Effect of cold treatment on the concentric and eccentric torque-velocity relationship of the quadriceps femoris

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Abstract:
This study examined the effect of cold treatment on the force-velocity relationship of the quadriceps muscle of 16 athletes. Each subject performed three maximal concentric and eccentric quadriceps contractions on the Kin-Corn at 25, 50, 75, 100, 125, 150, 175 and 2000s-1. On one of two testing sessions, subjects received a 20 min ice application prior to testing, and for the remaining session, no ice was applied. The results revealed no significant change in the torque-velocity relationship. A trend analysis revealed linear relationships for the concentric ice [F (1,15) = 82.23] and no ice [F (1,15) = 44.86] conditions as well as for the eccentric ice [F (1,15) = 38.58] and no ice [F (1,15) = 26.40] conditions. There were no significant differences between the concentric ice and no ice means at any velocity, but peak torque at 20005- 1 was significantly different from peak torque at 25-100%-1. For eccentric contractions there was a difference between ice and no ice means, with an increase of 20% and 16% for the ice condition at 175 and 200's- I, respectively. For the eccentric ice conditions across velocities, the PT at 20005-1 was significantly different from the PT at 125-200's -1. This suggests that the application of ice will not decrease strength but may in fact result in an increase in eccentric strength.

Article:

1. INTRODUCTION

The most common modality used by athletic trainers is ice. Cold is often used in conjunction with exercise as a part of rehabilitation. Additionally, athletes often use ice prior to or during competition to decrease trauma and pain. There is a vast amount of literature supporting the physiological effects of cold; however, the effect of cryotherapy on muscular strength and the torque-velocity relationship is unclear.

There have been many studies performed using isometric assessment as a strength indicator after cold application. However, because force is being measured at only one angle, isometric assessment may not be a valid indicator of strength through the full range of motion. Theoretically, isokinetic strength assessment is a better assessment of strength since muscular force is measured throughout a full range of motion. In one of the few studies examining

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isokinetic force and cold [6], a significant decrease in concentric isokinetic strength at 60°s-' was found after a 20 min ice immersion. A second study [3], using the velocities of 30, 180, and 300°s-1 demonstrated no significant decrease in concentric isokinetic strength when ice was applied for 30 min prior to testing. It should be noted that neither of the above studies examined the effects of cold on eccentric force production.

Only one study [1] has examined the effect of temperature differences on the force-velocity relationship. This study found that as temperature increased, the force-velocity curve became flatter. While at colder temperatures, the curve became more curvilinear.

In summary, there are contradictory reports on the effect of cold treatment on concentric isokinetic strength and limited literature concerning the effect of cold on eccentric isokinetic strength or on the torque-velocity relationship. Thus, the purpose of our study was to assess the effect of a cold application treatment on the eccentric and concentric torque-velocity relationship of the quadriceps muscle in athletes.

2. METHODS AND MATERIALS

2.1. ***Subjects***

Sixteen subjects, consisting of eight men (seven football and one basketball) and eight women (two lacrosse, three soccer, and three field hockey) university athletes (age = 20.4 ± 1.2 years, weight = 84.4 ± 23.4 kg, height = 175.5 ± 12.0 cm, body fat% = 15.6 ± 4.7) participated in the study. Prior to testing, all subjects were screened for any prior lower extremity injury or adverse reaction to cold. Subjects also gave informed consent prior to testing.

