Effect of High Voltage Pulsed Galvanic Stimulation on Torque output of Quadriceps Femoris Muscle: The Roles of Stimulus Frequency and Location

Omaima Kattabei
Basic Science Department, Faculty of Physical Therapy, Cairo University.

ABSTRACT

Numerous electrical stimulation papers have been published using a variety of frequency and electrode placements for augmentation of muscle strength, making cross comparisons difficult. The purpose of this study was to investigate the optimal pulse frequency either (20 or 100Hz) and two electrode placements that could be used to increase the torque of the quadriceps femoris muscle (QF) in healthy subjects. Forty eight healthy males' volunteers from Physical Therapy students with this study. A pre test - post test design with matching were used in this study. The subjects were assigned to one of four equal groups. The pulse frequency 20 and 100Hz were combined with each of the following electrode placements: (1) femoral triangle/transverse distal quadriceps (F) and (2) transverse proximal/distal quadriceps (Q). The isometric torque of the non dominant quadriceps was evaluated at 60° of knee flexion, using Akron rehabilitation system before training and after six weeks of training. High voltage pulsed galvanic stimulation (HVPGS) was administered three times a week with maximum tolerable intensity for 15 minutes per session for the four groups according to their frequency and electrode placement assigned. ANOVA and t-test was used for analysis of data. Results revealed that HVPGS produced statistically highly significant increase in the torque of the QF muscle after 6 weeks training for all groups. But no statistical significant differences among the two pulse frequencies (20 and 100Hz) that selected in terms of muscle strength gained in spite of tendency towards the pulse frequency 100Hz. Regarding the placement configuration, no significant differences were observed among all groups suggesting that the F or Q electrode placement appear to be preferable for maximizing electrical stimulation (ES) induced torque, although the tendency toward the Q electrode placement and should be considered when interpreting ES studies.

***Key words:** High voltage pulsed galvanic stimulation, pulse frequency, Quadriceps femoris muscle, electrode configuration.*

INTRODUCTION

Recently the surge of interest and research in ES has provided a variety of view points as to the benefits that ES may lend to the areas of sports and rehabilitation. The renewed clinical interest in the use of ES techniques as means for improving the strength capability of normally innervated muscle has led to numerous recent studies. Some investigators have evaluated training programs, while others have focused on the relationship between voluntary and electrically stimulated muscular contraction intensities[11,12,19]. When using ES for augmentation of muscle strength the criteria describing ES intensity, frequency and electrode placement have varied widely. The mechanism for muscle strengthening using an electrically induced muscle contraction is the same as that of a voluntary muscle contraction by substantially increasing the muscle functional load and is only dependent on the load at the tendon, measured as torque. To produce overload, the muscle must exceed the minimum electrically evoked torque production threshold, the point at which the contraction produces measurable and meaningful tension in the muscle[7,22].

According to Walmsley et al.,[29] Kotz believed that in order for a current to be successful in ES, it must generate tensions beyond that produced by a maximum voluntary contraction to maximally recruited all muscle fibers to full tetany while at the same time producing little or no pain which concurrent with HVPGS used in the present study.

It was reported in the literature that ES increased isometric QF muscle strength in healthy subjects.[12,19,25] A common problem in drawing comparisons among these studies is the variety of ES current formats and application techniques. The ES techniques for QF muscles described in the published literature have been various stimulation frequencies including the following: 20[17], 30 to 35[6,19], 45, 50[25,29], 60[29], 65[3], 80[25] and 100Hz.[12,18,19] A side from variations in the ES current frequency, several different waveforms, pulse durations application techniques and subject types were examined in these studies[5].

Pulse frequency is considered one important characteristic when using ES to determine the strength of contraction and the rate of force fatigue.[27] The selection of a specific electrical stimulation current frequency generally has been a subjective decision on the part of the investigators, aiming at achieving the greatest muscular contraction intensity through the recruitment of motor units with minimal subject discomfort[9,16].

