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Effect of Cryotherapy on Lower Limb Flexibility and Power in Recreational Players: An Experimental Study

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ABSTRACT

Introduction: Cryotherapy has been a widely used thermotherapy modality in sports injuries. The main focus of research on cryotherapy was to find out its effects on functional performance measures of the players. Cryotherapy is known to dampen the stretch reflex and reduce muscle temperature which might indirectly influence the flexibility and power which are the important components of any performance. Hence, it becomes necessary to study the changes, if any, on the flexibility and power post cryotherapy application.

Aim: To determine the effects of cryotherapy on lower limb flexibility and power in adult recreational players.

Materials and Methods: The present study was an experimental study conducted on 40 recreational players of either gender, between the age range of 18-25 years, who played various forms of recreational sports and had hamstrings and calf muscle tightness were included in the study. Hamstring tightness was assessed by Active Knee Extension Test (AKET) and calf muscle tightness by Weight Bearing Lunge test (WBLT), while power was assessed by vertical jump test. Both the limbs were given cold pack on bilateral calf and hamstrings for 20 minutes for three days. Outcomes were measured on 3rd day and paired t-test was used to analyse the pre and post-treatment difference, p-value less than 0.05 was considered as significant.

Results: A total of 40 recreational players were included in the study with the mean age of 22.15±1.36 years, of which 20 were males and 20 were females with mean Body Mass Index (BMI) of 23.07±3.36 kg/m^2. The right calf muscle flex (pretreatment=13.7 cm to post-treatment=14.71 cm, $p<0.05$) along with left side flexibility (pretreatment=14.2 cm to post-treatment=15.07 cm, $p<0.05$). The hamstring flexibility improved significantly from mean, pretreatment=45.6 degrees to post-treatment=50.6 degrees ($p<0.05$) on the right side while on the left side, a non significant improvement from pretreatment=52.38 degrees to post-treatment=55.22 degrees (p=0.011) was seen. The power showed a non significant reduction from pretreatment=17.61 to post-treatment=16.76 (p=0.016).

Conclusion: Cryotherapy increases the flexibility of calf and hamstring muscles and reduces lower limb power after three days of cryotherapy application.

Keywords: Calf flexibility, Hamstring flexibility, Ice pack, Vertical jump test

INTRODUCTION

Cryotherapy is considered to be an efficient treatment for acute and chronic musculoskeletal injuries [1]. It involves local or generalised reduction of tissue temperature which may lead to varying remedial effects. It acts by varying the metabolism, nerve conduction, haemodynamics and biomechanical properties [2]. The application of cryotherapy in sports injuries has been widely studied which have shown both the beneficial as well as deleterious effects on functional performance [2-4].

Functional Performance is essential for any player in order to achieve his/her goal. It consists of various parameters ranging from strength, flexibility, power to agility, endurance, balance and coordination. Muscle flexibility has been defined as the capacity of a muscle to be stretched thereby allowing a joint (or possibly more than one joint) to move through its Range Of Motion (ROM) and this is related to decreased capacity of a muscle to be deformed [4]. Particularly in the field of rehabilitation, flexibility of the hamstring and calf muscles is important in postural balance, complete maintenance of the ROM of the ankle, knees and hips, injury prevention and better performance of musculoskeletal function [5]. These muscles form the key structures in maintaining the stability and mobility of the posterior kinetic muscle chain. Similarly, leg muscle power in general and particularly vertical jump performance are considered important components for successful athletic performance. Vertical jump has been specifically used in order to assess an athlete's anaerobic power in order to screen them for physically challenging activities [6,7].

Studies have been found that the reduction in the muscular temperature continues even after the removal of cryotherapy modality [8-10]. Also, application of cryotherapy has shown vasoconstriction, slowing the alpha motor neuron conduction, prolonging muscle action potential and changing the force production [11-13]. All these factors might show some changes on the muscle flexibility and in the lower limb power thereby having an effect on either increasing or reducing the risk of injury and hence influence the functional performance, specifically if a sports player wishes to return to the sports after cryotherapy application. Changes owing to the application of superficial and deep thermal modalities and thereby on muscle temperature rely on the procedure of application, duration of application, area to be targeted and initial temperature of the targeted location [11]. Some of the most commonly used modalities are crushed ice (packaged), cold water immersion (whirlpool), cold packs, evaporation spray, vaporised liquid nitrogen, cool air for cryotherapy. Among these cold packs are found to be more often used to manage on field injury prevention due to its feasibility.

Since cryotherapy is widely used in clinical sports medicine and rehabilitation just after or during exercise, it is necessary to better understand its acute effects on physical performance [3,11,12]. It becomes imperative to find any alteration in lower limb flexibility and power, which form the basic performance skills for any player, especially of the posterior kinetic chain muscles, owing to the cryotherapy application. This might help to further plan for the preventive management required to reduce the risk of potential injuries. Thus the purpose of this study was to find out the effects of cryotherapy application on the flexibility of hamstrings and calf muscles along with lower limb power.

