The Effect of Cryotherapy on Knee Joint Position Sense

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Study design: experimental design **Purpose:** To investigate the effect of cryotherapy on knee joint position sense. Cryotherapy is commonly used before knee exercises to minimize inflammation & to allow individual to resume activity without pain. But whether it is safe for use before exercise needs to be evaluated**. Setting**: Rehabilitation department, Indian Spinal Injuries Centre, New Delhi.

Subjects: 50 healthy subjects. **Material:** Continuous Passive Motion Machine, Aircast Autochill Cryocuff Unit, Air Splints, Handkerchief, Cotton Gauge, Weighing Machine, Stadiometer, Body marker.

Methods: Two groups were formed, group 1 and 2. Baseline Joint Position Sense (JPS) score were measured at 3 predetermined angles (25°, 45° and 60° of knee flexion) using passive-passive technique, 2nd reading was taken immediately after 20 minutes of cryotherapy (experimental group - group 1) or no cryotherapy (control group - group 2) and 3rd reading was taken after 20 minutes of cryotherapy or no cryotherapy condition. **Outcome Measure: Knee** Joint Position Sense. **Data Analysis:** Statistical tests were performed using the STATA 7.0 and SPSS software. Paired t-test for within group comparison and unpaired t-test for between group comparisons was used. Result: Inaccuracy of JPS increased in all three angles after 20 minutes of cryotherapy ($p < 0.05$). But it did not come back to baseline JPS score even 20 minutes after completion of cryotherapy. Conclusion: 20 minutes of cryotherapy lessens the sensitivity for JPS. These findings may be significant and should be taken into account for therapeutic programmes that involve exercise immediately after a period of cooling.

Key Words: Joint Position Sense, Cryotherapy, Passive – Passive technique

Introduction

Sherrington first defined proprioception in 1906 and is credited with some landmark proprioception experiments. Since then, many researchers have continued his work in an attempt to determine peripheral control mechanism. Sherrington originally defined proprioception as afferent information traveling to central nervous system (CNS) 1. It is currently acknowledged that proprioception is a complex entity encompassing several different components such as the sense of position, velocity, movement detection, and force and that the afferent signals that give rise to them may well have origin in different types of receptors.6 Joint position sense is the ability to determine the location of a joint in space whereas kinesthesia is the ability to detect movement.7

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It is mediated by cutaneous receptors in the skin and proprioceptors in muscles, tendon, ligament and joints, as well as visual and vestibular input which signal to central nervous system (CNS) both the stationary position of the limb and the speed and direction of movement.5 These all inputs can be used on a conscious or unconscious (reflexive pathways) levels so that motor tasks are performed smoothly.7

The most common methods used to quantify proprioception attempt to alter or perturb the afferent information during joint motion. The resultant change in motor output is then used to infer control process .The goal of modification technique is to affect the afferent information while not disturbing the mechanical properties of muscles being tested .1Cryotherapy has become common tool for disrupting afferent signals and modify neuromuscular control while measuring proprioception1 Most proprioception research has examined the elbow, wrist, shoulder and ankle. Some authors have attempted to generalize their findings to other joints; however proprioceptive control may differ depending on

the joint tested.1

In the present study our focus is on the joint position sense, defined as awareness of actual position of limb.

Cryotherapy is local application of cold for therapeutic reasons. It is an umbrella term covering several specific techniques. The clinical rationale for the use of cryotherapy focuses on the control of pain, swelling and other negative sequelae of musculoskeletal trauma.8Both physiological and clinical evidence suggest that cold application can reduce nerve conduction velocity, decrease local blood flow and suppress cellular metabolic rate. These effects in turn, reduce the inflammatory reaction to trauma, lessen pain, retard oedema formation and reduce secondary hypoxic injury .4Confusion exist within clinical practice and published literature over the therapeutic benefits and application protocols of cold modalities. This is important clinically because achieving a desired physiologic response by using cryotherapy requires skin tissues to be cooled to specific levels3. Cold induced analgesia begins after the localized skin surface temperature lowers to approximately 13.6^{o}C. To minimize cellular metabolic rate, skin surface and tissue temperature should be maintained near 10^{o}C.4

Cryotherapy has been used for the treatment of soft tissue injury in knee joint.The aim of cryotherapy is primarily to reduce the total amount of tissue damage , muscle spasm , swelling , & pain and to reduce the disability time and allow faster rehabilitation after injury.2

Cryokinetics is a rehabilitation procedure that combines cold and exercise following acute joint injury.9 Recurrent studies have shown that the combination of exercise and cryotherapy is effective in the rehabilitation of soft tissue injuries. Cryotherapy is currently used before exercise to minimise inflammation and to allow individuals to resume sports without pain. However, no report has shown the effectiveness and safety of cryotherapy for knee joint before exercise.2.