The question then arises as to magnitude of contractile force that can be elicited by an ES. HVPGS has been used for pain reduction, ulcer healing, edema reduction, increasing joint mobility, prevention of disuse atrophy and augmentation of muscle strength[3,7,8]. The short pulse duration of this current allows a high intensity stimulus with less comfort.

During electrically stimulated muscular contractions (ESMC), the same frequency of the stimulation is delivered to all the activated motor unit, the contractions are relatively synchronous.[16] Motor unit firing frequency, controlled indirectly by the ES frequency, is a major contributor to muscle tension. ESMC are thought to be characterized by reversal of the normal motor unit recruitment pattern and selectively activating the type II muscle fibers, which are more readily fatigued than type I muscle fibers. If the reversal of normal motor unit recruitment order occurs during ESMC and if maximal tetanus of type II muscle fibers is desired, then ES current frequency may be an important factor. Because the clinician can deliver only one ES current frequency at a time per electrode pair, the advantage of one frequency, in terms of subject tolerance and high intensity muscular contraction is of practical importance in making treatment decisions[7].

Electrode placements have generally included the lumbosacral/plexus femoral triangle[4,8,20], femoral triangle/distal thigh[8,12], femoral triangle/motor points of the QF muscles[13,29], femoral triangle/vastus medialis muscle[5,12] and the proximal/distal thigh[12,13].

Often, exact configuration details of these electrode placements are unknown. As a result when comparing and interpreting ES studies, major questions arise as to whether electrode placement and frequency can affect the muscle torque produced and subsequently, the results of a rehabilitation program.

Direct comparisons of electrode placements using similar electrical stimulus conditions, application techniques and test protocols have been reported in the literatures. Ferguson et al.,[8] studied the involuntary quadriceps torque produced using five different electrode placements and ES protocol to tolerance levels. They reported that greater quadriceps torque was produced when using a femoral triangle vastus medialis, vastus lateralis or rectus femoris motor point placement than with stimulation of the femoral nerve proximally with no distal ipsilateral electrode placement or stimulation of the quadriceps with both electrodes placed distally.

Brooks et al.,[4] studied the effect of longitudinal or transverse electrode placements on involuntary quadriceps torque outputs while using a proximal/distal thigh electrode placement with similar machinery and ES intensity to Fergusen et al.,[8]. They concluded that greater quadriceps torque was produced with longitudinal electrode placement.

Hartsell and Kramer[13] compared isometric knee extensor torques produced using three methods to induce muscle tension with three electrode placements, lumbosacral plexus/femoral triangle (LS), femoral triangle/transverse distal quadriceps (F) and transverse proximal/distal quadriceps muscle (Q). They found that the F and Q electrode placement produced similar torques, greater than the torque produced with the LS electrode placement.

Whether specific electrode placements and criteria describing ES frequency are more effective than others has yet to be determined. Practical, not all electrode placement sites are accessible in all patients. Knowledge of placement site effectiveness in different situations is required to help clinicians determine optimal selection.

The purpose of this study was to determine to what extent different frequencies and electrode placements with HVPGS affected isometric quadriceps torque in healthy subjects.

The hypotheses of this study were that HVPGS would augment the torque of QF muscles anf this influence would vary in magnitude depending on the stimulus frequency and location.

SUBJECTS, MATERIALS AND METHODS

Subjects

Forty eight healthy male volunteers were recruited for this study from the Faculty of Physical Therapy students with mean age

All subjects were free from any musculoskeletal diseases affecting the lower limb. Subjects who miss two separate or successive sessions were excluded from the study. All subjects were non smokers and not taking any medications that affect their performance.

Instrumentations

1- Dynamax II high voltage pulsed galvanic stimulator (U.S. Medical Crop.) with mono phasic twin-peak pulse waveform was used in this study. The intensity of the stimulator up to 500 volts and pulse frequency option on the stimulator ranges from 1 to 140 pulse/sec. It includes two output leads at one polarity in conjunction with a single opposite polarity.