2.2. ***Isokinetic assessment***

The Kinetic Communicator II (Chattecx Corp., Hixson, TN) was used to assess the torque-velocity relationship of the quadriceps muscle. Each subject performed a 5 min warm up period on a stationary bicycle before testing. Following the warm-up, we determined leg dominance by having subjects kick a ball. Subjects were then placed in a seated position on the dynamometer with the lateral epicondyle of the dominant knee aligned with the axis of rotation. Velcro straps were secured around the hips, thigh and lower leg for stabilization. Gravity correction was performed at the start of each session. Each subject then performed three maximal eccentric and concentric contractions from 10 to 90° of flexion at 25, 50, 75, 100, 125, 150, 175 and 200°s-1. To reduce the effect of velocity order, we randomly assigned subjects to one of eight rotated velocity orders with no one order used more than twice. At each velocity, subjects performed two submaximal and one maximal concentric and eccentric contraction for familiarization. Subjects were given a 1 min rest between familiarization contractions and test contractions and between test contractions and familiarization contractions of the next velocity to reduce fatigue. There was no verbal encouragement given throughout the testing session.

2.3. ***Cold application***

All subjects received the ice or no ice conditions on one of two separate days. The order of ice and no ice conditions was counter-balanced. While seated on the isokinetic dynamometer, we placed a cold compression device (Cryo-cuff, Aircast) on the subject's thigh for 20 min prior to isokinetic assessment. The cuff was placed on the thigh at 30% of the distance from the superior pole of the patella to the anterior superior iliac spine. During testing, we drained and refilled the cryo-cuff after every two test velocities to maintain the cooling effect throughout the test.

2.4. *Statistical analysis*

Data were extracted from the mean curve of the three concentric and eccentric contractions at each velocity. The highest value on the mean curve was identified as peak torque. Initially, we performed a repeated measures ANOVA with three variables (ice, contraction type and velocity) to analyze the data. A trend analysis for velocity was then performed on the highest order interaction involving the velocity i and contraction type factors. A Tukey post hoc test was used to test differences between the means.

3. RESULTS

The three way repeated measures ANOVA revealed that the ice by contraction by velocity interaction was significant [F (1,15) = 2.25]. The trend analysis revealed linear relationships for the concentric ice [F (1,15) = 82.23] and no ice [F (1,15) = 44.86] conditions as well as for the eccentric ice [F (1,15) = 38.58] and no ice [F (1,15) = 26.40] conditions (Fig. 1).

A Tukey post hoc test revealed no significant difference between the concentric ice and no ice conditions at any velocity, but did reveal that peak torque (PT) at 200°s-1 was significantly less than the PTs at 25-100°s-1 within the ice condition. For eccentric contractions, there was a significant difference between ice and no ice conditions, with an increase of 20% and 16% for the ice condition at 175 and 200°s-1, respectively. For the eccentric ice condition across velocities, the PT at 200°s-1 was significantly greater than the PT at 50 and 75°s-1, and the PT at 25°s-1 was significantly less than the PTs at 125-200°s-1.

4. DISCUSSION

The major finding of our study suggests that the application of cold treatment prior to muscular activity does not alter the torque-velocity relationship or decrease strength, but may in fact result in increases in eccentric strength at specific velocities. In contrast to the Mattacola and Perrin [6] study, our results revealed that there was no significant difference in concentric isokinetic strength after the application of cold. The reason for this discrepancy may be related to differences in test protocols. Mattacola and Perrin used an ice immersion for their cold treatment, used a smaller muscle group, and immersed the entire muscle area. They also used a different dynamometer (Cybex Division of Lumex, Ronkonkoma, NY) which employeed a continuous rather than interrupted test protocol.

In contrast, Haymes and Ryder [3] applied ice to the quadriceps and produced results similar to ours. Our study, was also in contrast to Binkhorst et al. [1] which found that a decrease in temperature caused the force velocity curve to become more curvilinear. We found that in both the ice and no ice condition, and for both eccentric and concentric contractions, the force velocity relationship remained linear. Again, these differences may be due to differences in methods. Similar to Mattacola and Perrin [6], Binkhorst et al. [1] used an ice immersion technique and a much smaller muscle group than we did. Thus, it is possible that they more thoroughly cooled the musculature producing different results.

As previously mentioned, eccentric strength had significantly increased with the cold treatment at the two highest velocities tested. Ice is known to decrease muscle spindle activity and nerve conduction velocity [2]. This might allow the muscle to generate more tension on eccentric contraction and create a greater force before the stretch receptors activate and cause the muscle to reduce tension.

