Comparison between warming up effect of isokinetic training and pulsed shortwave on Quadriceps muscle strength

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ABSTRACT
Background: Adequate warm up before exercise, not only decreased delayed onset muscle soreness occurred but also elevated skin and body temperature through increased whole blood volume, and improve exercise performance. The purpose: To compare between the immediate effects of pulsed shortwave diathermy versus isokinetic training on Quadriceps muscle peak torque. Subjects and Methods: Forty healthy males with mean age (26.7±5.82) years were assigned into two equal groups. Group I received isokinetic exercise training of Quadriceps muscle in the form of concentric-eccentric training at 60⁰/sec. Group II received pulsed shortwave diathermy 20 minutes for the Quadriceps muscle. Isokinetic dynamometer was used for training and evaluation of isokinetic concentric and eccentric peak torques of the dominant Quadriceps muscle. Results: For group I, there were no significant differences between pre-study and post-study in mean values of concentric and eccentric peak torque of Quadriceps muscle. For group II, the mean values of concentric and eccentric peak torque of Quadriceps muscle increased significantly post-study. Conclusion: Pulsed shortwave diathermy improves concentric and eccentric peak torque of the dominant Quadriceps muscle better than the isokinetic training in healthy males.

Keywords: shortwave - concentric - eccentric – Quadriceps muscle.

INTRODUCTION
The effects of heating on the contractile properties of skeletal muscle have been studied extensively. It is clear that increasing muscle temperature increases the speed of muscle contraction, thereby decreasing the time to reach peak tension. Furthermore, these findings are consistent irrespective of whether muscle temperature is elevated as a consequence of exercise or passive heating. (¹)

Diathermy is a therapeutic modality that has been used for orthopedic injuries. However, the usefulness and therapeutic benefits of diathermy are not well understood in comparison with other modalities. Diathermy has had limited use as a therapeutic modality over the last 3 decades. (²)

Shortwave is a type of electromagnetic radiation whose frequency commonly used is 27.12 MHz with a wavelength of 11.6 m. (³) It is also described as either continuous shortwave diathermy or pulsed shortwave diathermy (PSWD). (⁴)

Gray et al. (2006) suggested that muscles must be warmed-up in order to contract as fast as possible. (⁵) At the same time Bishop (2003) suggested that a warm muscle reduces the viscosity leading to more efficient contraction. (⁶) It is well known that neuromuscular function is temperature sensitive. Changing of muscle temperature can affect voluntary muscle contraction. (⁷)

Peres et al. (2002) and Draper et al. (2004) focused on the effect of diathermy on joint range of motion, which includes muscle, ligament, joint capsule, and tendon properties. (⁸, ⁹) While the relationship between heat especially deep heat and muscular strength has received limited attention. The influence of the heat effects on muscle torque in males and females is still unknown. (¹⁰)

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. (¹¹) 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. (1, 12)

Due to the contradictions and limited number of studies that examined the effects of passive heating on muscle peak torque, a conclusion cannot be made. There is a great need for additional research. To our knowledge no previous studies compared between the immediate effects of applying PSWD versus isokinetic exercises on Quadriceps muscle peak torque (PT) in healthy males. Therefore the main purpose of this current work was to examine this effect in an attempt to use this information in clinical practice to enhance muscle performance of Quadriceps muscle.

METHODS
Forty healthy males with age ranged from 20-35 years participated in this study. Subjects were randomly assigned into two equal groups. Group I received isokinetic exercise training of the dominant Quadriceps muscle in the form of concentric-eccentric training at 60°/sec. Group II received PSWD for the dominant Quadriceps muscle.

Subjects excluded from this study that had metal implants, cardiac pacemakers, peripheral vascular diseases of the lower limb, fever, professional athletes and history of cardiovascular or sensory problems.

Instrumentation
I- 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) was used to objectively assess strength of the muscles that would be difficult to obtain using manual testing techniques. (13) It was used for training and measurement of isokinetic concentric and eccentric PT of the dominant Quadriceps muscle.

II- Shortwave diathermy

Shortwave diathermy is an electrotherapeutic agent applied by physiotherapists for the treatment of various conditions. (14) Diatermed II 4022 device manufactured by Carci Ltd, Brazil was used in this study (Fig. 1).

Testing procedures
1- Pre experimental instructions

Each subject was asked to complete the personal data that include the subject’s name, age, address and telephone number, then the height and weight of each one were recorded by the height and weight scale. A brief orientation session was given to each subject before testing about the nature and purpose of the study, the used equipment and the tasks to be achieved.