2- Akron Rehabilitation System (Huntleigh Tchnololgy PLC) was used to measure the isometric torque of the QF muscle. The system has visual and audio biofeedback. Objective assessment provided via monitor who displays torque, range of movement, total work done and numbers of repetitions completed.

Design of the study

A pre test - post test design with matching were used in this study. Matching attempted to reduce differences between the experimental groups on the dependent variables at the pre test. Subjects were assigned to 1 of 4 equal groups in which HVPGS was administered. The stimulation frequency (Frequency factor) and site (Location factor) were assigned as follows: group (1) received frequency 100Hz to the femoral triangle/transverse distal QF muscle (F), group (2) received frequency 100Hz to the transverse proximal/distal QF muscle (Q), group (3) received frequency 20Hz to (F) electrode placement and group (4) received frequency 20Hz to the (Q) electrode placement. Thus the frequency had two levels (100 and 20Hz) and there were two levels for location (F) and (Q) of the QF muscle.

Electrical stimulation was administrated three times per week for eight weeks. At each training session the intensity of HVPGS was adjusted to the current that could be maximally tolerated by each subject as the ability to tolerate high levels of electrically induced contraction has been widely suggested as a requisite for electrically mediated muscle strengthening[2,24].

For each subject, peak isometric torque of the non dominant QF muscle was evaluated pre and post training with HVPGS. All subjects were instructed to maintain their normal daily activities but not engage in any other exercise training program during the study.

Procedures

[I] Evaluative procedures

All subjects were fully acquainted with details of the procedures which were under taken through a demonstration session. Each subject was allowed 5 minutes of warming upon a stationary bicycle before muscle torque evaluation. The dominant lower extremity was the preferred limb with which to kick a ball. Akron was used to measure the torque of the QF muscle and was calibrated prior to each test session. Each subject was seated on the machine bench with knees off the edge with adjusting the back support to allow hip angle 100° to the horizontal and the knee positioned at 60° flexion. This test position has been to be reliable for yielding maximal QF muscle torque[15,20]. The subject was stabilized in this test position by straps around the trunk, waist and thigh. The resistance arm was moved so that the resistance piece was rested on the subject's leg. Each subject held into the side of the bench with both hands during the test procedure. Each subject was asked to perform a maximal contraction of the knee extension following the command pull. Three trails were made and the mean was recorded. One minute rest was allowed between each trail. During all contractions, the subject watched the pointer of the torque dynamometer and was encouraged verbally to exceed their previous highest torque value.

[II] HVPGS procedures

Bipolar technique with three standard carbon rubber electrodes consisting of two negative electrodes (cathodes) and one dispersive electrode (anode) were used to stimulate QF muscle. Sponge pads soaked in tap water were used between the electrode and the subjects' skin. The electrodes were positioned as follow: 1) one cathode (10 cm X 8 cm diameter) was placed transversely over the motor point of the vastus medialis muscle and another equal size cathode was placed over the motor point of the vastus lateralis muscle. The anode electrode (10 cm X 12 cm) was placed proximal to other two cathode electrodes over the femoral nerve in the femoral triangle (F). Both cathodes were placed transversely over the proximal and distal margins of the quadriceps femoris muscle 3 cm proximal to superior pool of the patella and 3cm distal to the mid point of the inguinal ligament. While the anode electrode was placed proximally to the cathode electrode over the distal part of the vastus medialis muscle (Q) following to Kramer[18].

High voltage pulsed galvanic stimulation (HVPGS) was administered three times a week with maximum tolerable intensity for 15 minutes per session for the four groups according to their frequency and electrode placement assigned. Duty cycle was set at 10 seconds on and off. Pulse frequency (20 or 80Hz) depending on the group assignment.

