Original Research Article doi: 10.5455/ijtrr.000000243

International Journal of Therapies & Rehabilitation Research
http://www.scopemed.org/?jid=12

E-ISSN 2278-0343

Effect of Pulsed Shortwave Diathermy on Average Isometric Peak Torque of Quadriceps Muscle in Normal Subjects

Magdy Elnaggar,Ph.D [1]; Haytham M.Elhafez,Ph.D [1]; Hala Elhabashy,M.D.[2];Magda G.Sedhom,Ph.D. [1];Dina Othman Shokri,M.Sc.[3]

[1]*Faculty of Physical Therapy,Cairo University, Egypt*
[2]*Faculty of Medicine, Cairo University, Egypt*
[3]*Faculty of Physical Therapy,Badr University in Cairo , Egypt*

ABSTRACT

Objective: *To study the effect of deep heating produced by a 20 minute application of thermal pulsed shortwave diathermy on isometric average peak torque of the quadriceps muscle in normal subjects.*

Methods*: Fifteen normal subjects participated in this study. They were tested before and immediately after the application of pulsed shortwave diathermy using isokinetic dynamometer. The testing procedure consisted of 3 consecutive repetitions of maximum voluntary isometric contraction trails of the dominant quadriceps femoris muscle on isokinetic dynamometer.*

Results: *There was no significant effect of using pulsed shortwave diathermy on isometric average peak torque of quadriceps in normal subjects.*

Conclusion: *The finding of this study suggests that the isometric average peak torque of quadriceps is not influenced by single session of thermal pulsed shortwave diathermy.*
Key words: *Shortwave diathermy, Quadriceps muscle, Heating, Temperature, Peak torque.*

INTRODUCTION

Methods of warm-up can be divided into two categories, passive and active **(1).** A passive warm-up involves increasing muscle or core temperature through the use of heat modalities **(2).** Active warm-up is the increase in muscle or core temperature through exercises **(3).**

The value of warming–up is a worthy research problem because it is not known whether warming–up benefits, harms, or has no effect on individuals **(4).** Research is conflicting in regards to the beneficial effects of heating on strength performance. Variations in intensity of temperature, method of heating and site of temperature measurement are diverse among studies **(5, 6).**

Despite limited scientific evidence supporting the effectiveness, warm-up routines prior to exercise are well accepted in practice. The majority of the effects of warm-up have been attributed to temperature related mechanisms. It has also been hypothesized that warm-up may have a number of psychological effects **(7).**

Pulsed shortwave diathermy is one of the thermal modalities commonly used to increase intramuscular temperature **(8, 9).** The introduction of pulsed shortwave diathermy was driven by its possible athermal effects, while Silverman and Pendleton **(10)** and others **(11-13)** demonstrated that pulsed shortwave diathermy may also induce an elevation of tissue temperature that is dependent on the total average power delivered**.**

Some investigators **(14, 15)** found a significant correlation between muscle temperature and maximal isometric strength in normal subjects and reported a significant increase in isometric muscle strength after increase of muscle temperature by active warm-up. In another studies **(16-18)** in which shortwave diathermy was used as a method of deep heating, a significant increase in quadriceps isometric strength was observed.

On the other hand, some investigators **(19-21)** found no significant change in muscle strength after immersion in 40° C water bath heat application in normal subjects. Other studies **(22-24)** found that muscular strength did not change significantly in any of the passively heated conditions compared to the controls. In addition to that a study by Thornley et al **(25)** found that an isometric knee extension peak torque was not significantly affected by local different temperature gel pack application.

The relationship between deep heat and muscular strength has received limited attention. Furthermore, there are contradictions between the limited numbers of studies that examined the effects of passive deep heating on muscle peak torque. Consequently there is a great need for more research in this area in order to reach a conclusion. Therefore the purpose of this current work is to examine the effect of using pulsed shortwave diathermy on average isometric peak torque of quadriceps in normal subjects in an attempt to use this information in clinical practice to enhance muscle performance.

