

# Effect of Ice Massage on Lower Extremity Functional Performance and Weight Discrimination Ability in Collegiate Footballers

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**Background:** Cryotherapy, in the form of ice massage is used to reduce inflammation after acute musculoskeletal injury or trauma. The potential negative effects of ice massage on proprioception are unknown, despite equivocal evidence supporting its effectiveness

**Objectives:** The purpose of the study was to test the influence of cooling on weight discrimination ability and hence the performance in footballers.

**Patients and Methods:** The study was of same subject experimental design (pretest-posttest design). Thirty male collegiate football players, whose mean age was 21.07 years, participated in the study. The participants were assessed for two functional performance tests, single leg hop test and crossed over hop test and weight discrimination ability before and after ice massage for 5 minutes on hamstrings muscle tendon.

**Results:** Pre cooling scores of Single Leg Hop Test of the dominant leg in the subjects was 166.65 ( $\pm 10.16$ ) cm and post cooling scores of the dominant leg was 167.25 ( $\pm 11.77$ ) cm. Pre cooling scores of Crossed Over Hop Test of the dominant leg in the subjects was 174.14 ( $\pm 8.60$ ) cm and post cooling scores of the dominant leg was 174.45 ( $\pm 9.28$ ) cm. Pre cooling scores of Weight Discrimination Differential Threshold of the dominant leg in the subjects was 1.625  $\pm$  1.179 kg compared with post cooling scores of the dominant leg 1.85 ( $\pm 1.91$ ) kg. Pre cooling scores of single leg hop and crossed over hop test of the dominant leg in the subjects compared with post cooling scores of the dominant leg showed no significant differences and it was also noted that the weight discrimination ability (weight discrimination differential threshold) didn't show any significant difference. All the values are reported as mean  $\pm$  SD.

**Conclusions:** This study provides additional evidence that proprioceptive acuity in the hamstring muscles (biceps femoris) remains largely unaffected after ice application to the hamstrings tendon (biceps femoris).

**Keywords:** Sports Injury; Proprioception; Functional Performance; Cryotherapy

## 1. Background

Cold in the form of cryotherapy, has been used since the time of ancient Greeks, as an analgesic to reduce inflammation after acute musculoskeletal injury or trauma (1). Cryotherapy is commonly used to reduce temperature, metabolism, inflammation, pain, circulation, muscle spasm and symptoms of delayed onset muscle soreness (2). There are various methods of ice application such as ice pack, cold pack, cold water immersion, ice massage, vapocoolant sprays etc. Ice massage is widely used in managing sports injuries (3). The potential negative effects of ice massage on proprioception are unknown, despite equivocal evidence supporting its effectiveness (4). Some authors have reported that skin temperature of 13.6°C reflects local analgesia and 12.5°C reflects a 10% reduction in nerve conduction velocity (5). Skin surface temperatures between 10°C and 11°C reflect a 50% reduction in cellular metabolism, with an onset of cell hypometabolism occurring at 15°C. Therefore an efficient cryotherapeutic agent should

have a pre application temperature within range of 10 to 15°C (4).

Proprioception acuity is defined as an individual's ability to sense joint position movement, and force to discriminate movements of the limbs (2, 4). Their receptors are located in joint capsules, ligaments, muscles, tendons and skin to detect stimuli such as pain, pressure, touch and movement. Therefore their function is critical to both sport performance and activity of daily living. The ability to sense joint position; however, is only one of the perceptual attributes of the proprioceptive system, which also includes the ability to sense movement (amplitude and angular velocity) and to perceive force and weight (6). Functional performances tests help observe an athlete's performance in physical activities that simulate the muscular and joint stresses encountered. These tests are routinely used in deciding when an individual can safely resume unrestricted sporting activities (7, 8).

## 2. Objectives

The hamstring muscle is one of the commonly injured muscles in footballers, out of which the biceps femoris tendon is more prone to injuries (9). As stated earlier, tendons contain receptors for proprioception; we therefore undertook the study to find out the effect of ice massage on proprioception, assessed through the lower extremity weight discrimination ability and functional performance test scores.

## 3. Patients and Methods

### 3.1. Participants

A sample of convenience of 30 collegiate football players between 18-24 years, who have given their consent, took part in the study. The mean  $\pm$  SD of age, weight and height of the subjects were  $21.07 \pm 1.18$  years,  $64.48 \pm 11.31$  kg and  $168.83 \pm 9$  cm respectively. The body fat and BMI was also calculated and it was found to be  $10.76 \pm 1.04$  (mean  $\pm$  SD) and  $23$  (mean  $\pm$  SD) respectively.

