلاج بالثلج علي نفس العضلة لمرضي المجموعة الثانية ، تم قياس إصابة العصب لكل مريض عن طريق منحني القوة / الوقت قبل وبعد العلاج الذي استمر اثنا عشر أسبوعا متتالية بمعدل ثلاث جلسات أسبوعيا .

أظهرت النتائج وجود فروق ذات دلالة إحصائية في كلا المجموعتين عند مقارنة النتائج قبل وبعد العلاج لكل مجموعة علي حدة، بالإضافة إلى حدوث فروق ذات دلالة إحصائية عند مقارنة نتائج المجموعتين بعد فترة العلاج لصالح المجموعة التي تم إضافة التنبيه بالاهتزاز الكهربائي إلى برنامج العلاج الطبيعي لها .

وتفسير مثل هذا التحسن الملحوظ في نتائج المجموعة الأولي يعود إلى تأثير التنبيه بالاهتزاز الكهربائي الذي يؤدي إلى انقباض الألياف العضلية خارج الكبسولة عن طريق زيادة التنبيهات العصبية الحسية ، ولذلك يوصي بإضافة هذا النوع من التنبيه إلى برنامج العلاج الطبيعي مع التأكيد علي ضرورة الإسراع في بدء العلاج حتي يمكن تحقيق أفضل النتائج .