Cryotherapy before exercise may result in inadequate peripheral feedback for the position sense and may change biomechanic properties of the knee joint, resulting in knee injury when exercise is resumed.2It is important , not only for athletes but also for non athletes , for researchers to present data on the laxity , stiffness , and position sense of healthy knee joint after cryotherapy , so that the effectiveness and safety of using this therapy before resuming sports activities should be clarified.2

The purpose of present study is to investigate whether cryotherapy influences position sense of knee

Methodology

Convenient sample of 50 subjects were included in the study. The study was conducted at I.S.I.C hospital, New Delhi.

All the subjects (n = 50) who met the following inclusion and exclusion criteria were randomly assigned and recruited for the study.

Inclusion Criteria

1. Age: 20 yrs to 30 yrs

2. Right leg dominant

Free from pain and discomfort in

and around their knee .

4. No pathological conditions affecting the musculoskeletal or neuromuscular systems.

Exclusion Criteria

History of back, hip, knee, or ankle injury, surgery or pathology.

2. Systemic involvement

3. Subjects having any contraindications to cryotherapy including area of decreased sensation, areas of decreased blood flow, Raynaud's disease or previous cold allergies or reactions.

Study Design

The study was a pre test post test (experimental) design to measure the joint position sense before and after application of cryotherapy.

There were two groups:

Experimental Group (Group 1): 25 subjects Control Group (Group 2): 25 subjects Group 1 – 20 minutes of application of cryotherapy. Group 2 – No cryotherapy application, just lying for 20 minutes.

The joint position sense score was measured before application of cryotherapy, just after

completion of cryotherapy, 20 minutes after completion of cryotherapy.All joint position sense score were measured on the same day.

Instrumentation

1. Continous Passive Motion (CPM) machine – KNEE KINETEC model OPTIMA (Smith & Nephew Kinetec)
2. Aircast Autochill Cryo Cuff unit with knee joint cuff.
3. Air splints (ankle – foot, hip and thigh)
4. Handkerchief
5. Cotton gauge
6. Weighing machine
7. Stadiometer
8. Body marker
9. Watch

Procedure

Subjects received verbal description of all the procedure and were included in the study after informed consent form was signed. The subjects were instructed to remove their trousers and socks and were asked to wear shorts extending not below midthigh to allow for acclimatization to room temperature for 10 minutes.

Thereafter subjects were made to lie supine with right leg on CPM machine. Air splints were applied to thigh, lower leg and foot to be tested to neutralize cutaneous sensations from these areas. After fixing straps, CPM machine was adjusted so that the axis of machine is in line with that of subject's knee joint, defined using lateral femoral epicondyle. Subjects were blind-folded and cotton gauge was given in the ears for preventing any visual or auditory input respectively to joint position sense. All movements were performed on right knee joint.

The knee joint was passively moved from its starting position (0 degrees) to one of the three pre determined joint angles, that is target angles (25, 45, 60 degrees), at a speed of two degrees per second. The knee joint was rested at target angle for five seconds (same durations for all trials) by the investigator and the subject was instructed to remember the position of knee joint (practice 1). The knee was brought back to different randomly assigned starting angle between 10 to 15 degrees from original starting position and rested for 5 seconds; similar procedure was repeated (practice 2). The knee was again flexed with subject instructed to stop the machine with hand held remote to identify the target angle (reading). The absolute difference between preset angle and perceived angle i.e. angle reproduced was recorded.

Absolute Error = ¦Target Angle - Angle Reproduced¦

For each of the pre-determined angles, three readings were taken and their mean was taken as the final value of that angle as taken as the final value of that angle.

Data Analysis

This data was analyzed by means of paired t-test for within group comparisons and by unpaired t-test for between group comparisons through SPSS software.