The subjects were selected from Jamia Millia Islamia, New Delhi, football team and the participant should be free from lower extremity injury for at least 6 months prior to testing. Then the subject's height and body weight were recorded. Then the subjects were assessed for weight discrimination ability and functional performance test before and after ice massage. The weight discrimination ability and functional performance test were done randomly to minimize the order effect. The study was of same subject experimental design (pretest-posttest design). The study was approved by institutional ethics committee of Jamia Millia Islamia, New Delhi. The materials and instrument used in the study was Quadriceps chair, stationary bike, weighing scale and height stadiometer.

### 3.2. Weight Discrimination Ability Testing

The ability of the participants to discriminate weights (differential threshold of weight discrimination ability) was tested on the Quadriceps chair equipped with the lever system that allowed for loading of free weights. The actual unloaded weight of right lever was considered as standard (2.5 kg measured separately on a precision numeric scale). This is the appropriate weight to prevent fatigue during testing because participants had to perform many repeated lifting movements. A set of metric metal weights (0.11, 0.28, 0.40, 0.50 kg was used) to gradually increase the mass of standard weight. These comparison weights corresponded to increments of 4% (2.61 kg), 11% (2.78 kg), 16% (2.90 kg), and 20% (3kg) from standard. This set of comparison weights covers the human capacities for weight discrimination along a continuum from easy (i.e. 16% and 20% changes). A set of metric metallic weights were used to gradually increase the mass to increasingly difficult discrimination (4% and 11% changes). The sub-

jects were seated comfortably on the chair. Hips were flexed to approximately  $100^\circ$  and knee resting at  $90^\circ$ . The leg pad was adjusted in height to approximately 5 cm of the medial malleolus of the leg and the participants were asked to perform knee flexion after receiving a tactile cue (a tap on the knee) with varying loads. Five practice trials with easy i.e. 20% increment (0.5 kg) and 11% increment (0.28 kg) were performed. 2 Alternative Forced Choice (2 AFC) procedure was performed with each trial consisting of 2 weight presentations, the standard weight (2.50 kg) and comparison weight (i.e. 0.5 kg 20% increment, 3 kg). The participants were instructed to lift each weight (knee flexion) successively and report which weight within the sequence (the first or second weight) felt heavier. The order of presentation (standard versus comparison) was pseudorandom, and 2 alternatives were equally probable within a block of 14 trials. Full knee flexion (concentric) followed by extension (eccentric) was performed (1). No feedback was provided on discrimination performed during or after formal testing. The differential thresholds, individual's ability to identify the minimum amount of increment in weight, of all the subjects were calculated using the formula:

$$G_{75} = g_{low} + (0.75 - P_{low}) / (P_{high} - P_{low}) \times (g_{high} - g_{low})$$

$G_{75}$ : Discrimination threshold by convention in a 2 AFC paradigm (75% level);  $G_{low}$ : Weight in kg corresponding to lowest performance (last weight presented);  $G_{high}$ : Weight in kg corresponding to the highest performance;  $P_{low}$ : Probability of correct response at lowest performance (usually 50% correct);  $P_{high}$ : Probability at highest performance level (1<sup>st</sup> weight presented).

### 3.3. Functional Performance Tests

The tests were conducted on the dominant leg. Dominance of the leg was determined by asking the subjects to naturally kick a ball. The general warm up required the participants to ride a stationary bike at a steady, comfortable speed for 3 minutes followed by gentle quadriceps, hamstrings, and gastrocnemius stretches. Stretching involved three repetitions of each stretch using a 10 second hold. Three trials of both single hop and cross over hop test were performed. To minimize fatigue, participants were given 45 seconds rest between each practice trial and 1 minute prior to actual testing.

### 3.4. The Single Hop Test

It was measured using a standard tape secured to the floor. Each subject began the test by standing on the dominant limb with the toes lined at the tape measure's zero mark. The recorded measure was placed from the zero mark to the place where subject's heel hit the ground upon completing the single hop on the dominant limb. The distance in centimetres, was then measured. Three

such trials were conducted and then the average was calculated (7).