[III] Data analysis

For the purpose of statistical analysis descriptive statistics including mean and standard deviation (S.D.) of the peak isometric torque of the QF muscles were used. Paired t-test was performed to further distinguish between the effect of frequency and location on the peak isometric torque of the QF muscle pre and post HVPGS training in each group. ANOVA was used to determine any significant differences between all groups. The level of significance for all tests was set at 0.05.

RESULTS

Table (1) represents the mean and S.D. of the QF isometric torque for the 4 experimental groups in which there was highly significant increase ($P<0.0001$) in the muscle torque between pre and post HVPGS training for all groups.

Table (1): Comparison of the mean QF muscle torque between pre and post HVPGS training for all groups.

Groups	Mean QF muscle torque (N.m)			t-test	P value
	Pre training	Post training	Percentage of differences		
Group (1)	81.09±22.15	134.2±31.36	65.49%	11.65	0.0001*
Group (2)	82.13±26.63	130.9±32.16	59.38%	8.95	0.0003*
Group (3)	84.24±25.52	133.9±40.60	58.95%	6.431	0.0001*
Group (4)	79.80±27.8	125.6±41.13	57.39%	6.80	0.0004*

Significance was set at 0.05.

Figure (1) graphically illustrated the effect of frequency factor [100Hz and 20Hz] and the location factor [(F) and (Q)]. There were no statistically differences among the two pulse frequencies in spite of tendency toward 100Hz. Regarding to the placement configuration, no significant differences were observed between (F) and (Q) in spite of tendency toward (Q) electrode placement for increasing the torque of the QF muscle.

In addition, ANOVA test revealed that there was a statistically non significant difference of QF isometric torque between the four groups at pre and post HVPGS training as shown in table (2).

Table (2): Results of ANOVA among the four groups for the QF muscle isometric torque at pre and post HVPGS.

Source variation		Sum squares	Mean squares	F-test	P value
Pre training	Between Within Total	1004.32 22617.89 23622.21	502.16 611.29	0.821	0.448
Post training	Between Within Total	5287 52628.5 57915.5	2643.5 14422.4	1.858	0.170