Our study also differs from others who have reported on the eccentric torque-velocity relationship. Westing, et al. [8] assessed the torque-velocity relationship of the quadriceps across three velocities and found that eccentric force remained unchanged as velocity increased. Their results differed from earlier force-velocity studies [4,5] performed on animals which revealed an increase in eccentric force as velocity increased. In both testing conditions we used, there was a steady increase in eccentric strength as velocity increased. Both our study and the Westing, et al. study used trained males, but differed in the instrumentation used and the number of velocities assessed. Thus, the difference may be due to instrumentation or the effects of the cold treatment.

Westing et al. [7] postulated that the presence of a neural inhibiting system in humans may have accounted for the absence of increases in eccentric force with increases in test velocity. In support of this theory, Westing et al. [9] found that when electrical muscle stimulation was superimposed on maximal volitional eccentric, concentric, and isometric contractions, only eccentric force was enhanced. It is possible that the anesthetic effect of the ice used in our study enabled subjects to 'override' the neural inhibitory feedback from golgi tendon organs, cutaneous pain, and free nerve endings within muscle. While only speculation at this point, the effect of cold on the eccentric torque-velocity curves deserves further study.

In conclusion, more research is needed on the effect of cold on eccentric contractions using different

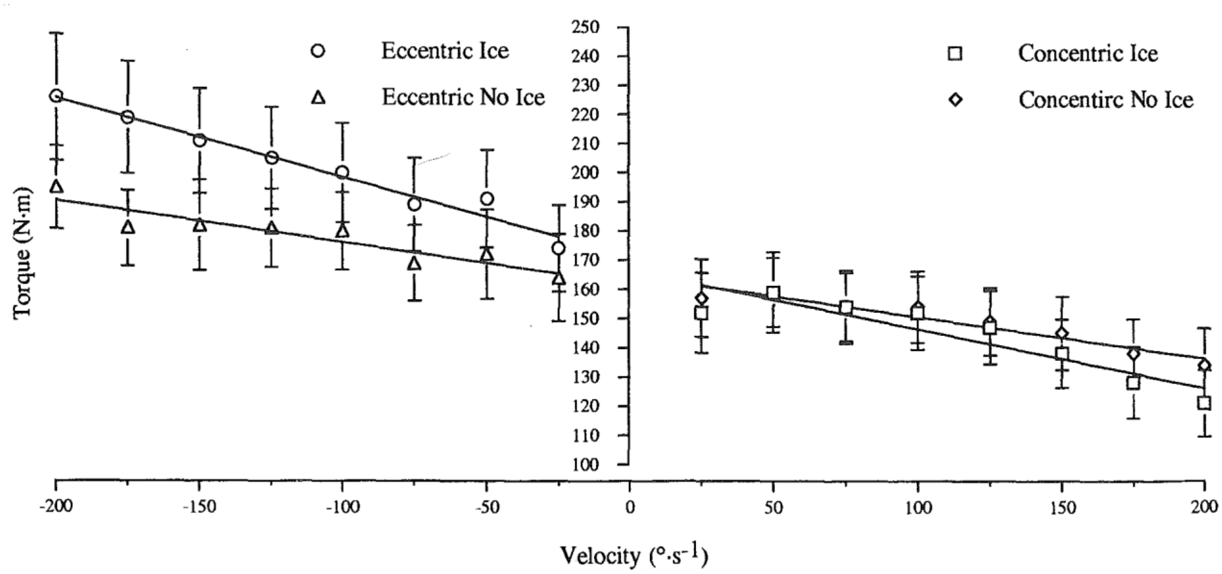

Fig. 1. The torque-velocity relationship of the quadriceps femoris under ice and no ice conditions.

muscle groups. Also, there is a need for strength assessment after different types of cold applications to assess the effects of various modalities available to clinicians.

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