MATERIALS AND METHODS:

Participants

Fifteen normal male and female subjects with age ranged from 20-35 years with a mean of 28.73 (±4.44) and body mass index ranged from 22-26.5 kg/cm^2 with a mean of 26.42(±3.32) participated in this study. All the participants provided written informed consent prior to the participation in the study.

Exclusion criteria

Subjects with Metal implants, cardiac pacemakers, peripheral vascular diseases of the lower limb, pregnancy, fever, professional athletes, history of lower limb pain within the last 3 months, history of cardiovascular or sensory problems were excluded from the study.

Instrumentation

A. **The Biodex system 3 isokinetic dynamometer:** The Biodex system 3 isokinetic dynamometer multi-joint testing and rehabilitation system (Biodex medical system, Shirely, New York, USA) is one of the modern isokinetic systems that are widely used in research, clinical settings and rehabilitation **(Fig. 1).**

Figure 1: The Biodex system 3 isokinetic dynamometer

B.Shortwave diathermy: Diatermed II 4022 device manufactured by Carci Ltd, Brazil was used in this study **(Fig. 2).**

Figure 2: Diatermed II shortwave diathermy

PROCEDURES:

Assessment procedure of quadriceps isometric average peak torque

Each subject was familiarized with testing procedure by performing 3 consecutive learning trials for quadriceps muscle. The subject was instructed to sit on the biodex chair with knees off at the edge of the chair, adjusting the back support to allow hip angle of 85 degree to the horizontal. The subject was stabilized in the test position by straps around the trunk and thigh. The inferior portion of the shin pad was adjusted 2 inches above the medial malleolus of the tested limb. The fulcrum of the lever arm was aligned with the most inferior aspect of the lateral epicondyle of the femur of the tested limb (anatomical axis of rotation of the tested knee) **.**The speed of dynamometer was set at zero degree per second (isometric contraction) and the knee was positioned at 6o° flexion as recommended by **(26-30)** as shown in (**Fig.3).**

Figure 3: Assessment of quadriceps isometric average peak torque with the knee positioned at 6o° flexion

Each subject was instructed to hold into the sides of the chair with both hands during the testing procedures. Subject was instructed to perform three consecutive maximum voluntary isometric contraction (MVIC) trials of the dominant quadriceps femoris muscle group. Each trial was held for five seconds which was followed by relaxation for five seconds**.** During the test, each subject received constant verbal encouragement to exert his maximum effort.

The final result of isometric strength testing were provided in the form of testing data chart and graph record**.** The mean value of the 3 repetitions of the experimental set in newton meter (Nm) was selected as an indicator for the quadriceps average isometric peak torque**.** This was done before and after the experimental procedures.

Experimental procedure

The diathermy unit used was diatermed II 4022, with frequency of 27.12 MHz. The diathermy was set to a treatment time of 20 minutes; Peak power (PP) of 250 W and pulse width (PW) of 400 µs. The maximum power supplied by the equipment was used with a pulse repetition rate (PRR) of 400 Hz in order to obtain a mean power (MP) of 40 W based on the work of **(11, 31,32).**

The participant was positioned in supine lying on the treatment table. Shortwave diathermy application was given in pulsed mode, through coplanar technique. Capacitive electrodes were used and one of them was placed 3 cm below the anterior superior iliac spine and the other electrode was placed 3 cm above the patella as recommended to be used by **(30)** and showed in **(Fig.4).** This procedure was done for each subject in this study. This was preceded and followed by isometric assessment of quadriceps peak torque.

Figure 4: The placement of capacitive electrodes of the shortwave on quadriceps muscle

Data analysis and results

For the purpose of data analysis the statistical package for the social sciences (SPSS) computer program (version 18 windows) was used. P-value ≤ 0.05 was considered significant.