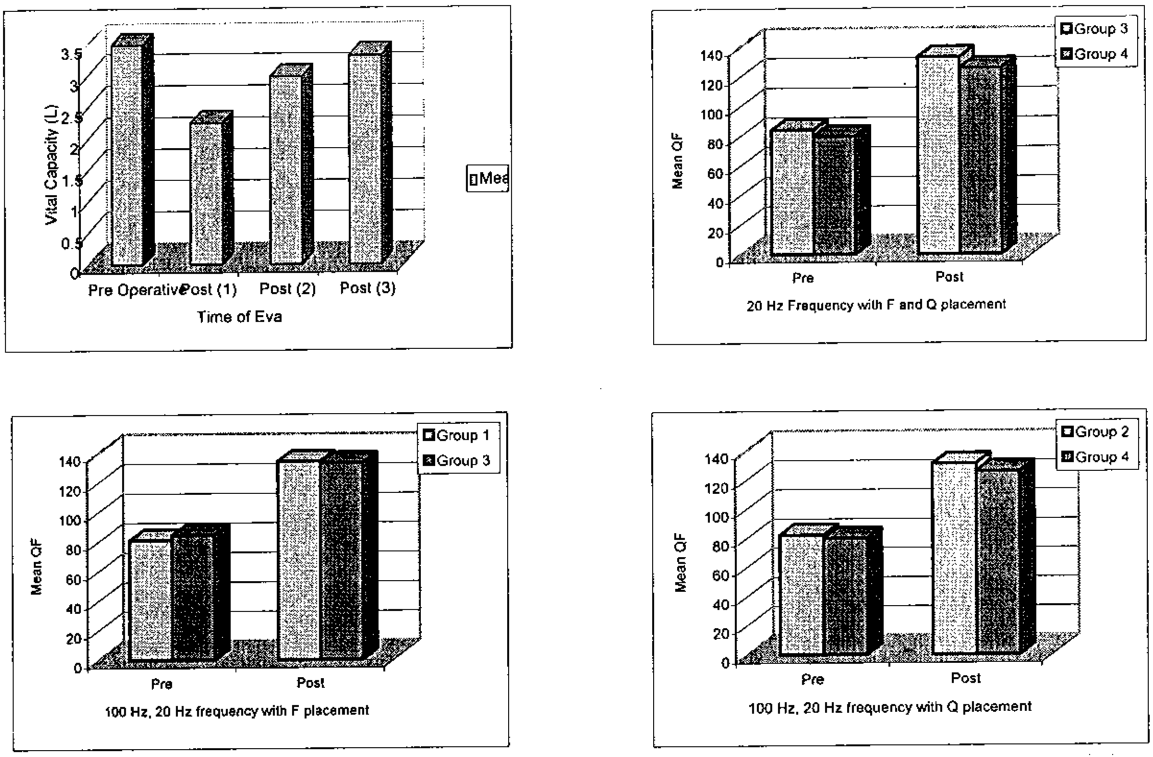

Fig. (1): Comparison of the mean values of the QF muscle torque before and after HVPGS of the four groups.

The site of stimulation (F versus Q) and frequencies (high frequency 80Hz versus low frequency 20 Hz) were variables that did not influence the resulting peak isometric torque of the QF muscle.

DISCUSSION

In the present study the results supported the hypothesis that HVPGS would augment torque of QF muscle in healthy subjects. While did not support that stimulus frequency and location would play an important role in determining the extent to which HVPGS influenced the torque of QF muscle.

It would appear that the two pulse frequencies (20 and 100Hz) that were included in the design of this study produced a highly significant increase ($P<0.0001$) in the torque of the QF muscle. But no statistical significant differences were found between them in spite the tendency toward a high frequency (100Hz).

These findings were in agreement with Moher et al.,[25] who found that HVPGS was capable of producing contractile forces ranged from (17 to 85%) of maximal voluntary isometric contraction (MVIC) with no significant differences between the three pulse frequencies (50,80 and 120Hz) in their effectiveness. Also there was a consistency in results with Balogun et al.,[3] using frequency (20,45 and 80Hz) which attributed their results to the narrow range of pulse frequencies in their study.

In contrast Kramer[17] used different type of electrical stimulation and reported that (50 and 100Hz) were effective than 20Hz in terms of the torque produced by quadriceps muscle. The disagreement between the finding of the present study and Kramer's may be attributed to the use of different stimulus parameters (waveform and pulse duration). The waveform was asymmetrical bidirectional and the pulse duration was one millisecond. The used HVPGS have very short pulse duration, which allow deeper penetration with high intensity with comfort (twin peak, monophasic current), thus direct stimulation of the deep muscle and nerves could be very effective[3,25]. Also, the lower torque values of the superimposed contractions at 20Hz at Kramer study may be attributed to the skin sensory discomfort associated with 20Hz frequency which is not the same situation with HVPGS in this study.

Because the available studies have used a variety of ES units, current formats, application techniques and subjects types (healthy athletes[24,27] and non athletes[6,21,28]), the relationship between different frequencies and strength gain in these studies (torque) is difficult to determine precisely or compaired with the finding of the present study.

Stimulus pulse rate affect the tension developed in the normal muscle and various muscles may have varied responses to stimulations[7]. Also, the strength gained directly correlated with the training contraction intensities and the ability of the individuals to tolerate strong and longer contraction[12]. The greater torque value at the 20 and 100Hz frequencies may be attributed to both frequencies being closer to or exceeding, the tetanus frequency of the activated motor units. Although a wide range of frequencies has been reported for continuous isometric contractions[17], researchers generally agree that increasing the stimulation frequency beyond tetanus frequency does not alter the force output of the muscle because maximal tetanus already has been achieved[16].