Results

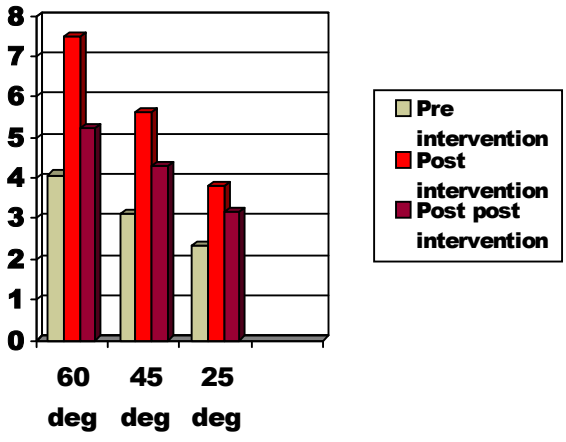
Inaccuracy of JPS increased in all three angles after 20 minutes of cryotherapy . But it did not come back to baseline JPS score even 20 minutes after completion of cryotherapy.

Joint position sense error- within group

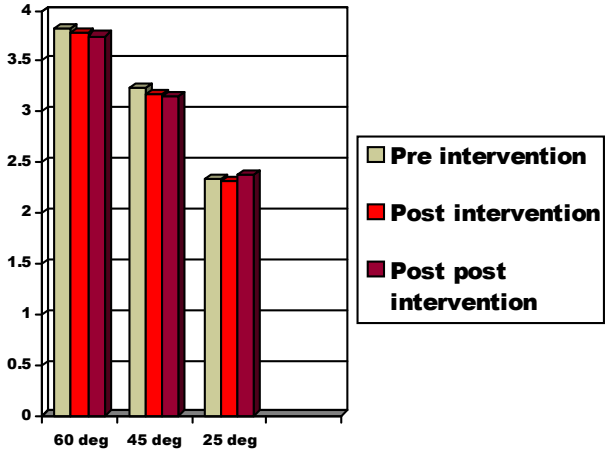
Angle	Pre intervention	Post intervention	Post post intervention	t - value		
				Pre intervention Vs Post intervention	Pre intervention Vs Post post intervention	Post intervention Vs Post post intervention
Flexion 60°	4.08±2.84	7.50±4.62	5.24±2.61	4.58**	3.96**	3.93**
Flexion 45°	3.12±1.59	5.61±3.37	4.28±2.10	4.38**	4.15**	3.90**
Flexion 25°	2.33±1.27	3.81±2.03	3.18±1.59	4.80**	3.98**	4.27**
Flexion 60°	3.82±1.84	3.79±1.84	3.75±1.84	0.49	1.08	0.66
Flexion 45°	3.23±1.69	3.18±1.65	3.16±1.70	0.75	1.07	0.64
Flexion 25°	2.34±1.21	2.32±1.00	2.28±1.04	0.25	0.79	0.96

Note: ** significant at 0.01 level

In graphical representation where x axis is degree of knee flexion (predetermined target angles) and y axis is error in degrees made by subjects at each target angle, experimental group shows significant error in JPS score post cryotherapy and post post cryotherapy at all three angles with maximum at 60° angle of knee flexion. Whereas in control group there is no significant change in JPS score in pre, post, post post test condition at all three angles.



Experimental Group



Control Group

Discussion

There was significant joint position sense error at all target angles after application of cryotherapy, within the group and also between the groups. These effects can be explained neurophysiologically by reference to reduction of

nerve conduction velocity (NCV) and eventual blocking of conduction. Abramson et al showed an approximately linear inverse co-relation between NCV and degree of tissue cooling.2Lee et al reported that skin temperatures at which subcutaneous nerves start to show significant reduction of velocity are at approximately 25 degrees celsius and below. Below 15 degree celsius, nerve conduction failure occurs.2

Investigators have reported that monosynaptic reflex amplitude decrease following muscle cooling which points out to decrease in nerve conduction velocity and muscle spindle firing rates as potential causes.9 Jennifer et al reported, with ice pack over the Flexor Carpi Ulnaris, there was marked and progressive reduction in the motor conduction velocity of the ulnar nerve of 11.6 %. The mean velocity from ten subjects was reduced from 52.6 to 46.5 m/s with 24 minutes of icing.11 When the ice was applied to the elbow, there was even greater reduction in conduction velocity to achieve a maximum drop of 29.4 %. Here the velocity dropped from 52.8 to 37.3 m/s with 20 minutes of icing.28 The changes observed in NCV are thought to be caused by a fall in tissue temperature adjacent to the nerve.11Buchthal and Rosenfalck reported that the conduction velocity in human sensory nerve drops about 2.0 m/s/^{o}C change in intramuscular temperature.

