Influence of Low Frequency Pulsed Current Versus Russian Current on Quadriceps Muscle Torque And Soreness

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ABSTRACT

Background: *Neuromuscular electrical stimulation (NMES) is used by therapists in muscle strength rehabilitation. Two types of stimulators have aroused special interest, one type produce low frequency pulsed currents and the other, medium frequency alternating currents modulated at low frequencies as Russian current.* ***The purpose:*** *of this study was to investigate which is more effective in increasing muscle torque and in decreasing pain response (Russian current or low frequency pulsed current).* ***Design and Subjects:*** *A pretest-post test (2×2) design with repeated measurement was used in this study. Thirty healthy female physical therapy student and employees participated in this study, their age ranged between 18-32 with mean age (24.9 ± 0.96), assigned randomly to two equal groups:- group I (n=15 female subjects) had their non dominant quadriceps femoris muscle stimulated with Russian current for ten minutes, 3times/week for 4 weeks***.*** *Group II (n=15 female subjects) had their non dominant quadriceps femoris muscle stimulated with rectangular symmetrical biphasic current for ten minutes, 3times/week for 4 weeks.* ***Methods:*** *The isometric torque of the non dominant quadriceps was evaluated at 60 degrees of knee flexion, using Biodex III isokinetic dynamometer before and after training. Each subject was asked to rate their soreness after 48 hours of electrical stimulation every session by usingvisual analogue scale (VAS). A matched paired t-test was used to distinguish between the two groups before and after electrical stimulation. Un-paired t-test was used to further distinguish between both types of electrical stimulation.* ***Results:*** *The results revealed that neuromuscular electrical stimulation produced significant increase in the quadriceps muscle torque (25.93% and 15.96%) in group I and group II respectively (p<0,0001). As regard to muscle soreness there was a significant difference between the two groups (p<0.05) during the second week of training. Also there was no significant difference between the two groups in quadriceps muscle torque (p>0.05) at the end of training.* ***Discussion and conclusion:*** *The finding revealed that neuromuscular electrical stimulation can improve the strength of normal innervated muscles and the Russian current have the advantage over the low frequency pulsed current in terms of strength gained without muscle soreness.*
Key Words: *Electric stimulation, Russian current, muscle torque.*

INTRODUCTION

Neuromuscular electrical stimulation (NMES) is used by therapists in muscle strength rehabilitation, it has become clinically established in post traumatic and inactivity related weakening as a method of inducing muscle contractile activity[9]. NMES result in increased muscle strength, muscle fiber hypertrophy and increased muscle cross sectional diameter when used over a period of several weeks[1].

Clinically, like low frequency currents, MFAC are predominantly used for sensory and motor stimulation[11]. But Russian current is preferable to low frequency Pulsed Current because the stimulation is more comfortable and strong. Neuromuscular excitation become stronger up to 1,250 to 1,500 Hz, remained constant to 2,500 Hz and decreased between 2,500 and 5,000 Hz. Also physical sensation and discomfort decreased steadily with increasing frequency up to 5,000 Hz[13].

The electrical properties of tissue provided the reason for introducing Russian current into clinical practice. The skin acts as a capacitive barrier to the flow of current[11,13]. As the frequency of the applied current increases, the skin offers a progressively lower impedance this contrast with the high skin impedance associated with low frequency alternating current, also a higher proportion of electrical energy is available to stimulate tissue under the superficial epidermis[13]. This can be important when motor nerves, usually deeper, are to be stimulated[11,12].

The amount of force produced in an electrically induced muscle contraction depends on a number of factors. They include the extent of recruitment of motor nerve fibers and their frequency of excitation[1,13]. The more fibers that are recruited and the higher their firing rate, the greater the force of contraction[12].