In the present study, there was significant increase in muscle strength following application of HVPGS for 6 weeks which ranged from 57.39 to 65.49% of the MVIC. Group (1) increased by 65.49%, group (2) increased by 59.38%, group (3) increased by 58.95% and group (4) increased by 57.39% of the MVIC.

Numerous studies[2,812,13,17,19,22] had demonstrated strength gain in normal innervated muscle ranged from (22 to 88%) that consistent with the present results.

Strength gained that obtained in the present study may be due to the fact that ES targets and trains type II muscle fiber more effectively than does active exercise[3]. Geerdes et al.,[10] assessed the optimal time to start stimulation on gracilis muscle rabbits and stated that ES induced a change in muscle composition from type II to type I fibers and concluded that during stimulation the percentage of type I muscle fibers increased from mean of 4.6% to 41%. The externally applied current through the tissue takes the path of least resistance and recruits the lower resistance (large diameter) fibers than the higher resistance (small diameter) fibers[1,2]. Also, the afferent input from cutaneous stimulation results in inhibitory input to type I alpha motor neuron and excitatory input to type II alpha motor neuron at the same level of the spinal cord[9].

The results of this study suggested that while HVPGS is capable of producing significant increase of the contractile force of the QF muscle, it was apparently that it is not capable of producing contractile forces in the excess of 100% of the MVIC in agreement with Kramer et al.,[19], Walmsley et al.,[29]and Hartsell and Kramer[13].

No significant differences were observed between the F and Q electrode placements, suggesting that selection preference between the F and Q electrode placements may be made at the discretion of the clinician/patient. An electrode configuration similar to F and Q electrode placements used in the present study has been supported by Hartsell[12] and Hartsell and Kramer[13]. An electrode configuration similar to the electrode placement used in the present study has been also supported by Ferguson et al.,[8] and Locicero[22] and an electrode configuration similar to the Q electrode placement was favored by Brooks et al.,[4].

The conclusion disagrees with the study by Cox et al.,[5] who observed that lumbosacral/femoral triangle electrode placement was preferable to the F electrode placement and produced highest peak and average torques and greatest strength increment. Their observation may have been influenced by the small sample (N=15) of male intervarsity athletes and the specific stimulation waveform used. Cox et al.,[5] used a biphasic asymmetrical waveform with a one ms pulse duration, whereas the current used a sinusoidal waveform with a 0.4ms pulse duration. The shorter waveform may have produced less sensory discomfort leading to higher knee extensor torques. Unfortunately, 60% of the subjects stated that they could tolerated greater electrical stimulus intensity than the stimulator could provide. As a result, they did not produce maximally tolerable contractions using ES, whether this is attributable to low stimulator output or high subject tolerance is unclear. Non of the subjects in the present study could have tolerated more current intensity than the HVGPS could provide. The relative effectiveness and interactions among different waveform, pulse durations and subject perceptions still remain unclear.

Overall, these data imply that the hypothesis of this study that HVPGS would augment the torque of QF muscle should be accepted and alternative hypothesis that this torque would vary in magnitude depending on the stimulus frequency and location rejected.

CONCLUSION

HVPGS produced statistically highly significant increase in the torque of the QF muscle after 6 weeks training for all groups. But no statistical significant differences among the two pulse frequencies (20 and 100Hz) that selected in terms of muscle strength gained in spite of tendency towards the pulse frequency 100Hz. Regarding the placement configuration, no significant differences were observed suggesting that the F or Q electrode placement appear to be preferable for maximizing ES induced torques, although the tendency toward the Q electrode placement and should be considered when interpreting ES studies.

REFERENCES

1- Alon, G.: High voltage stimulation: Effect of electrode size on basic excitatory responses, Phys. Ther., 65: 890-895, 1985.