MATERIALS AND METHODS

An experimental study was conducted at the Dr. D.Y. Patil College of Physiotherapy, Pimpri, Pune, Maharashtra, India from December 2020 to March 2021. The Institutional Ethical Clearance of Dr. D.Y. Patil College of Physiotherapy was obtained prior to the study (Ethical Number: DYPCPT/ISEC/19/2021).

Sample size calculation: A sample size of 40 was calculated using the Primer Software (version 6.0) with 10% power and 95% confidence interval.

Inclusion criteria: Forty recreational players of either gender, between the age range 18-25 years were selected, who played various forms of recreational sports, having bilateral hamstrings and calf muscle tightness as assessed on AKET and WBLT.

Exclusion criteria: Players with recent lower limb musculoskeletal injuries or injuries in the past six months, those who had undergone any type of surgeries or any other conditions impairing the performance were excluded.

A non probability convenient sampling was done where the participants were screened randomly on the basis of age, gender, BMI and for tightness of hamstrings and calf muscles. Those fitting into the inclusion criteria were informed about the procedure and written informed consent was taken. Included subjects were also assessed for power using the single leg vertical jump performance test. Measurements of AKE test, WBLT and single leg vertical jump test were noted as pretest measures.

Active Knee Extension Test

To perform the AKE test [14], subjects were made to lie in supine position and the opposite lower limb was fixed with one of the therapist hand. The lower limb which was to be assessed was held by the subject in 90° hip and knee flexion. The subjects were asked to perform knee extension as much as possible and hold the position for about five seconds while keeping the hip in 90°. Universal goniometer was used to measure ROM of knee extension. The degree of knee extension angle was taken twice for each leg and the mean angle was considered for analysis.

Weight Bearing Lunge Test

To perform the WBLT [15], subjects were asked to stand facing the wall in comfortable tandem standing, with both the hands on the wall. A measuring tape was secured on the floor starting from the wall and the forward foot was placed over it, parallel to the tape. The forward leg middle toe was at particular centimetre of the tape according to the sample, with heel and knee perpendicular to the wall. Subject was asked to lunge forward so that his/her knee touches the wall without lifting the heel of the forward leg. Subjects were asked to do repeated modified lunge with one centimeter increment to achieve maximum distance on WBLT. Maximum distance covered was recorded as pre outcome measure for calf muscle flexibility.

Single Leg Vertical Jump Test

To perform single leg vertical jump test [16], the subject was tested with the dominant lower limb determined by asking the subject to kick a ball. The subject was then asked to mark the wall in standing reach position as the starting point. The subject was asked to stand on the dominant leg on the side of the wall and instructed to crouch on the testing leg and jump as high as possible marking the maximum reach on the wall again. The difference between the subject's standing reach and maximum vertical jump reach was recorded. Three trials were done for the dominant limb and the mean/average value taken. This was recorded as pre outcome measure for power.

Cryotherapy in the form of ice packs (4-6°C) was applied simultaneously to bilateral hamstrings and calf muscles. The subjects were instructed to lie in the prone position, followed by ice pack application for 20 minutes, once daily for three consecutive days. After the 3rd day, AKET, WBLT and vertical jump test were reassessed and recorded as post outcome measure for hamstring flexibility, calf muscle flexibility and power respectively.

STATISTICAL ANALYSIS

Statistical Analysis was done using the primer of biostatistics software (version 6.0). The Shapiro-Wilk test was done to check the normal distribution. The analysis for demographic characteristics was done in frequency and percentage while paired t-test was used to find the pre and post difference of outcome measures. The p-value <0.05 was considered to be significant.

RESULTS

Total 40 recreational players were selected for the study with the mean age of 22.15±1.36 years and BMI 23.07±3.36 kg/m^2. The data presented in [Table/Fig-1] depicts the gender distribution with their mean age and BMI. Flexibility of the calf muscles (both right and left sides) showed a significant improvement post cryotherapy application on the 3rd day as depicted in [Table/Fig-2] along with significant improvement in the right hamstring flexibility as shown in [Table/Fig-3]. Statistically, no significant improvement was seen in the left hamstring flexibility [Table/Fig-3] and lower limb power [Table/Fig-4].

Gender	Mean age (years)	Mean BMI (kg/m^2)
Males (n=20)	21.75±1.43	23.75±3.58
Females (n=20)	22.55±1.35	22.29±3.36

[Table/Fig-1]: Sample characteristics.

Calf flexibility (in cm)	Right side	Left side
Pretreatment	13.7±2.289	14.2±2.364
Post-treatment	14.71±2.292	15.07±2.366
Mean difference	-1.01	-0.875
t	-5.533	-5.159
p-value	<0.05	<0.05

[Table/Fig-2]: Effect of cryotherapy on flexibility of calf muscles.
Test: paired t-test

Hamstring flexibility (in degrees)	Right side	Left side
Pretreatment	45.67±10.57	52.38±11.45
Post-treatment	50.67±10.19	55.22±11.58
Mean difference	-5	-2.85
t	-4.795	-2.678
p-value	<0.05	0.011

[Table/Fig-3]: Effect of cryotherapy on flexibility of hamstring muscles.
Test: paired t-test

Power (cm)	Mean
Pretreatment	17.61±5.125
Post-treatment	16.76±5.255
Mean difference	0.8475
t	2.520
p-value	0.016

[Table/Fig-4]: Effect of cryotherapy on lower limb power.