Kolomogrov-Smirnov test was used to test the normal distribution of the study variables before and after assessment. Paired t-test was used for comparison within group.

Kolomogrov-Smirnov test showed that age, weight, height, body mass index, isometric average peak torque before and after the experimental procedure were normally distributed as shown in **table (1).**

Table (1): Test of normality for demographic data and study variable

Variables	z-value	P-value
Age (years)	0.57	0.89
Weight (Kg)	0.71	0.69
Height (cm²)	0.75	0.61
BMI (kg/cm²)	0.72	0.67
Isometric average peak torque before	0.46	0.98
Isometric average peak torque after	0.90	0.39

Effect of pulsed SWD on isometric average peak torque of quadriceps

There was no significant difference between the pre heating mean of 134.42(± 40.68) and the post heating mean of 132.93(±30.15) with t-value =0.22 and P =0.82 as shown in **Fig (5).**

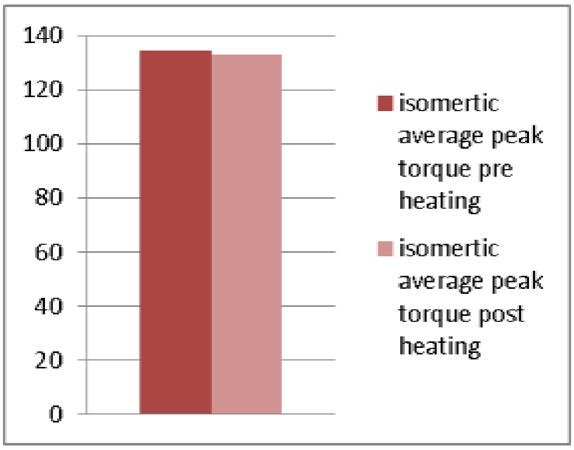

Figure 5: Isometric average peak torque

DISCUSSION

There was no significant effect of using pulsed shortwave diathermy on isometric average peak torque of quadriceps muscle in normal subjects. The result of the current study is consistent with the theory which states that increased muscular temperature may increase action potential, conduction velocity, the rate and synchronization of cross bridge cycling, thereby increasing dynamic, but not isometric strength (**6, 33**). The finding of this current study coincides with previous research studies **(1,6, 19, 24,34)** who found that warm-up did not affect isometric strength.

Torque did not change during maximal voluntary contraction associated with heat produced by shortwave diathermy which can be explained by the fact that there is no need of greater blood, nutrients, ATP or oxygen contribution, since it is a voluntary phasic muscular contraction of high intensity and short duration, in which the proposed interval is sufficient to totally recover the energetic supplies **(30, 35**).

Another explanation why no significant change was noted could be attributed to the application of a single treatment of thermal pulsed shortwave diathermy rather than a series of treatments. The additive effects of pulsed shortwave over a series of treatments is a question yet to be addressed by researchers.

In agreement with the finding of our study, Bhoir **(36)** conducted study to determine the immediate effect of heat application upon hand grip strength measured with dynamometer. Pre-intervention grip strength was assessed for individuals who were asked to dip hand in hot water (40°C-42°C) for 30 second. Immediately after dipping grip strength was reassessed. They found that there was no significant increase in grip strength after heat application.

On the other hand, our finding is not supported by some previous investigators **(16, 37, 38)** who found that isometric strength was decreased after heat application. While others (**17, 39, 40)** showed an improvement of muscle performance after passive or active warm-up. These different findings may be due to the variability in the degree of temperature increase and warm-up methods as well as testing protocols.

Summary and conclusions

The thermal effect generated by pulsed shortwave diathermy did not show significant increase of isometric average peak torque of quadriceps muscle in normal subjects. A single 20 minute pulsed shortwave diathermy application on quadriceps muscle with mean power of 40 W was not effective to increase quadriceps isometric average peak torque. Multiple sessions and different parameters of pulsed shortwave diathermy may be required to produce a significant effect.