### 3.5. The Cross Over Hop Test

Subjects began the test by standing on the right side of the dominant limb on a line 6 m long and 15 cm wide secured to the floor. A tape measure was secured on the top of the line. They hopped over to the left side, back over to the right and then back over to the left side using only the dominant limb. Each subject began the test with the toes lined at the tape measure's zero mark. The recorded measure was the distance from the zero mark to the place where the back of the subject's heel hit the ground upon completing the third hop. The test score was the total distance hopped in centimeters. Three trials were taken and end average distance was calculated (8). The single hop test and cross over hop test are reliable tests for measuring functional performance in athletes. The standard error of measurements (SEM) for single hop test reported was + 3.49 and for cross over hop test was + 5.28 (10). Both the tests were reported to be good predictors of knee stability after rehabilitation related to injuries (11).

### 3.6. Ice Massage

The subject wore appropriate clothing. An ice cup was massaged on the medial and lateral hamstring tendons for 5 minutes in the prone lying position. All ice cups were stored at fixed temperature in the same refrigerator (5). The ice massage was done on the dominant leg and dominance of leg was found by asking a subject to kick a ball. The leg with the subject kicked the ball was considered to be dominant for the particular subject (12). Room temperature was maintained at 25°C. The medial hamstrings consist of two muscles namely semitendinosus and semimembranosus which take origin from ischial tuberosity and get inserted into medial condyle and up-

per part of tibia, while the lateral hamstrings which consist of long head and short head of biceps femoris take origin from ischial tuberosity get inserted into head of fibula. The ice massage was applied in the upper 1/3rd of tendons of lateral hamstrings.

### 3.7. Statistical Analysis

Pre and Post ice massage differential threshold of weight discrimination ability values and functional performance tests were analyzed using paired t test using STATA 11.0 statistical software. A significance level of  $P \leq 0.05$  was fixed. A post hoc power analysis was done using GPower 3.1 (13).

## 4. Results

Pre cooling scores of single leg hop and crossed over hop test of the dominant leg in the subjects (mean  $\pm$  SD) compared with post cooling scores of the dominant leg showed no significant differences and it was also noted that the weight discrimination ability (weight discrimination differential threshold) didn't show any significant difference (Table 1).

Pre cooling scores of Single Leg Hop Test of the dominant leg in the subjects (mean  $\pm$  SD = 166.65  $\pm$  10.16 cm) compared with post cooling scores of the dominant leg (mean  $\pm$  SD = 167.25  $\pm$  11.77 cm). Pre cooling scores of Crossed over Hop Test of the dominant leg in the subjects (mean  $\pm$  SD = 174.143  $\pm$  8.597 cm) compared with post cooling scores of the dominant leg (mean  $\pm$  SD = 174.446  $\pm$  9.280 cm). Pre cooling scores of Weight Discrimination Differential Threshold of the dominant leg in the subjects (mean  $\pm$  SD = 1.625  $\pm$  1.179 kg) compared with post cooling scores of the dominant leg (mean  $\pm$  SD = 1.848  $\pm$  1.912 kg). The effect size and post hoc power analysis report is tabulated in Table 1.

**Table 1.** Comparison of Single Leg Hop Test and Crossed Over Hop Test and Weight Discrimination Ability (Differential Threshold) Pre and Post Cooling on the Dominant Leg (n = 30)<sup>a</sup>

Variables	Pre Cooling <sup>b</sup>	Post Cooling <sup>b</sup>	T Value	P Value	Effect Size	Power
Single leg hop test, cm	166.66 $\pm$ 10.16	167.26 $\pm$ 11.77	-0.29	0.8	0.05	0.77
Cross over hop test, cm	174.14 $\pm$ 8.59	174.45 $\pm$ 9.28	-0.20	0.8	0.03	0.83
Weight discrimination ability <sup>c</sup> , Kg	1.6251 $\pm$ 1.18	1.8485 $\pm$ 1.912	-1.012	0.3	0.18	0.51

<sup>a</sup> Analysis of data was done by paired t test.

<sup>b</sup> Data are presented as mean  $\pm$  SD.

<sup>c</sup> Differential threshold.