MATERIALS AND METHODS

Design of the study

A pretest – post test (2 x 2) design with repeated measurement was used in this study. Thirty female healthy subjects aged between 18-32 years old participated in this study. They were randomly assigned into 2 equal groups (group I and group II). Subjects in group I (n=15 female) had their non dominant quadriceps femoris muscle stimulated with Russian current 10/50/10 protocol meaning that 10 seconds "on",50 seconds "off " and 10 stimulation cycles with burst modulated current at 50Hz. The current is applied at a maximum tolerable level. The stimulation is applied directly over the muscle with 2.5 KHz Alternating Current[12]

Group II (n=15 female) had their non dominant quadriceps femoris muscle stimulated with rectangular symmetrical biphasic current as the biphasic form produced 40% more electrically induced strength than the short monophonic one[3,5]

The duty cycle was set at 10 seconds on and 50 seconds off, the pulse duration was set at 200 micro seconds and pulse frequency was set at 50 Hz following the protocol of Laufer et al, 2001[8].

Electrical stimulation in group I was administered 3 times / week for 4 weeks. In group II electrical stimulation was administered for 3 times/ week for 4 weeks. At each stimulation session, the intensity of the stimulator was adjusted to the current that could be maximally tolerated by each subject for 10 minutes[8,12]

Instrumentation

- Phyaction 785-series. Was used to deliver neuromuscular electrical stimulation with Russian current.
- Sonopuls 992 device was used to deliver neuromuscular electrical stimulation with rectangular biphasic symmetrical current.
- Biodex system 3 Isokinetic dynamometer was used to measure the peak torque of maximum voluntary isometric contraction (MVIC) of non dominant quadriceps muscle.
- Visual analogue scale was used to indicate the intensity of muscle soreness[10]. The VAS consisted of a/10cm horizontal line the ends of which defined the minimum (no muscle soreness) and maximum (extreme muscle soreness) each subject place a mark on the line to indicate the intensity of muscle soreness[7,10].

Procedures

Biodex system 3 Isokinetic dynamometer was used to assess torque generated by the non dominant quardriceps femoris muscle group during MVIC before and after training. The subject was asked to sit on the dynamometer with knees off at the edge of the plinth with 60^{o} Flexion, the back support was set at 120^{o} of posterior incline[6,8]. Each subject was instructed to give maximum voluntary isometric torque via verbal coaching to kick as hard as he can during the 3 second contraction[8].

Data analysis and statistical design

The data of this study were analyzed statistically by using the following.

- Descriptive statistics including the mean and standard deviation.
- Dependent and independent t-test was used to further distinguish between both types of electrical stimulation.
- The level of significance for all tests was set at (P < 0.05).

RESULTS

Subjects criteria

Thirty healthy female volunteers' subjects participated in the study. Their ages ranged from 18-32 years with mean age (24.9 ± 0.96), their weights ranged from 50 - 80 kg with mean weight (63.5 ± 2.59) and their heights ranged from 155 - 170 cm with mean height (162.6 ± 1.13). The subjects were randomly divided into two equal groups. Group I received NMES with Russian current, group II received NMES with biphasic rectangular waveform. Independent t-test among the two groups showed no significant differences for age where t-test value was 1.424 (P < 0.166), weight where t-test value was 0.489 (P<0.629) and height where t-test value was 0.447 (P<0.659) as shown in table (1) and figure (1).

Table (1) Physical criteria of the subjects in each group

Variable	Group I		Group II		t-value	P value	Significance
	Mean	SD	Mean	SD			
Age(years)	24	±0.87	25.93	±1.04	1.424	0.166	NS
Weight(Kg)	62.67	±2.45	64.47	±2.74	0.489	0.629	NS
Height(Cm)	162.27	±0.87	163.0	±1.39	0.447	0.659	NS