2- Alon, G.; Kantor, G. and Smith, G.: Peripheral nerve excitation and planter flexion stimulation in male and females, J. Orthop. Sports Phys. Ther., 29: 218-224, 1999.

3- Balogun, J.; Onilari, O. and Akeju, O.: High voltage electrical stimulation in the augmentation of muscle strength: Effect of pulse frequency, Arch. Phys. Med. Rehabil., 74: 910-915, 1993.

4- Brooks, M., Smith, E. and Currier, D.: Effect of longitudinal versus transverse electrode placement on torque production by quadriceps femoris muscle during neuromuscular electrical stimulation, J.Orthop. Sports Phys. Ther., 11:530-534, 1990.

5- Cox, A., Mendryk, S., Kramer, J. and Hunka, S.: Effect of electrode placement and rest interval between contractions on isometric knee extension torques induced by electrical stimulation at 100Hz, Physiother. Can., 38(1): 20-27, 1986.

6- Currier, D. and Mann, R.: Muscular strength development by electrical stimulation in healthy individuals, Phys. Ther., 63: 915-921, 1983.

7- Delitto, A. and Synder-Mackler, L.: Two theories of muscle strength augmentation using precutaneous electrical stimulation, Phys. Ther., 70: 158-164, 1990.

8- Ferguson, J., Blacklely, M., Knight, R., Sutlive, T., Underwood, F. and Greathouse, D.: Effects of varying electrode site placements on the torque output of an electrically stimulated involuntary quadriceps femoris muscle contraction, J. Orthop. Sports Phys. Ther., 11: 24-29, 1989.

9- Garent, R. and Stephens, J.: Changes in the recruitment order of motor units produced by cutaneous stimulation in man, J. Appl. Physiol, 311: 463-473, 1981.

10- Geereds, B., Heineman, E. and Freling, G.: Vascular and stimulation delays in dynamic muscluo plasty Surgery, 121(4): 402-410, 1997 (Abst.).

11- Halbach, J. and Straus, D.: Comparison of electromyostimulation to isokinetic training in increasing power of the knee extensor mechanism, J. Orthop. Sports Phys. Ther., 2: 20-24, 1980.

12- Hartsell, H.: Electrical muscle stimulation and isometric exercise on selected quadriceps parameters, J.Orthop. Sports Phys. Ther.,8: 203-209, 1986.

13- Hartsell, H. and Kramer, J.: A comparison of the effects of electrode placement, muscle tension and isometric torque of the knee extensors, J. Orthop. Sports Phys. Ther.,15(4): 168-174, 1992.

14- Keating, J. and Matyo, T.: The influence of subject and test design on dynamometric measurements of extremity muscles, Phys. Ther., 76(8): 866-889, 1996.

15- Keppel, H.K.: Mechanisms for increasing force during voluntary contractions, Appl. Physiol., 226: 1005-1010, 1996.

16- Kosarov,D. and Gydikov, A.: Dependence of the discharge frequency of motor units in different human muscles upon the level of the isometric muscle tension, Electromyogr. Clin. Neurophysiol., 16: 293-306, 1976.

17- Kramer, J.: Effect of electrical stimulation current frequencies on isometric knee extension torque, Physiother. Can., 67(1): 31-38, 1987.

18- Kramer, J.: Muscle strengthening via electrical stimulation, Phys. Rehabil. Med., 1:97-133, 1989.

19- Kramer, J., Lindsay, D., Mage, D., Mendrky S. and Wall, T.: Comparison of voluntary and electrical stimulation torque, J.Orthop. Sports Phys. Ther., 5: 324-331, 1984.

20- Kramer, J. and Semple, J.: Comparison of selected strengthening techniques for normal quadriceps, Physiother. Can., 35: 300-304, 1983.