Figure 1: Diatermed II shortwave diathermy

2- Assessment of Quadriceps isokinetic peak torque.

- Calibration of the unit was performed prior to use according to the manufacturer guidelines. The personal data of each subject were introduced into the computer.

- The subject was secured on the seat by a ten cm wide strap was placed diagonally on the subject chest and thigh strap attach to the seat was used to stabilize the thigh. Subject seated on the dynamometer’s chair with back rest is upright. The axis of rotation of the knee was aligned with the axis of the dynamometer’s and the cuff was attached approximately two fingers above the lateral malleolus. Each subject was familiarized with the testing procedure by performing 3 consecutive learning trials of knee extension . Velocity was set at 60°/sec and knee range of motion was set from 0 to 90 degree and the mode of contraction was concentric-eccentric for two sets of three repetitions at maximal effort. The first set acted as learning while the second set was the experimental set. (15)

- For the concentric/eccentric knee extension test, each subject was instructed to kick as hard as he could against the resistance of the lever arm until his knee became straight, and then resist the machine as it pulls his leg back as quick and as hard as possible. During the test, the subject received constant verbal encouragement to “kick out” during the concentric phase and “resist” during the
• The mean value of PT of the 3 repetitions of the experimental set in Newton meter (Nm) for each of the concentric and the eccentric contraction was selected as an indicator for isokinetic strength of Quadriceps muscle.

Training procedures
I. Application of pulsed shortwave diathermy
• The diathermy unit used was with frequency of 27.12 MHz. The diathermy was set to a treatment time of 20 minutes; Peak power of 250 W and pulse width of 400 μs. The maximum power supplied by the equipment was used with a pulse repetition rate of 400 Hz in order to obtain a mean power of 40 W based on the work of Draper et al. (1999), Garrett et al. (2000) and Marek (2005). (17,18,19)
• The participant was positioned in supine lying on the treatment table. Shortwave diathermy application was given in pulsed mode, through coplanar technique. (Fig.2) 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 Boldrini et al. (2013). (12)

II. Application of isokinetic exercise training:
The same position and instructions used for testing was used in isokinetic exercising of the dominant Quadriceps muscle. During exercising, the subject was instructed to do four sets of five concentric-eccentric knee extension repetitions for a total of 20 repetitions with 30 second rest period between each set. Two minutes rest period was given between the training and assessment procedure.

RESULTS
I- Demographic data of the subjects:
There were no significant differences between the two groups in their mean age, weight and height; where their P-values were 0.143, 0.731, and 0.547 respectively as shown in table (1).

Table (1) General subject characteristics:

<table>
<thead>
<tr>
<th>Item</th>
<th>Group I Mean±SD</th>
<th>Group II Mean±SD</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>26.7 ± 5.82</td>
<td>28.9 ± 4.4</td>
<td>-1.529</td>
<td>0.143</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.7 ± 6.27</td>
<td>169 ± 5.76</td>
<td>-0.349</td>
<td>0.731</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>69.2 ± 8.45</td>
<td>70 ± 8.9</td>
<td>0.613</td>
<td>0.547</td>
</tr>
</tbody>
</table>

II- Pre study mean values within both groups:
There were no significant differences between the two groups pre-study in their mean values of concentric and eccentric PT of Quadriceps muscle of the dominant leg as P value was 0.101 and 0.196 respectively as shown in table (2).

Table (2) Pre study means values within both groups:

<table>
<thead>
<tr>
<th>Items</th>
<th>Concentric PT (Nm)</th>
<th>Eccentric PT (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>110.41 ± 18.618</td>
<td>44.05 ± 11.815</td>
</tr>
<tr>
<td>Group II</td>
<td>123.96 ± 30.695</td>
<td>40.17 ± 7.591</td>
</tr>
<tr>
<td>t-value</td>
<td>-1.725</td>
<td>1.339</td>
</tr>
<tr>
<td>P-value</td>
<td>0.101</td>
<td>0.196</td>
</tr>
</tbody>
</table>
III- Post study mean values within both groups:
There was significant difference between the two groups post-study in mean values of concentric PT of Quadriceps muscle of the dominant leg in favor to group II as P value was 0.014, while there was no significant difference between the two groups in mean values of eccentric PT of Quadriceps muscle as P value was 0.794 as shown in table (3).