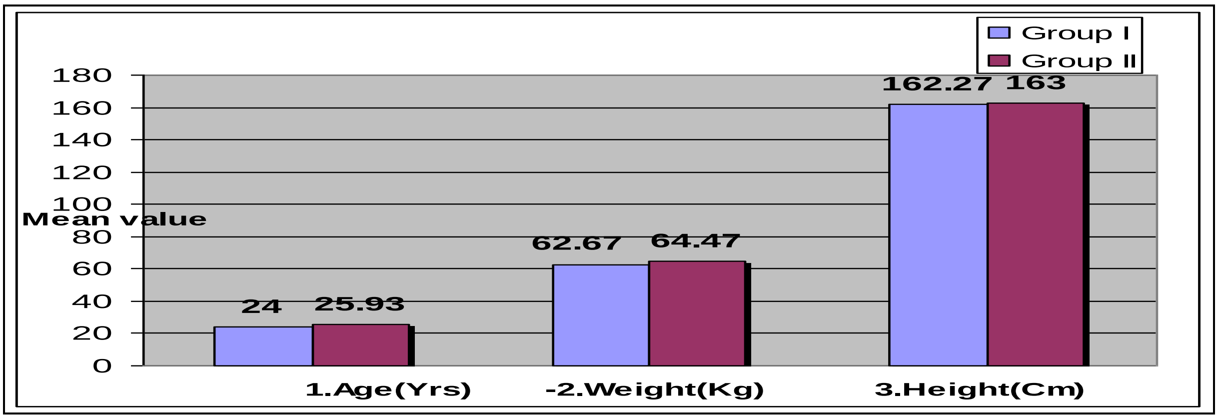

Fig. (1): Physical characteristics of subjects in each group.

Results of dependent t-test among the groups to test the differences in the QF isometric peak torque before and after ES in both groups.

The mean values of the QF isometric peak torque before and after ES were compared in both groups. Paired t-test was performed. It revealed that there were no significant differences among the two groups in QF isometric peak torque before and after electrical stimulation in both groups. Where t value was 1.103 and P value was < .289 as shown in table (2) and figure (2).

Table (2) Independent t-test for difference in peak torque between group I&II

Variable	**Group I**		**Group II**		**t-test**	**P value**	**Significance**
	Mean	**SD**	**Mean**	**SD**			
Difference	28.86	±4.76	22.30	±3.08	1.103	.289	NS

NS=Non significant

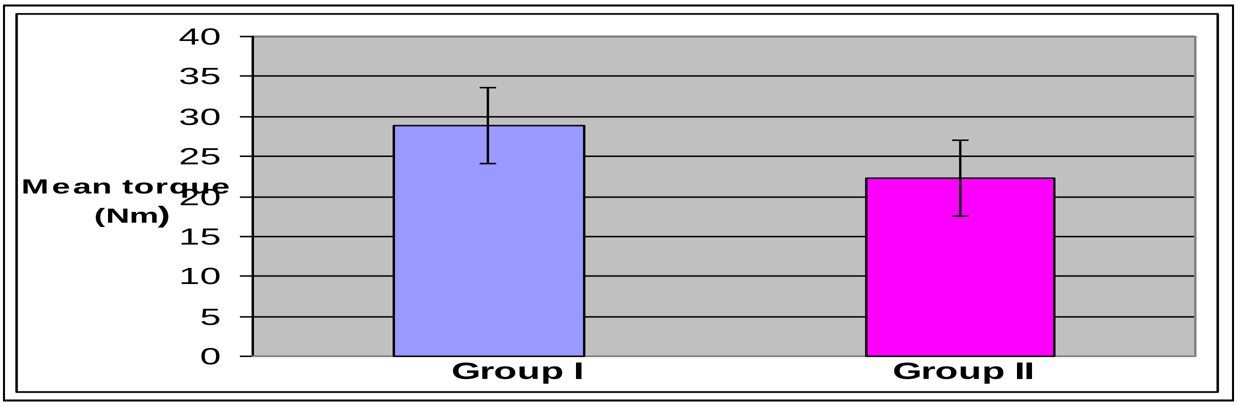

Fig. (2) Difference in peak torque between group I&II.