Acknowledgement: The authors would like to thank all the participants who kindly accepted voluntarily to participate in the study.

References

1-Bishop D .Warm up I: Potential mechanisms and the effects of passive warm up on exercise performance. Sports Med 2003; 33: 439–454.

2-Evans R K, Knight K L, Draper D O, Parcell A C: Effects of warm –up before eccentric exercise in indirect markers of muscle damage. Medicine and Science in Sports and Exercise 2002; 34, 1892-1899.

3-Bishop D. Warm up II: Performance changes following active warm up and how to structure the warm up. Sports Med 2003; 33: 483–498.

4-FradkinAJ, Zazryn T R, Smoliga JM. Effects of warming-up on physical performance: A systematic review with Meta-analysis. J Strength Cond Res 2010; 24:140-148.

5-Gray S A, Nimmo M. The effect of active, passive or no warm-up on metabolism and performance during high intensity exercise .Journal of Sports Sciences 2001; 19:693-700.

6-Stewart D, Macaluso A, De Vito G. The effect of an active warm-up on surface EMG and muscle performance in healthy humans. Eur J Appl Physiol 2003; 89: 509–513.

7-Khan M H, Nuhmani S, Kapoor G, Ahmed N, Agnihotri D. Effects of ice with active warm up and active warm up alone on performance in football player. IJBAR 2012; 3: 841-846.

8-Starkey C. Therapeutic Modalities. Clinical application of shortwave diathermy.3rd ed. Philadelphia, PA: F. A. Davis; 2004. 209-219.

9-Draper D O, Hawkes A, Johnson AW, Diede M, Rigby J. Muscle heating with the Megapulse II shortwave diathermy and ReBound diathermy. J Athl Train. 2013; 48:477-482.

10-Silverman DR, Pendleton L. A comparison of the effects of continuous and pulsed short-wave diathermy on peripheral circulation. Arch Phys Med Rehabil 1968; 49: 429-436.

11-Draper DO, Knight K, Fujiwara T, Castel JC. Temperature change in human muscle during and after pulsed shortwave diathermy. J Orthop Sports Phys Ther 1999; 29:13-22.

12-Al-Mandeel M M, Watson T. The thermal and nonthermal effects of high and low doses of pulsed short wave therapy (PSWT). Physiother Res Int 2010; 15: 199–211.

13-Murray CC, Kitchen S. Effect of pulse repetition rate on the perception of thermal sensation with pulsed shortwave diathermy. Physiother Res Int 2000; 5:73-84.

14-King PC, Mendryk S, Reid DC, Kelly R. The effect of actively increased muscle temperature on grip strength. Med Sci Sports Exerc 1970; 2: 172- 175.

15-Asmussen E, Bonde-Petersen F, Jorgensen K. Mechanoelastic properties of human muscles at different temperatures. Acta Physiol. Scand 1976; 96: 197–216.

16-Chastain P B. Effect of deep heat on isometric strength. Phys Ther 1978; 58:543-546.

17-Cetin N, Aytar A, Atalay A, Akman MN. Comparing hot pack, shortwave diathermy, ultrasound, and TENS on isokinetic strength, pain, and functional status of women with osteoarthritic knees: A single-blind, randomized, controlled trial. Am J Phys Med Rehabil 2008; 87:443-451.

18-Heggannavar A B, Dharmayat R S,Nerurkar S S, Kamble S A. Effect of russian current on quadriceps muscle strength in subjects with primary osteoarthritis of knee: A randomized control trial.International Journal of Physiotherapy and Research 2014; 2:555-560.

19-Davies C T M, Young K. Effect of temperature on the contractile properties and muscle power of triceps surae in humans .J Appl Phys 1983; 55, 191–195.

20-Crose L E. Depression of muscle fatigue curves by heat and cold. Res Q Exerc Sport 1958; 29: 19-31.

21-Cornwall M W. Effect of temperature on muscle force and rate of muscle force production in men and women. J Orthop Sports Phys Ther 1994; 20:74-80.