DISCUSSION

The present study was conducted on 40 recreational players, of which 20 were male and 20 were female players. The results of the current study showed a significant increase in flexibility of calf muscles, bilaterally along with right side hamstrings. Flexibility of left hamstrings also did show improvement and power also showed a decrease, although it was statistically insignificant. It has been indicated in previous studies that spinal excitability has been inhibited by local cold stimulation while nerve conduction velocity has been reduced [17-19]. It is known that, inhibited activity of muscle spindles and afferent fibres are responsible for inhibiting muscle activation during its elongation, thus allowing greater stretch at the given load [20,21]. Reduced neural activity due to cryostimulation supports the findings from the present study that ROM was increased immediately after cold pack application by improvement in flexibility. These changes are most likely influenced by reduced skin temperature and consequential reduction in neural activity. Fonda B et al., reported skin temperature of the lower extremity reduced more than 10°C immediately after WBC for 150 sec in a cryosauna [18]. A study by Minton J, also shows an increase in active ROM of the hip after applying ice to the hamstrings supporting the previous findings [20].

Brasileiro JS et al., conducted a study which compared the effects of local cooling and warming on flexibility of the hamstrings and this study showed a significant increase in ROM of knee extension after cooling than warming [21]. The present study showed similar results where flexibility of the hamstring muscles increased significantly after ice pack application for three days. Cooling may be responsible for reduction in nerve conduction velocity and thus producing two important effects i.e., reduction in spindle discharge and reduction in pain. The muscle extensibility is limited due to increased degree of tension in the agonist muscle. The increased tension is generated by the facilitative stimulus from the muscle spindles during elongation of the musculature. Reduction in muscle spindle discharge leads to a consequent decrease in muscle tension and thus increasing the tissue extensibility. Relaxation of the muscle may also be achieved after cryotherapy application as a result of fall in the frequency of muscle spindle discharges and thereby decreasing the muscle tension [21,22]. Pain sensation related to muscle spasm also allows longer elongation of the targeted muscle [23,24].

The vertical jump is a test used to assess the functional performance [25,26]. For vertical displacement, triceps surae is considered to be the primary power source, second to the hip extensors. Hence, vertical jump test was used as it specifically tests the power output of this muscle group. The anaerobic power of the hip, knee, and ankle extensors is primarily tested by vertical jump, hence supporting the motive of testing the hamstrings by single-legged vertical jump. Risberg MA and Ekeland A, suggested that double leg vertical jump test is most likely associated with the ability to perform daily functions, whereas single leg tests are more closely associated with the functional stability encountered during more demanding activities [27].

The results of the present study of a decrease in single leg vertical jump height after the application of cryotherapy for 20 minutes is in the agreement with the studies done by Davies CT and Young K [28]. Similarly, Fischer J et al., found a decrease in functional performance on the shuttle run and single-legged vertical hop immediately after icing the hamstrings muscle group [29]. They suggested the decrement in the power can be due to the impaired ability of the muscle spindle to trigger the stretch reflex which may further reduce the amount of action potential which is required to produce eccentric loading phase of muscle contraction. It is proven that the Achilles tendon which was pre cooled showed a decrease in the action potential amplitude, twitch contraction, and twitch conduction time following maximum tendon taps [28]. There may be some negative influences in the resultant force development within the muscle and myotatic reflex's protective mechanism [29]. Howard Jr RL et al., concluded that the most important component is the strength which is needed for high velocity movements during athletic activity [13]. A positive relationship between power and cooling has also been established where reduction in power is post cooling along with decreased metabolic and force generating mechanism within the muscle [29]. In contrast with prior experiments, there have been studies reporting no decrement in power after cryostimulation [30]. The lack of deficits in the functional performance in this study may be attributed to the fact that power might also be influenced by cryotherapy application if given on joints where as in this study only muscles were targeted. This observation may help resolve conflicting results of many comparable prior studies investigating a similar cryotherapy modality. The objective of this study was to focus on the influence of cryotherapy on the hamstrings and calf muscle complex and thereby on flexibility and power. However, cryotherapy application on joints and assessing its effects can be a scope for future research.

Limitation(s)

Recreational players with reduced flexibility and power were only included, further studies might also be done to see similar effects during the on-field assessment and treatment, assessing other functional performance parameters. This study also did not consider the time period of training just before the cryotherapy application which might also impact the effect. Other lower limb muscle groups were not given cryotherapy.

CONCLUSION(S)

The present study suggests that cryotherapy increases the flexibility of hamstring and calf muscles significantly and clinically, it showed reduction in lower limb power. Hence, cryotherapy can be a safe modality to increase flexibility, even when used for short term duration and might reduce lower limb anaerobic power. Future research can be done to see similar effects of cryotherapy if applied to other lower limb muscles. Other functional performance skills and measures should also be assessed post cryotherapy application in different players.

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