## 5. Discussion

The study resulted in the following main finding that both functional performance tests, single leg hop test and crossed over hop test and the weight discrimination ability remained unaffected with ice application. Our study has shown that proprioceptive acuity in the hamstrings muscle, as reflected in the ability to perceive

differences in weight, is unchanged after 5 minutes of ice application. After cooling, the perception of force signals generated during weight lifting remained accurate in most participants. Thus, proprioceptive abilities appear to be relatively insensitive to the cooling. This finding raises the question of why proprioception is

unaffected, whereas there is a change in thresholds for cutaneous sensations after cooling. One obvious possibility is that common methods of cooling are simply not effective in decreasing the temperature in deep tissue, where important proprioceptors are located (4). Indeed, studies have shown that the degree of cooling achieved in deep tissues varies widely depending upon the method used (i.e. ice packs versus gel packs or cold-water immersion) (14). We used a conventional method to cool the hamstrings muscle (ice massage for 5 minutes). Although we did not monitor tissue temperature, other authors have reported significant reductions in intramuscular temperature using similar applications (4). There are findings which suggest that 5 minutes application of ice massage lead to temperature changes up to the depth of 3 to 4 cm (15). Thus, we can reasonably assume that our cooling method was effective in decreasing muscle temperature. Another related issue pertains to the persistence of the cooling effect. As stated in the methods section, the participants were tested immediately after application and testing took 30 minutes to complete. Therefore, one may argue that by the time the testing procedure ended, the temperature had already returned to its pre application levels. Although we cannot rule out this possibility and the degree of cooling achieved in each individual may have been different, due to uncontrolled factors such as thickness of adipose tissue. A recent study showed that an ice wrap applied over the anterior thigh for 30 minutes produced significant cooling in deep tissues (2 cm) that persisted up to 20 minutes after application (16). Thus, it is very unlikely that all of the cooling-induced effect had completely vanished by the time the post cooling testing procedure was administered. Our method of application was ice massage which appears to cool muscle more rapidly than any other cryotherapy technique (14). Whatever the issues about the depth and duration of temperature changes, cooling is known to produce marked and persistent slowing of peripheral nerve conduction. The H reflex latency which reflects conduction in proprioceptive afferents from muscle spindles has been shown to increase on average by 5.3 m/s (14). Thus peripheral signals of cutaneous and muscle origin are reduced after cooling. A reduction in skin afferents, although critical for tactile and pain sensations, is of less consequence for proprioceptive abilities. Indeed, skin mechanoreceptors contribute little to proprioceptive acuity because signals from muscle spindles appear to be critical for joint position sense and movement.

We deliberately restricted the cold application to the hamstrings tendon to reproduce situations often encountered in sports. The application therefore did not cover the joint or large muscle belly. The major role ascribed to tendon organs in the genesis of sensations of force and effort may explain why weight discrimination was preserved in most participants, since tendon organs were, presumably, less affected by cooling. Evidence sug-

gests that afferents from tendon organs are not markedly affected by changes in muscle temperature (4). Yet there remains the possibility that, even with a profound reduction in afferents from muscle spindles or tendon organs, weight discrimination can still be performed on the basis of corollary discharges associated with the active-lifting movements. Some participants did experience a decline in their ability to discriminate weight after cooling but it was marginal.

Our study shows that functional performance remains unaffected after 5 minutes of ice massage. Some researchers have reported minimum change in agility assessed with functional performance test post ice application (16). These changes can be due to subjects' apprehension after icing which made them score low on the performance tests, cold induced joint stiffness, reduction in joint dexterity and increased viscosity of fluid within the joint; but we used single leg hop test and cross over hop test which were not used in those studies. These findings suggest that there is no change in proprioceptive acuity and performance of the lower extremity among the football players after 5 minute of ice massage on the lateral hamstrings tendon. Thus clinically, ice massage can be used for the treatment during acute on field injuries.

Future research is required to address how much reduction in nerve conduction velocity, skin, core, or intramuscular or joint temperature is required before the decline in limb weight discrimination ability becomes apparent. Study of other components (i.e. strength and flexibility) which might be affected after ice therapy and in upper extremity dominant sports can be a scope for future research. Our protocol studied the effect of only 5 minute ice massage on the lateral hamstrings tendon in collegiate football players. Moreover the sample size was very small without using appropriate methods to calculate the required number of samples and also our subject population was male predominant; thus the results of the study may not be generalized to all populations.

This study provides additional evidence that proprioceptive acuity in the hamstring muscles (biceps femoris) remains largely unaffected after ice application to the hamstrings tendon (biceps femoris). Thus, a rapid return to play after ice therapy may not be necessarily detrimental for the athlete.

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## Authors' Contributions

Concept/Design: Geeta Sharma and Majumi M. Noohu; Acquisition of Data: Geeta Sharma, Data Analysis/Interpretation: Geeta Sharma and Majumi M. Noohu, Manu-

script Preparation: Majumi M. Noohu and Geeta Sharma, Critical Revision of the Manuscript: Majumi M. Noohu, Approval of the Article: Majumi M. Noohu and Geeta Sharma.

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