22-Muke R, Heuer D. Behavior of EMG parameters and conduction velocity in contractions with different muscle temperature .Biomed Biochim Acta 1989; 48: S459-S464.

23-Holewijn M, Heus R. Effects of temperature on electromyogram and muscle function. Eur J Appl Phys 1992; 65: 541–545.

24-Petrofsky J, Laymond M. Muscle temperature and EMG amplitude and frequency during isometric exercise. Aviat Space Environ Med 2005; 76:1024-1030.

25-Thornley L J, Maxwell N S, Cheung S S. Local tissue temperature effects on peak torque and muscular endurance during isomertric knee extension. Eur J Appl Physiol 2003; 90:588-594.

26-Snyder-Mackler L, Garrett M, Roberts M. A comparison of torque generating capabilities of three different electrical stimulating currents. J Orthop Sports Phys Ther 1989; 10:297-302.

27-McLoda TA, Carmack JA. Optimal burst duration during a facilitated quadriceps femoris contraction. J Athl Train 2000; 35:145-150.

28-Yocheved L, Julie D R, Peter M L, Gad A. Quadriceps femoris muscle torque and fatigue generated by neuromuscular electrical stimulation with three different wave forms. Phys Ther 2001; 81:1307-1316.

29-Lyons LC, Robb BJ, Irrgang JJ, Fitzgerald KG.Differences in quadriceps femoris muscle torque when using a clinical electrical stimulator versus a portable electrical stimulator. Phys Ther 2005; 85:44-51.

30-Boldrini F C, Lopes A D, Liebano R E. Effects of shortwave diathermy on the quadriceps femoris muscle torque during neuromuscular electrical stimulation and voluntary contraction in healthy individuals. Rev Bras Med Esporte 2013; 19: 247-251.

31-Garrett CL, Draper DO, Knight KL. Heat distribution in the lower leg from pulsed shortwave diathermy and ultrasound treatments. Journal of Athletic Training 2000; 35:50-55.

32-Marek S M. The thermal effects of pulsed shortwave diathermy on muscle force production, electromyography,and mechanomyography .Master of Science in Physiology of exercise. The University of Texas at Arlington; 2005: 40, 41, 64.

33-Bergh U, Ekblom B. Influence of muscle temperature on maximal muscle strength and power output in human skeletal muscles. Acta Physiol Scand 1979; 107:33–37.

34-Altamirano KM , Coburn JW, Brown LE, Judelson DA. Effects of warm-up on peak torque, rate of torque development, and electromyographic and mechanomyographic signals. J Strength Cond Res 2012; 26:1296-1301.

35-Billeter R, Hoppeler H. Muscular basis of strength. In: Komi P. Strength and power in sport. Oxford: Blackwell Scientific Publications, 1996: 39-63.

36-Bhoir T, Anap D B, Prabhakar A J. Effect of cold & hot temperature on hand grip strength in normal individuals: Cross sectional study. VIMS Health Sci Journal: 2015; 2 :13-15.

37-Barnes S, Larson MR. Effects of localized hyper and hypothermia on maximal isometric grip strength. Am J Phys Med 1985; 64:305-314.

38-ELNaggar I M. Effect of shortwave diathermy on the electromyographic activity of the rectus femoris and vastus medialis muscle. Med J Cairo Univ 1996; 64:35-44.

39-Gray S R, De Vito G, Nimmo M A, Farina D, Ferguson R A. Skeletal muscle ATP turnover and muscle fiber conduction velocity are elevated at higher muscle temperatures during maximal power output development in humans .Am J Physiol Regulatory Integrative Comp Physiol 2006; 290:376-382.

40-Cochrane DJ, Stannard SR, Sargeant AJ, Rittweger J. The rate of muscle temperature increase during acute whole-body vibration exercise. Eur J Appl Physiol 2008; 103: 441–448.