Table (3) Post study means values within both groups

<table>
<thead>
<tr>
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<th>Concentric PT (Nm)</th>
<th>Eccentric PT (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>112.59 ± 22.65</td>
<td>48.29 ± 6.402</td>
</tr>
<tr>
<td>Group II</td>
<td>137.07 ± 26.206</td>
<td>47.49 ± 14.452</td>
</tr>
<tr>
<td>t-value</td>
<td>-2.712</td>
<td>0.256</td>
</tr>
<tr>
<td>P-value</td>
<td>0.014</td>
<td>0.794</td>
</tr>
</tbody>
</table>

IV- pre-study and post-study for the two groups:
For group I, there were no significant differences between pre-study and post-study in mean values of concentric and eccentric PT of Quadriceps muscle as P value were 0.599 and 0.063 respectively. For group II, there were significant differences between pre-study and post-study in mean values of concentric and eccentric PT of Quadriceps muscle as P value were 0.004 and 0.014 respectively as shown in table (4).

Table (4) Comparison of pre and post study for two groups

<table>
<thead>
<tr>
<th>Items</th>
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<td>40.17±7.591</td>
</tr>
<tr>
<td>Pre-study</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>112.59±22.652</td>
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</tr>
<tr>
<td>Group II</td>
<td>137.07±26.206</td>
<td>47.49±14.452</td>
</tr>
<tr>
<td>Post-study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-value</td>
<td>-0.535</td>
<td>-1.972</td>
</tr>
<tr>
<td>P-value</td>
<td>0.599</td>
<td>0.063</td>
</tr>
</tbody>
</table>

DISCUSSION
In this current study, we used PSWD as a source of deep heating instead of continuous shortwave because continuous shortwave diathermy provides thermal elevation that produces a much greater risk of burns and patient discomfort as reported by Scifers (2004). Therefore, PSWD often is the treatment of choice.

The expected circulatory effects caused by diathermy initiate 12-15 minutes. Although previous studies reported that the greatest increase in temperature provided by diathermy occurs at 20 min and this is the most cited time in the literature. Thus 20 minutes was selected for the duration of heating in the current study, as this was the optimal time required to trigger therapeutic physiological effects.

The Quadriceps muscle is a prime mover in everyday life and sports; therefore, its function has been extensively studied. There was significant effect of using PSWD on concentric and eccentric PT of Quadriceps in healthy males.

It is assumed that increasing in muscles temperature leads to enhance muscle function due to more blood flow to the muscles. This theory has been developed based on the results of previous studies. Burke et al. (2000) demonstrating an improvement in dynamic training capacity followed by active or passive muscle warm up.

Our results showed that heating the muscle did the expected effect of increasing force level, as there is a linear relationship exists between the muscle temperature and the rate of the enzymatic processes, including ATPase activity as reported by (Gray et al. 2006; Bárány 1967).

The isokinetic strength results of the current study are consistent with the theory which states that increased muscular temperature may increase action potential conduction velocity and the rate and synchronization of cross bridge cycling, thereby increasing dynamic strength as concluded by (Stewart et al., 2003; Bergh and Ekblom, 1979).
The isokinetic strength results of the present study come in agreement with previous research studies of Bergh and Ekblom (1979). As there was significant increase in isokinetic PT of Quadriceps muscle has been described when leg extensions were preceded by an active warm-up. (27)

In agreement with our results Kar and Banerjee (2013) investigated the influence of active and passive warming up on motor performance of the athletes. It was found that both active warm-up by related activity and unrelated activity and passive warming-up by sauna bath and use of massage had significant influence on motor performances of subjects. (28)

In this current study, the increase of muscle temperature had positive effect on isokinetic PT of Quadriceps muscle. On the contrary the study by Altamirano et al. (2012) showed that increase of muscle temperature by dynamic warm-up did not affect stretching increase flexibility more than stretching alone. JOSPT.2004; 34(1):13-20.

Our results are also not supported by the work of Albuquerque et al. (2011) who found that the concentric and eccentric PT of Quadriceps measured by isokinetic dynamometer did not change significantly after the different protocols used for increase of intramuscular temperature. (30)

From this study we can conclude that: Using PSWD as warming up method increase isokinetic concentric and eccentric PT of the dominant quadriceps muscle than the isokinetic training in healthy males.

Conflict of Interest: None.

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9- Draper D, Castro J, Feland J, Schulthies S and Eggett D: Shortwave diathermy and prolonged
19- Marek S: 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; page 40-41-64.