Miglietta concluded that intramuscular temperature is reduced after 20 to 30 minutes of cold application.14Above mentioned studies reveal that there is decrease in nerve conduction velocity and eventual blocking of conduction with decrease in tissue temperature. Also, 20 minute cryotherapy is sufficient to lower intramuscular temperature and to affect nerve conduction velocity (NCV).

In addition, the change in biomechanical properties of the knee joint might be attributed to the impairment of the position sense. The motion of a stiffer knee joint might prevent adequate signals from being provided by mechanoreceptors in the knee joint capsule, muscles and ligaments.2In the present study, 20 minutes after removal of cryo cuff, joint position sense is still impaired significantly. It can be explained on the following evidences:

Petajan and Watts reported that rate of cooling is more than the rate of rewarming. Ronald Bugaj also reported that rewarming does not occur as rapidly as cooling. He found the rate of cooling 2.7 degree celsius per minute while rewarming occured at 1.9 degree celsius per minute after 10 minutes of cryotherapy.12 Hartvikren also documented prolonged effect of local cooling. He found that after 20 minutes of cold application, ankle clonus completely disappeared for upto 8 hours. This prolonged effect was attributed to direct cooling of muscle spindle.14

Young Ho Kim documented that since the vasoconstricted subcutaneous fat layer acts as an insulating material during the cryotherapy, temperature of deeper structures changes very little. Therefore, the effects of cryotherapy last longer. In addition, vasoconstriction induced by cryotherapy reduces blood flow, it takes longer for the cold tissue to recover its original temperature.13

In the present study, the measurement of joint position sense has been done by passive- passive method, which is considered to be pre requisite for measuring joint position sense.12 This method has been used by many others to measure joint position sense. Tsang et al reported that the passive knee joint repositioning test produces highly repeatable data, with intra class co-relation of 0.90.5The assessment of proprioception using "Reproduction of passive positioning" is a valid and established method described by Barett.15 To perform passive presentation – passive replication technique, proprioception testing device was used which consisted of motor driven goniometer. The main aim of proprioceptive device was passive presentation to target position. M J Barlett et al and Thatia et al and many other researchers have used CPM machine to measure joint position sense of knee joint.17, 18, 19

A reliable method for the estimation of joint position sense is the measurement of the reproduction of a specific target position, the difference between the target and estimated position being used. Joint position sense is expressed as the absolute error. (AE) The reason for using a passive and non-weight bearing protocol in joint repositioning test was to minimize the motor contribution, which has been found to aid proprioceptive acuity.20

In addition to pre post method selected for the study, control group was also taken, so that if there is any fatigue or practice effect, it can be eliminated by comparing these two groups. Also ipsilateral measurement is preferred to counterlateral measurement of joint position sense20 which has been done in the present study.Because of possible difference in joint position sense in dominant and non-dominant limbs, only the dominant leg was chosen. Kicking a ball was chosen as the test for leg dominance.

Skin temperature was not measured in the present study and it is a limitation of the present study. But Dahlstedt et al have shown effective reduction of skin temperature with use of auto chill cryo cuff unit device as recommended by the manufacturer22.A 20 minutes duration of cryotherapy is commonly used in clinical practice and is sufficient to lower intramuscular temperature21.

Heather et al reported that cooling does not affect knee proprioception. In this study, proprioceptive accuracy and timing were measured by passively moving the knee, then comparing the subject's active reproduction of the passive movement.17 Inconsensus with the result of this study might be due to active reproduction of passive movement, as explained before.Hooper et al showed significant difference in ankle position sense after 15 minutes of ice immersion.2

K.R Grab et al concluded that there remains no comprehensive method for measuring proprioception. The result of studies which use only either joint position sense or kinesthesia test must be interpreted with care23.

Furthermore, the terms proprioception, kinesthesia and joint position sense should not be used synonymously.

Conclusion

The findings of this study do support the experimental hypothesis that cooling knee joint for 20 minutes impairs the knee joint position sense. To avoid the risk of injury, when the exercise is resumed immediately after cooling, this fact should de considered.

Clinical Relevance

Since the present study shows significant effect of cryotherapy on knee joint position sense and knee joint position sense have important role in functional joint stability and motor control administration of exercises immediately after cryotherapy would not be safe. So exercises should not be given immediately after cryotherapy to avoid potential injury.

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