Frequency distribution for muscle soreness

The subjects were asked to rate their muscle soreness if present after 48 hours of stimulation every session by completing the form of visual analogue scale. Only ten subjects complained of muscle soreness during the second week of the study. Five subjects in group I and five subjects in group II. In group I, one subject choosed number one and four subject choosed number two. While in group two three subjects choosed number three and two subjects choosed number four as shown in table (3) and figure (3)

Table (3): Mean and standard deviation of muscle soreness

Variable	Group I		Group II		t-test	P value	Significance
	Mean	SD	Mean	SD			
Muscle soreness	1.8	±0.2	3.4	±0.25	6.53	.003	Significant

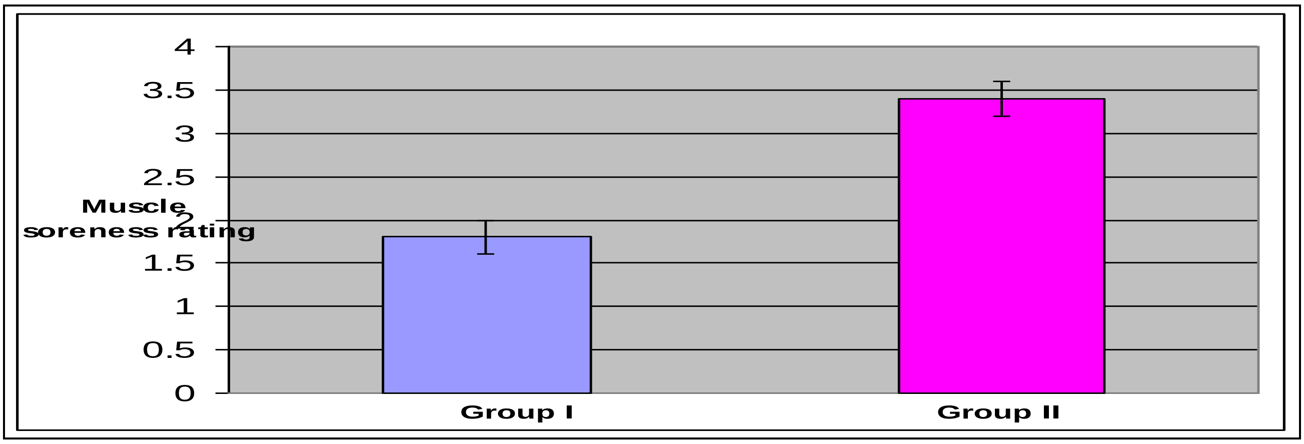

Fig. (3) VAS for muscle soreness during the second week of the training.

DISCUSSION

Within the limitations of this study, the application of both types of electrical stimulation produced significant increment (P < 0.0001) in the quadriceps femoris muscle isometric peak torque while comparing the effect of NMES isometric peak torque with that of before ES. However comparing the effect of both types of electrical stimulation among each others, no statistical significant differences were found between both types of electrical stimulation on the quadriceps muscle torque.

Russian current is preferable to low frequency pulsed current because the stimulation is more comfortable[13]. The rational for using Russian current is that the skin acts as capacitive barrier to the flow of the current. As the frequency of the applied current increases. The skin offers progressively lower impedance. This contrast with the high skin impedance associated with low frequency pulsed currents suggesting that Russian current is potentially more useful clinically[13]. It also minimize skin sensory discomfort, thus allowing the motor stimulation to be of greater intensity and resulting in greater muscular contraction forces through the recruitment of motor units that otherwise would be activated[13]. Furthermore with Russian current, a higher proportion of electrical energy is available to stimulate tissue under the superficial epidermis[11].

In addition, the increase in strength as being a function of the frequency and anesthetic effect allowing each stimulation a greater ability to recruit motor units as the intensity is increased. The pulse rate of electrical stimulation affects the amount of tension developed in a normal muscle. When pulse rates are below 40 Hz, incomplete tetany occurs. Whereas, maximum torque values and tetany have been shown to occur at approximately 50 Hz. Large diameter axons supplying large motor units and fast twitch fibers respond to stimuli delivered at greater than 1000 Hz. This higher frequency may not stimulate small motor units, but appears to be more comfortable since it may not stimulate the small "C" fibers that carry noxious pain signals and stimulates only the larger nerve fibers that control the voluntary muscular contraction of large motor units. This current may produce a moderate anesthetic effect cutaneously, but it does not inhibit the unpleasant sensation associated with the tetanous contraction of the muscle[4].