21- Kues, J., Rothstein, J. and Lamb, R.: The relationship among knee extensor torque produced during maximal voluntary

contractions under various test conditions, Phys. Ther., 74: 674-682, 1992.
22- Locicero, R.: The effect of electrical stimulation on isometric and isokinetic knee extension torque: Interaction of the kinest electrical stimulator and the cybex II, J. Orthop. Sports Phys. Ther., 13: 143-148, 1991.
23- Matsunaga, T., Shimida, Y. and Sato, K.: Muscle fatigue from intermittent stimulation with low and high frequency electrical pulses, Arch. Phys. Med. Rehabil., 80:48-53, 1999.
24- Miller, C. and Thepaut-Mathieu, C.: Strength training by electrostimulation conditions for efficacy, J. Sports Med., 14(1): 20-28, 1993 (Abst.).
25- Mohr, T., LaNita, D., Akes, T. and Landry, R.: The effect of high volt galvanic stimulation on quadriceps femoris muscle torque, J. Orthop. Sports Phys. Ther., 7(6): 314-318, 1986.
26- Scremin, A., Kutra, L. and Gentili, A.: Increasing muscle mass in spinal cord injury persons with a functional electrical stimulation exercise program, Arch. Phys. Med. Rehabil., 80: 1531-1536, 1999.
27- Strojnki, V.: Muscle activation level during maximal voluntary effort, J. Appl. Physiol, 72: 144-149, 1995.
28- Synder-Mackler, L., Delitto, A., Starlka, S. and Bailey, S.: Use of electrical stimulation to enhance recovery of quadriceps femoris muscle force production in patient following anterior cruciate ligament reconstruction, Phys. Ther., 74: 901-907, 1994.
29- Walmslay, R., Letts, J. and Vooy, S.: A comparison of torque generated by knee extension with maximal voluntary muscle contraction vis- a vis electrical stimulation, J. Orthop. Sports Phys. Ther., 6(1): 10-17, 1984.

الملخص العربي

تأثير التيار الجلفاني عالي الجهد على عزم العضلة الرباعية
دور تردد النبضة المنبهة وموقعها

يهدف هذا البحث إلى دراسة النبضات المختلفة (٢٠ ، ١٠٠) نبضة في الثانية ، وكذلك مكان التنبيه الكهربائي (ف ، ق) على زيادة عزم العضلة الرباعية ، وقد أجريت هذه الدراسة على ٤٨ طالبا من الأصحاء بكلية العلاج الطبيعي ، متوسط أعمارهم (١٨,٩ ± ١,٢) تم تقسيمهم عشوائياً إلى أربعة مجاميع متساوية . تم تقييم العزم للعضلة الرباعية غير السائدة قبل التدريب بجهاز أكرون للتأهيل وبعد ستة أسابيع . تم التنبيه الكهربائي بواسطة التيار الجلفاني عالي الجهد لمدة ١٥ دقيقة ثلاث مرات أسبوعيا لمدة ستة أسابيع . وتم معايرة شدة التيار على أقصى تيار يمكن احتماله بواسطة الفرد .

وقد أظهرت النتائج زيادة ذات دلالة إحصائية في عزم العضلة الرباعية بمقدار ٦٥,٤٩ % للمجموعة الأولى ، ٥٩,٣٨ % للمجموعة الثانية ، ٥٨,٩٥ % للمجموعة الثالثة ، ٥٧,٣٩ % للمجموعة الرابعة . لم يوجد فروق ذات دلالة إحصائية بين الترددات المختلفة (٢٠ ، ١٠٠) نبضة في الثانية وكذلك بين مكان التنبيه (ف ، ق) بالرغم من الزيادة الملحوظة للتردد (١٠٠) نبضة في الثانية ومكان التنبيه (ق) .

ويستخلص من هذه النتائج أن التيار الجلفاني عالي الجهد يمكن استخدامه لزيادة قوة العضلة الرباعية في الأشخاص الأصحاء ، ويفضل استخدام التردد (١٠٠) نبضة في الثانية ومكان التنبيه (ق) .