It was assumed that Russian current is preferable to LFPC because the stimulation is more comfortable and they concluded on this basis an assumption; if the stimulus is more comfortable, greater maximum force can be elicited. This seems to be a reasonable assumption. However when comparing different frequencies, it does not necessarily follow that if Russian current produces more comfortable contraction than LFPC, greater maximal contractions will be produced. The limited number of studies that have directly compared LFPC and Russian current are inconclusive with a consequent underestimation of the peak torque that can be elicited using Russian current. This explains the non-significant difference in muscle torque between both groups[4].

The secondary purpose of this study was to investigate the efficacy of both types of electrical stimulation on muscle soreness after forty-eight hours of electrical stimulation every session since the subject discomfort is often a limiting factor in using ES in clinical setting especially when high contractile forces are needed for strength training regimens[2,4].

Only ten subjects in this study complained of muscle soreness during the second week of training. The muscle soreness experienced by subjects in the low frequency Pulsed current group appeared higher than the Russian current group. The soreness was no longer present after the end of the second week of training. The subjects commented that they experienced soreness immediately after the end of the session but on the next session the soreness was disappeared completely.

Conclusion

Within the limitation of this study, the following conclusions are warranted.

1- NEMS produced statistically significant changes in the isometric strength of the QF after ES treatment.
2- When the torque value was expressed as a percentage of MVIC, it was found that NMES could produce increase about 25.94% in group I and 15.96% in group II.
3- Isometric strength of the QF muscle for group I (Russian current) was greater than group II (rectangular symmetrical biphasic current), but no statistical significant difference among the two types of electrical stimulation was found.
4- Muscle soreness resulted from low frequency pulsed current was greater than Russian current but disappeared in the next session and was not a deterrent to continue the training.

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الملخص العربى

فاعلية التيار منخفض التردد مقابل التيار الروسى على عزم وتعب العضلة الرباعية

المقدمة : يستخدم التنبيه العضلى العصبى فى برامج التأهيل لتقوية العضلات و يوجد منه نوعان أحدهما ذو تردد عالى و هو التيار الروسى والآخر ذو تردد منخفض لذلك تهدف هذه الرسالة إلى المقارنة بين تأثير كلا من النوعين على زيادة عزم العضلة الرباعية وتقليل الآلم العضلى بعد التدريب . **التجربة :** تم إجراء هذه الدراسة بكلية العلاج الطبيعي خلال المدة من أغسطس2005 إلى يناير2006 حيث إشتملت الدراسة على ثلاثين من الطالبات والموظفات الإناث الأصحاء بكلية العلاج الطبيعي . **الأشخاص :** ثلاثين من الطالبات والموظفات الإناث والذين تتراوح أعمارهم ما بين (18 –32سنة) بمتوسط (24.9±96,) تم تقسيم العينة إلى مجموع تين متساويتين عدد كل مجموعة خمسة عشر طالبة. تم تنبيه العضلة الرباعية بلستخدام تيارين مختلفين وهم التيارالروسى بالنسبة للمجموعة الأولى والتيارمنخفض التردد بالنسبة للمجموعة الثانية وقد تمت المعايرة على أقصى شدة تيار يمكن احتماله بواسطة الفرد لمدة عشرة دقائق. وقد استغرقت الدراسة العملية لهذا البحث اربعة اسابيع بواقع ثلاث مرات اسبوعيا. وقد تم قياس عزم عضلة الفخذ الأمامية قبل العلاج الكهربائي وبعد أربعة أسابيع من ه و التعب العضلى إذا وجد بعد مرور 48ساعة من الجلسات . **النتائج :** وقد تم تحليل البيانات إحصائيا ووجدت فروق ذات دلالة إحصائية في المجموعتين في عزم العضلة الرباعية قبل وبعد التنبيه الكهربائى فى كلا من المجموعتين ولا توجد فروق ذات دلالة إحصائية بين كل من التيار الروسي و التيار منخفض التردد علي عزم العضلة الرباعية و بالنسبة للتعب العضلى وجد فروق ذات دلالة إحصائية بين كل من المجموعتين و لكنه لم يلبث أن إختفى و لم يعرقل الأستمرار فى التدريب.